Workshop Manual

Engine repair

A
2(0)

MD22, TMD22, TAMD22

Engine repair

Marine Engines
MD22 • TMD22 • TAMD22

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Introduction

This Workshop Manual contains descriptions and repair instructions for Volvo Penta products or product versions contained in the contents list. Ensure that the correct workshop literature is being used.

Read the safety information and the Workshop Manual “General Information” and “Repair Instructions” carefully before starting work.

Important

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

WARNING! If these instructions are not followed there is a danger of personal injury, extensive damage to the product or serious mechanical malfunction.

IMPORTANT! Used to draw your attention to something that can cause damage, product malfunction or damage to property.

NOTE! Used to draw your attention to important information that will facilitate work or operations.

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

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

Generally, all servicing should be carried out with the engine switched off. However, some work, certain adjustments for example, require that the engine is running when they are carried out. Approaching a running engine is dangerous. Loose clothing or long hair can catch in rotating parts and cause serious personal injury.
If working in proximity to a running engine, careless movements or a dropped tool can result in personal injury. Avoid burns. Take precautions to avoid hot surfaces (exhausts, turbochargers, charge air pipes and starter elements etc.) and liquids in supply lines and hoses when the engine is running or has been turned off immediately prior to starting work on it. Reinstall all protective parts removed during service operations before starting the engine.

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

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

Never use start spray or similar to start the engine. An explosion may occur in the inlet manifold. Danger of personal injury.

Avoid opening the filler cap for the engine coolant system (freshwater cooled engines) when the engine is still hot. Steam or hot coolant can spray out. Open the coolant filler cap carefully and slowly to release the pressure before removing the cap completely. Take great care if a cock, plug or engine coolant line must be removed from a hot engine. It is difficult to anticipate in which direction steam or hot coolant can spray out.

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

Stop the engine and close the seacock valve before carrying out operations on the engine cooling system.

Only start the engine in a well-ventilated area. If operating the engine in an enclosed space, ensure that exhaust gases and crankcase ventilation emissions are extracted from the workshop area.

⚠ Always use protective goggles where there is a danger of pieces of metal, sparks from grinding, acid or other chemicals being thrown into your eyes. Eyes are very sensitive. Injury to them can lead to the loss of sight!

⚠ Avoid skin contact with oil! Long-term or repeated contact with oil can remove the natural oils from your skin. This can result in irritation, dry skin, eczema and other skin problems. Used oil is more dangerous to health than new oil. Use protective gloves and avoid using oil-soaked clothes and rags. Wash regularly, especially before meals. Use the correct barrier cream to prevent dry skin and to make cleaning your skin easier.

⚠ Most chemicals used in products (engine and transmission oils, glycol, petrol and diesel oil) and workshop chemicals (solvents and paints) are hazardous to health Read the instructions on the product packaging carefully! Always follow safety instructions (using breathing apparatus, protective goggles and gloves for example). Ensure that other personnel are not unwittingly exposed to hazardous substances (by inhalation for example). Ensure that ventilation is good. Handle used and excess chemicals according to the instructions.

⚠ Be extremely careful when tracing leaks in the fuel system and testing fuel injection nozzles. Use protective goggles! The jet ejected from a fuel injection nozzle is under very high pressure. It can penetrate body tissues and cause serious injury Danger of blood poisoning.

⚠ All fuels and many chemicals are inflammable. Ensure that a naked flame or sparks cannot ignite fuel or chemicals. Combined with air in certain ratios, petrol, some solvents and hydrogen from batteries are easily inflammable and explosive. Smoking is prohibited! Ensure that ventilation is good and that the necessary safety precautions have been taken before carrying out welding or grinding work. Always have a fire extinguisher to hand in the workplace.

⚠ Store oil and fuel-soaked rags and fuel and oil filters safely. In certain conditions, oil-soaked rags can spontaneously ignite. Replaced fuel and oil filters are environmentally harmful waste and should be disposed of at proper disposal areas together with engine and transmission oil, contaminated fuel, old paint, degreasing agents, and cleaning residue.

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

⚠ Always ensure that the positive and negative battery leads are correctly installed on the corresponding terminal posts on the batteries. Incorrect installation can result in serious damage to electrical equipment. Refer to the wiring diagram.

⚠ Always use protective goggles when charging and handling the batteries. The battery electrolyte contains extremely corrosive sulfuric acid. If this comes into contact with the skin, wash immediately with soap and plenty of water. If battery acid comes into contact with the eyes, immediately flush with copious amounts of water and obtain medical assistance.

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

⚠ Use the lifting eyes mounted on the engine / reverse gear when lifting the drive unit.
Always check that lifting equipment is in good condition and has sufficient load capacity to lift the engine (engine weight including reverse gear and any extra equipment installed).
Use an adjustable lifting beam or lifting beam specifically for the engine to raise the engine to ensure safe handling and to avoid damaging engine parts installed on the top of the engine.
All chains and cables should run parallel to each other and as perpendicular as possible in relation to the top of the engine.
If extra equipment is installed on the engine, thereby altering its center of gravity, a special lifting device is required to achieve the correct balance for safe handling.
Never carry out work on an engine suspended on a hoist.

⚠ Never remove heavy components alone, even where secure lifting equipment such as secured blocks are being used. Even where lifting equipment is being used, it is best to carry out the work with two people; one to operate the lifting equipment and the other to ensure that components are not trapped and damaged when being lifted.

When working on-board, ensure that there is sufficient space to remove components without danger of injury or damage.

⚠ Components in the electrical system, ignition system (gasoline engines) and fuel system on Volvo Penta products are designed and constructed to minimize the risk of fire and explosion. The engine must not be run in areas where there are explosive materials.

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

General information

About the workshop manual

This Service Manual contains descriptions and instructions for the repair of the following engines in standard format: MD22A, MD22L-A, MD22L-B, MD22P-B, TMD22A, TMD22-A, TMD22-B, TMD22P-C, TAMD22P-B. This Service Manual can show operations carried out on any of the engines listed above. As a result, the illustrations and pictures in the manual showing certain engines components, do not in some cases apply to all the engines listed above. However, the repair and service operations described are the same in all essential details. Where they are not the same, this is stated in the manual. Where the difference is considerable, the operations are described separately. The engine designation and engine number are displayed on the identification plate (see the chapter “Identifying numbers”). The engine designation and number should be given in all correspondence about the engine.

This Workshop Manual has been developed primarily for Volvo Penta service workshops and qualified personnel. Personnel using this book are assumed to have a grounding in marine drive systems and able to carry out the related mechanical and electrical work.

Volvo Penta is continuously developing their products. We therefore reserve the right to make changes. All the information contained in this book is based on product data available at the time of going to print. Any essential changes or modifications introduced into production or updated or revised service methods introduced after the date of publication will be provided in the form of Service Bulletins.

Spare parts

Replacement parts for electrical and fuel systems are subject to statutory requirements (US Coast Guard Safety Regulations for example). Volvo Penta Genuine parts meet these requirements. Any type of damage which results from the use of non-original Volvo Penta replacement parts for the product will not be covered under any warranty provided by Volvo Penta.

Certificated engines

If you own an engine certificated for any area where exhaust emissions are regulated by law, the following is important:

Certification means that an engine type is inspected and approved by the authorities. The engine manufacturer guarantees that all engines manufactured of that type correspond to the certified engine.

This places special requirements for maintenance and service as follows:

- The maintenance and service intervals recommended by Volvo Penta must be observed.
- Only genuine Volvo Penta replacement parts may be used.
- The service of injection pumps and injectors or pump settings must always be carried out by an authorized Volvo Penta workshop.
- The engine must not be modified in any way except with accessories and service kits approved by Volvo Penta.
- No modifications to the exhaust pipes and air supply ducts for the engine room may be undertaken.
- Seals may only be broken by authorized personnel.

In addition, the general instructions contained in the Instruction Manual concerning operation, service and maintenance must be followed.

⚠ **IMPORTANT!** Late or inadequate maintenance / service or the use of spare parts other than Volvo Penta original 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 Service Manual apply to work carried out in a workshop. The engine has been removed from the boat and is installed in an engine fixture. Unless otherwise stated reconditioning work which can be carried out with the engine in place follows the same working method.

Warning symbols occurring in the Workshop Manual (for their meaning see Safety information)

WARNING!

IMPORTANT!

NOTE!

are not in any way comprehensive since it is impossible to predict every circumstance under which service work or repairs may be carried out. For this reason we can only highlight the risks that can arise when work is carried out incorrectly in a well-equipped workshop using working methods and tools developed by us.

All procedures for which there are Volvo Penta special tools in this Workshop Manual are carried out using these. Special tools are developed to rationalize working methods and make procedures as safe as possible. It is therefore the responsibility of any person using tools or working methods other than the ones recommended by us to ensure that there is no danger of injury, damage or malfunction resulting from these.

In some cases there may be special safety precautions and instructions for the use of tools and chemicals contained in this Workshop Manual. These special instructions should always be followed if there are no separate instructions in the Workshop Manual.

Certain elementary precautions and common sense can prevent most risks arising. A clean workplace and engine eliminates much of the danger of injury and malfunction.

It is of the greatest importance that no dirt or foreign particles get into the fuel system, lubrication system, intake system, turbocharger, bearings and seals when they are being worked on. The result can be malfunction or a shorter operational life.

Our Joint responsibility

Every engine consists of many systems and components that work together. If one component deviates from the technical specifications this can have dramatic consequences on the environmental impact of the engine even if it is otherwise in good running order. It is therefore vital that wear tolerances are maintained, that systems that can be adjusted are adjusted properly and that Volvo Penta Genuine Parts as used. The engine Maintenance Schedule must be followed.

Certain systems (components in the fuel system for example) may require specialist expertise and test equipment. Some components are sealed at the factory for environmental reasons. No work should be carried out on sealed components except by authorized personnel.

Bear in mind that most chemicals used on boats are harmful to the environment if used incorrectly. Volvo Penta recommends the use of biodegradable degreasing agents for cleaning engine components, unless otherwise stated in a workshop manual. Take special care when working on-board, that oil and waste is taken for destruction and is not accidentally pumped into the environment with bilge water.

Tightening torque

Tightening torques for vital joints that must be tightened with a torque wrench are listed in Workshop manual “Technical Data”: and are in certain cases contained in work descriptions in this Manual. All torques apply for cleaned threads, screw heads and mating surfaces. Torques apply for lightly oiled or dry threads. If lubricants, locking fluid or sealing compound are required for a screwed joint this information will be contained in the work description. Where no tightening torque is stated for a joint use the general tightening torques according to the tables below. The tightening torques stated are a guide and the joint does not have to be tightened using a torque wrench.

Dimension	Tightening torques Nm
M5	5
M6	10
M8	20
M10	40
M12	70
M14	115

Protractor tightening torques

Tightening using both a torque setting and a protractor angle requires that first the recommended torque is applied using a torque wrench and then the recommended angle is added according to the protractor scale. Example: a 90° protractor tightening means that the joint is tightened a further 1/4 turn in one operation after the stated tightening torque has been applied.

Locknuts

Do not re-use lock nuts that have been removed during dismantling as they have reduced service life when re-used - use new nuts when assembling or reinstalling. For lock nuts with a plastic insert such as Nylock® the tightening torque stated in the table is reduced if the Nylock® nut has the same head height as a standard hexagonal nut without plastic insert. Reduce the tightening torque by 25% for 8 mm bolt sizes or larger. Where Nylock® nuts are higher, or of the same height as a standard hexagonal nut, the tightening torques given in the table apply.

Strength classes

Screws and nuts are divided into different strength classes, the class is indicated by the number on the bolt head. A high number indicates stronger material, for example a bolt marked 10-9 indicates a higher strength than one marked 8-8. It is therefore important that bolts removed during the disassembly of a bolted joint must be reinstalled in their original position when assembling the joint. If a bolt must be replaced check in the replacement parts catalogue to make sure the correct bolt is used.

Sealing compound

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

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

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

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

Ensure that mating surfaces are dry and free from oil, grease, paint and anti-corrosion agent before applying sealant or locking fluid.

Always follow the manufacturer's instructions for use regarding; temperature range, curing time and any other instructions for the product.

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

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

The following RTV agents are mentioned in the Service Manual: Loctite® 574, Volvo Penta 840879-1, Permatex®

No.3, Volvo Penta P/N 1161099-5, Permatex(r) No. 77. Old sealant can be removed using denatured alcohol in all cases.

Anaerobic agents. These agents cure in an absence of air. They are used when two solid parts, for example cast components, are installed face-to-face without a gasket. Used to seal and lock plugs, stud threads, stopcocks, oil pressure sensors etc. Cured anaerobic agents are glassy and the agents are colored to make them visible. Cured anaerobic agents are extremely resistant to solvents and the old agent cannot be removed. When reinstalling the part is carefully degreased and then new sealant is applied.

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

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

Safety precautions for Fluorine rubber

Fluorine rubber is a common material in sealing rings for shafts and O rings.

When fluorine rubber is exposed to high temperatures (over 300°C) it can release highly corrosive **hydrofluoric acid**. Exposing the skin to this chemical can cause serious burns. If splashed in the eyes it can cause malignant ulcers. Inhaling the fumes can damage the respiratory passages.

⚠ **WARNING!** Take the greatest care when working on engines that have been operating at high temperatures, for example an overheated engine that has seized or an engine involved in a fire. The seals must never be burned off when disassembling or be burnt afterwards in anything other than a special disposal site.

- Always used chloroprene rubber gloves (gloves for handling chemicals) and protective goggles.
- Treat removed seals in the same way as corrosive acid. All remains, even the ash can be extremely corrosive. Never use compressed air jets for blowing clean.
- Put old seal remnants in a plastic container, close it and stick a warning label on it. Wash gloves under running water before removal.

The following seals may contain fluorine rubber:

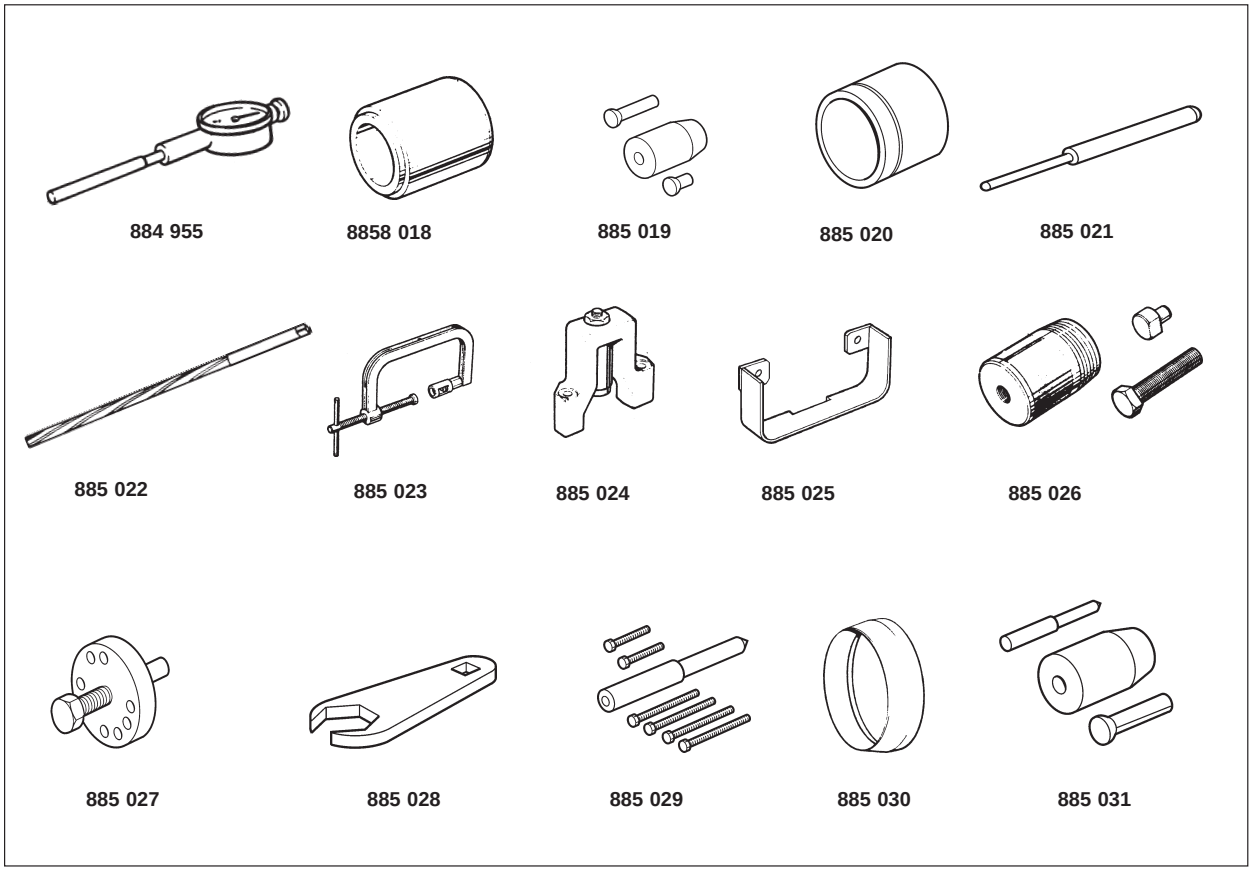
Crankshaft, camshaft and intermediate shaft seals.

O rings, wherever used. O rings for cylinder liner sealing are almost always fluorine rubber.

Note that seals which have not been exposed to high temperatures can be handled normally.

Special tools

In all cases where it is practical the tool number, except for the final digit, has been stamped on the tool, The final digit (after the hyphen) is a control number.



884955-6 Dial gauge assembly

885018-2 Installation tools for front stuffing box, camshaft.

885019-0 Puller for rear stuffing box, camshaft.

885020-8 Installation tools for rear stuffing box, camshaft.

885021-6 Presser / depresser for valve guides.

885022-4 Reamer for new valve guides.

885023-2 Valve spring tensioner.

885024-0 Camshaft mounting seats (set of three)

885025-7 Camshaft locking.

885026-5 Puller for front stuffing box, camshaft.

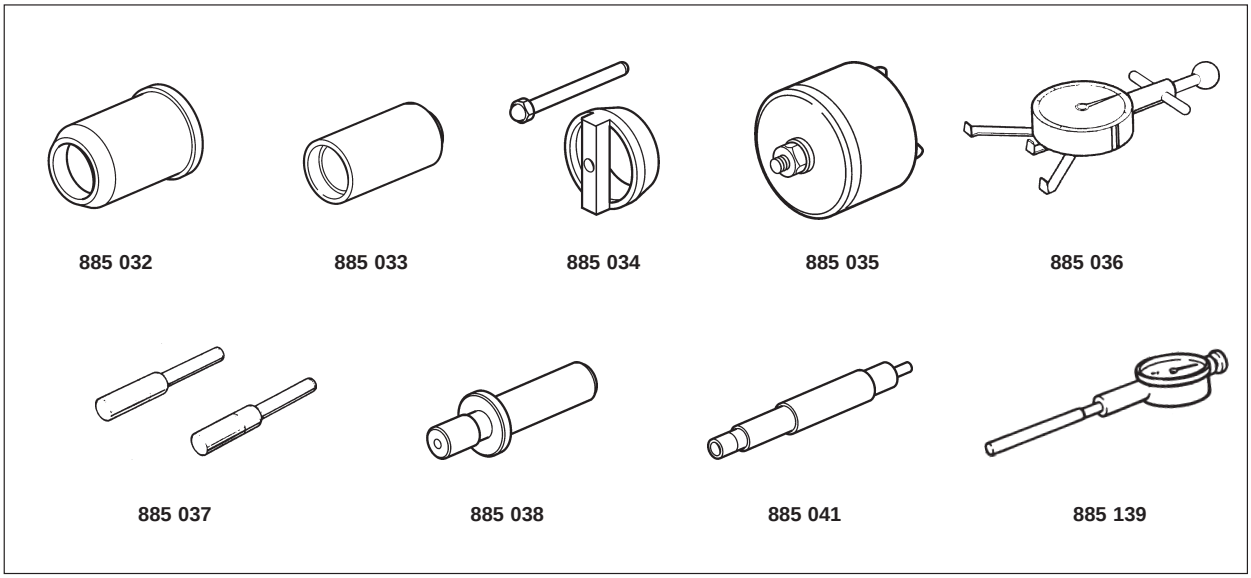
885027-3 Puller for injection pump and crankshaft pulleys (main tool).

885028-1 Dismantling / assembly wrench for the stop solenoid for the fuel injection pump

885029-9 Adapters for use with 885027.

885030-7 Protective socket for rear stuffing box, crankshaft.

885031-5 Puller for front stuffing box, crankshaft.



885032-3 Protective socket for front stuffing box, crankshaft.

885033-1 Installation tool for front stuffing box, crankshaft.

885034-9 Puller for rear stuffing box, crankshaft.

885035-6 Installation tool for rear stuffing box, crankshaft.

885036-4 Belt tension gauge for timing belt.

885037-2 Adjustment drifts for the camshaft and crankshaft.

885038-0 Alignment adapter for installing the sea-water pump.

885041-4 Adapter for checking compression.

885139-6 Dial gauge assembly (TMD22P, TAMD22 only)

Identifying numbers

Your engine and transmission has identification plates with identification numbers. This information should always be quoted when ordering replacement parts. The appearance and location of identification plates is shown below. The figures in brackets refer to the location of the identification numbers on the identification plate.

Engine

Product designation (1)

Serial number (2)

Product number (3)

Certification number (4)

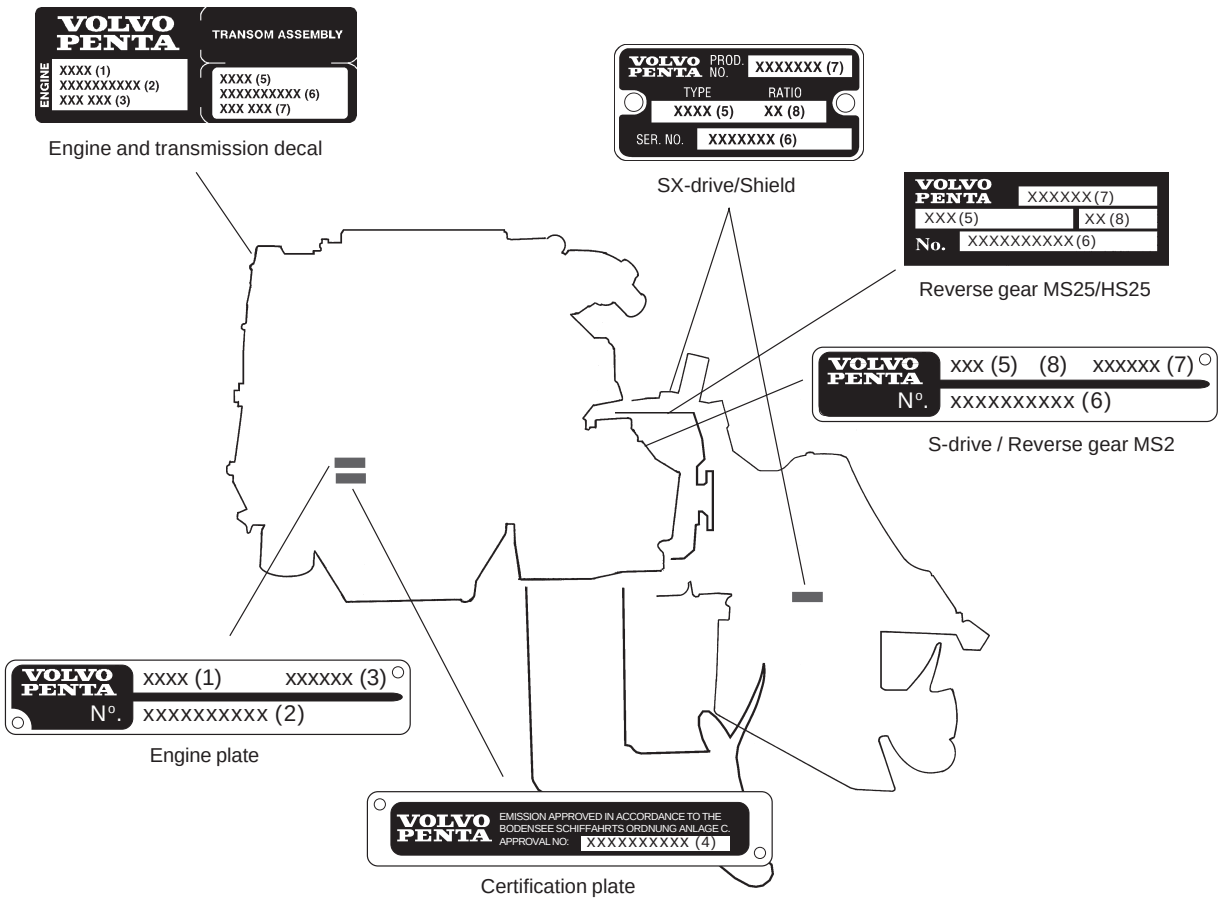
Drive / Shield / Reverse gear

Product designation (5)

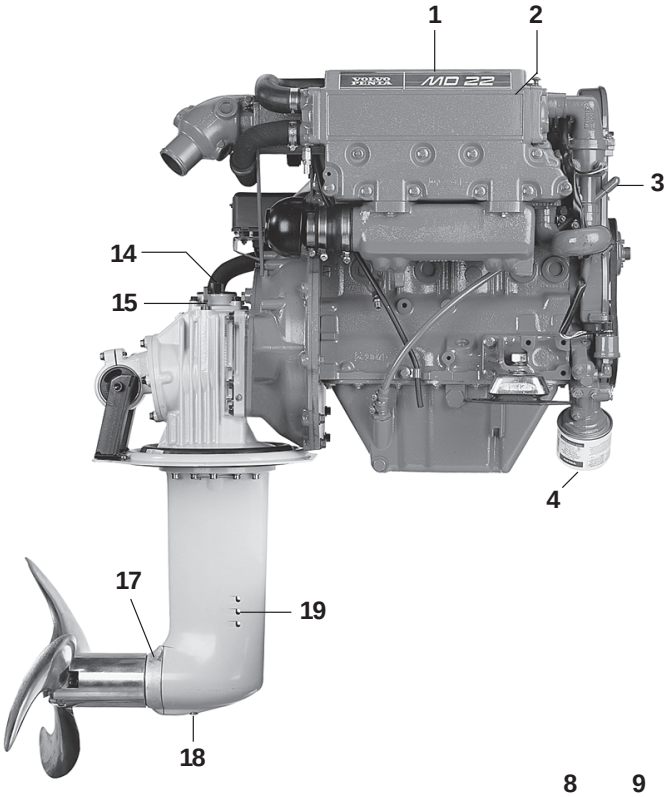
Serial number (6)

Product number (7)

Gear ratio (8)

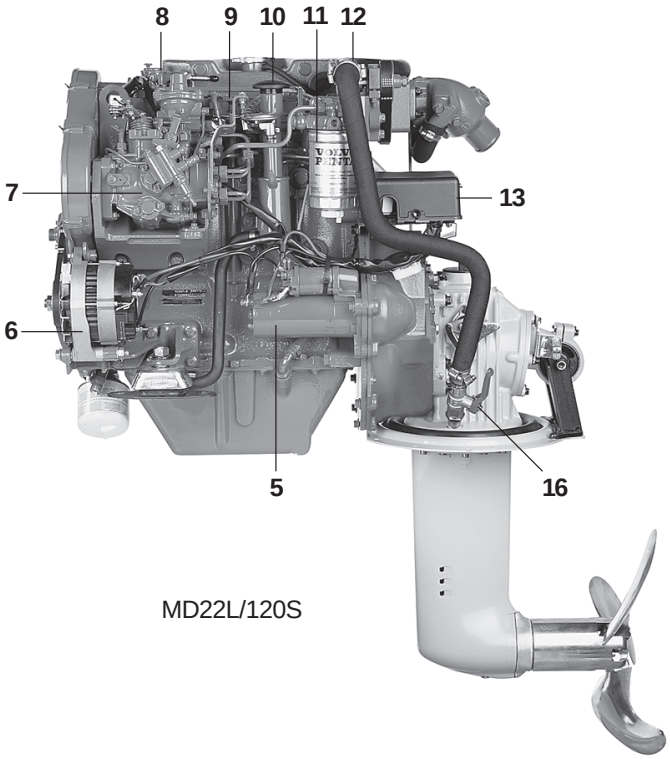


Engine presentation

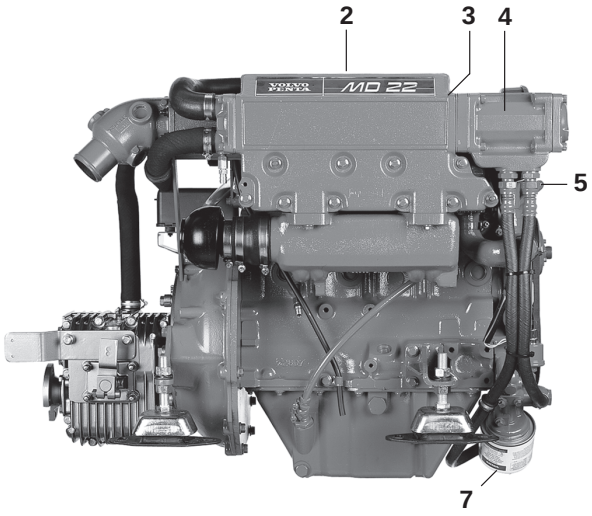


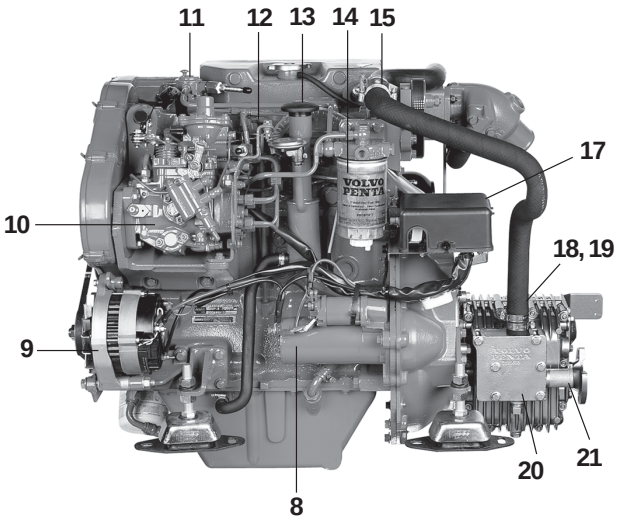
MD22L/120S

1. Coolant filler
2. Heat exchanger
3. Pipe for oil scavenging pump
4. Oil filter
5. Starter motor
6. Generator
7. Injection pump
8. Fuel feed pump
9. Dipstick (engine)
10. Oil filler cap (engine)
11. Fuel filter
12. Sea water pump
13. Central electronics unit
14. Topping up oil (drive)
15. Oil dipstick (drive)
16. Seacock
17. Sacrificial anode
18. Draining oil (drive)
19. Seawater intake

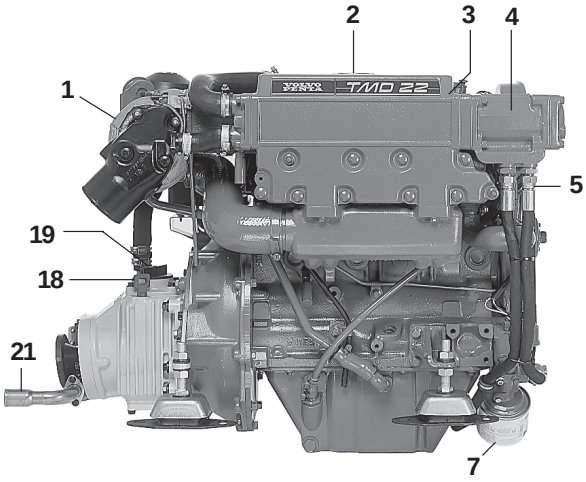


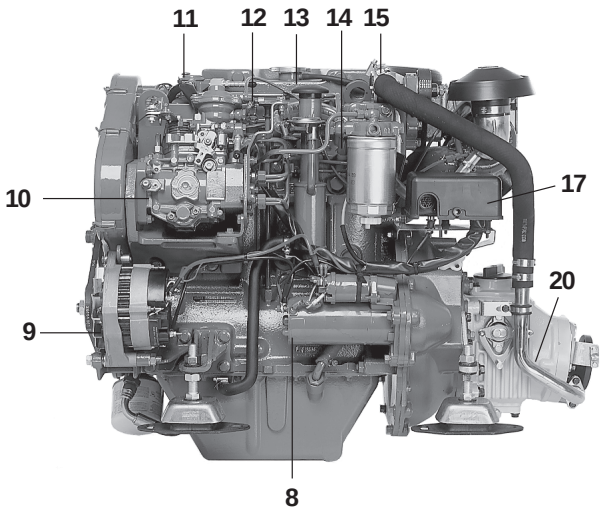
MD22L/120S



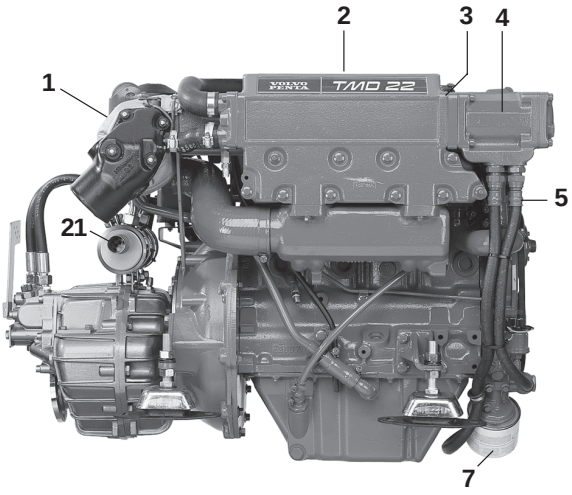


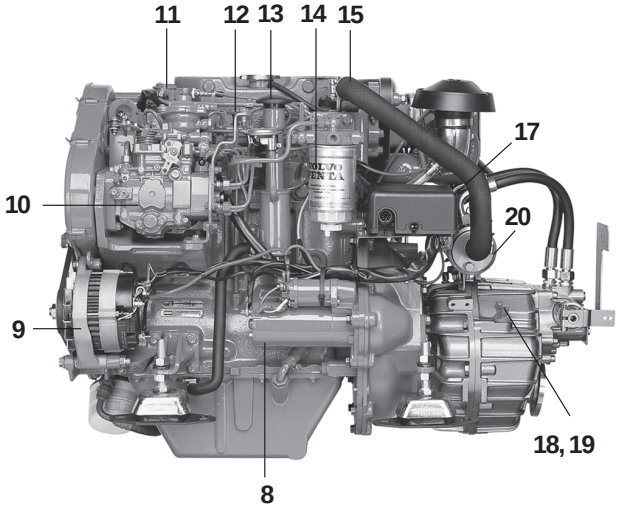
MD22P/MS25



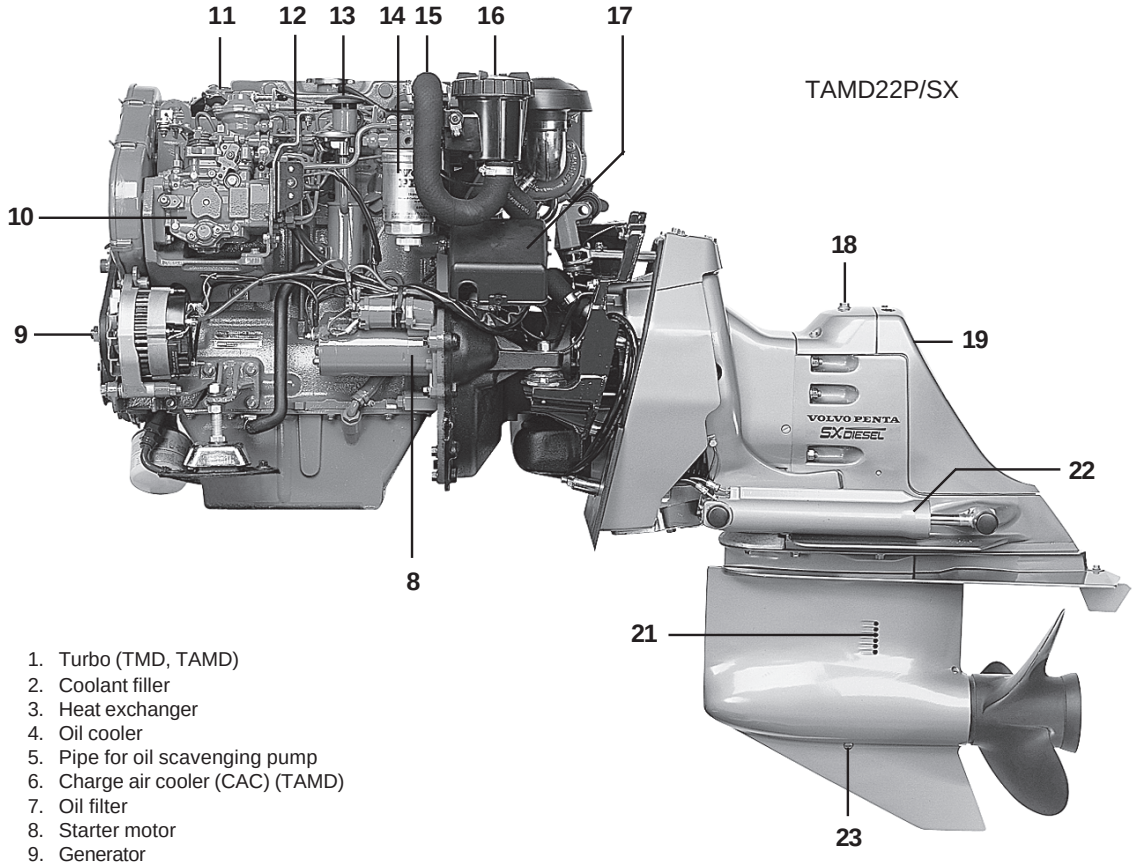


TMD22/MS2

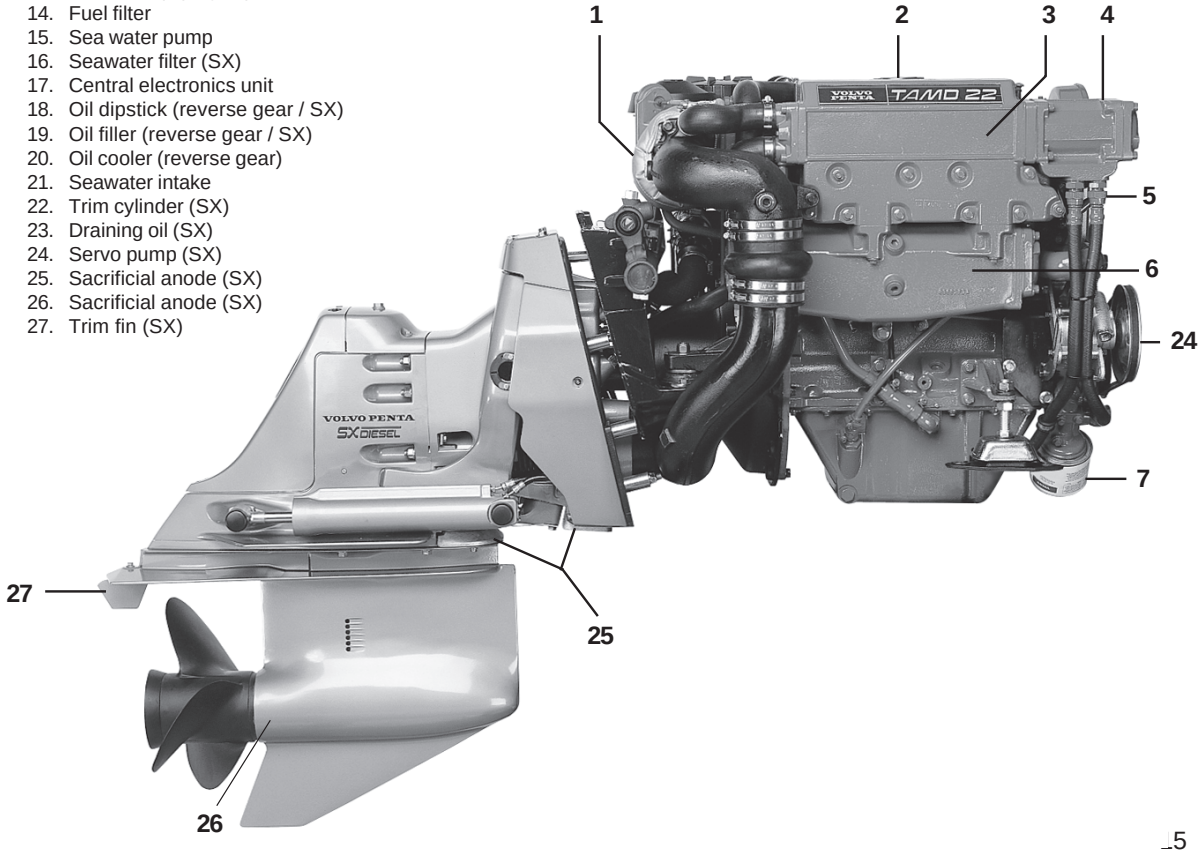




TMD22P/HS25



1. Turbo (TMD, TAMD)
2. Coolant filler
3. Heat exchanger
4. Oil cooler
5. Pipe for oil scavenging pump
6. Charge air cooler (CAC) (TAMD)
7. Oil filter
8. Starter motor
9. Generator
10. Injection pump
11. Fuel feed pump
12. Dipstick (engine)
13. Oil filler cap (engine)
14. Fuel filter
15. Sea water pump
16. Seawater filter (SX)
17. Central electronics unit
18. Oil dipstick (reverse gear / SX)
19. Oil filler (reverse gear / SX)
20. Oil cooler (reverse gear)
21. Seawater intake
22. Trim cylinder (SX)
23. Draining oil (SX)
24. Servo pump (SX)
25. Sacrificial anode (SX)
26. Sacrificial anode (SX)
27. Trim fin (SX)



Cylinder head

General

The carbon deposits in a diesel engine are small and therefore the number of operational hours do not give an indication of when it is time to recondition a cylinder head. The factors which determine when reconditioning is necessary are ease of starting the engine and the all round performance.

The cylinder head is made of aluminum and the head is drilled together with the camshaft cover in order to localize the camshaft bearing. The camshaft cams lie directly above the valves and affect them using the valve lifters, which are mounted on top of the valves. The shims are installed between the valve lifters and the top of the valves so that adjustment is possible.

The cylinder head has two valves per cylinder. Each valve is installed with a single valve spring.

The valves move in cast valve guides which are pressed into the cylinder head and can be replaced.

Both the valve stems are equipped with oil seals which pass over the top of the valve guides.

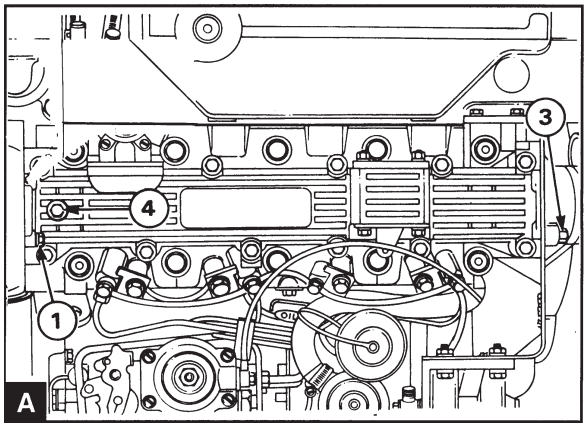
Valve seat inserts are installed in the cylinder head for both the inlet and exhaust valves.

Repair Instructions

Camshaft cover, replacement (12A-01)

Special tools: 885025

1



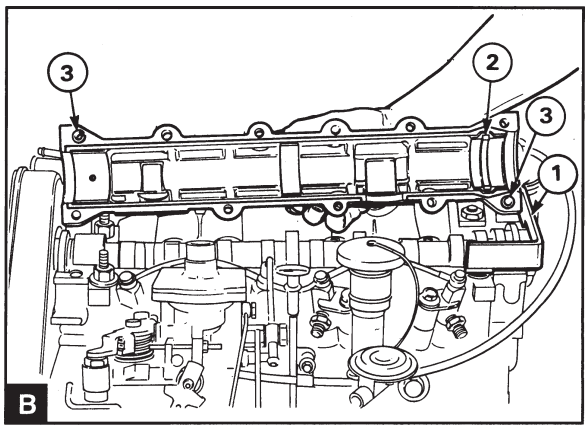
Remove the screws securing the camshaft cover front flange to the timing cover (A1).

Remove the screw installed through the seawater pump drive housing in the rear flange of the cover (A3). If it is too cramped to remove the cover, remove the mounting bracket for the sea water pump.

2

Remove the screw over the adjustment hole at the top of the front end of the camshaft cover (A4). Turn the crankshaft until the adjustment hole in the front of the camshaft front bearing journal corresponds with the hole in the cover. This makes it easier to dismantle the fuel supply pump and the camshaft cover.

3



Remove the engine lifting brackets. If nothing is driven from the rear end of the camshaft, remove the rear cover and install the camshaft lock 885025 (B1). This ensures that the camshaft does not tilt when the camshaft cover is removed.

4

Remove the fuel supply pump, operation 19A-03.

5

Remove the camshaft cover screws evenly in reverse order to that given in illustration D. Remove the screws and the cover (B). Ensure that the thrust washer (B2) remains in place in the cover.

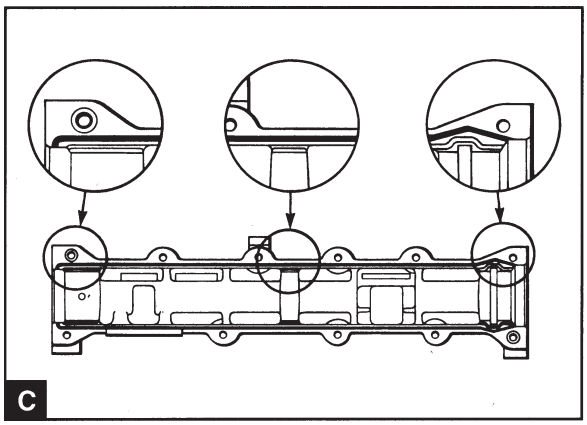
6

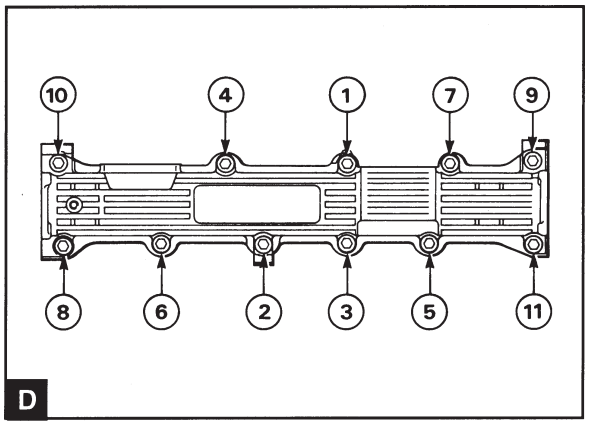
Check the cover and the camshaft thrust washer for wear and other damage. If the cover is damaged or worn a new cylinder head assembly, because the holes for the camshaft bearing journals are machined with the cylinder head and the camshaft cover installed to each other.

7

Check that the guide sleeves (B3) and thrust washer (B2) is correctly installed. Ensure that the camshaft front and rear stuffing boxes still remain in the correct position against the collar in the cylinder head and that are not crooked.

8





Check that the groove in the camshaft cover and the mating surfaces on the cylinder head and cover are clean. Apply a 2mm bead of silicon in the outer groove of the cover, but leave the inner groove empty as illustrated in illustration (C). Install the cover directly after the sealant has been applied. Install the mounting screws with the longer screws in each end of the cover. Tighten the screws in stages in order to hold the cover parallel to the cylinder head when it is tightened. Finally tighten the screws to **22 Nm** in the order displayed in the illustration (D).

9

Install and tighten the screw securing the seawater pump drive housing to the camshaft cover. If the installation bracket for the seawater pump has been removed, align the bracket before tightening it see operation 20A-08.

10

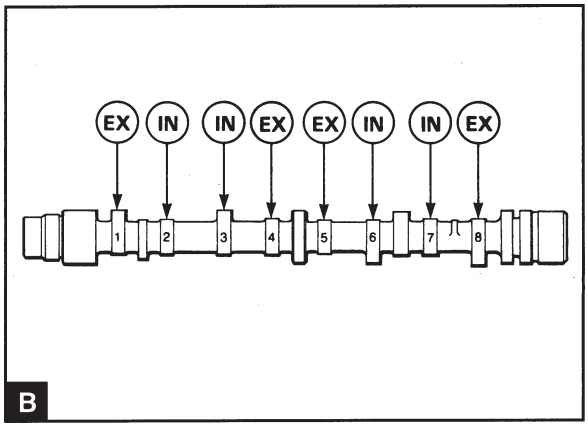
Install and tighten the screws securing the timing cover to the camshaft cover. Install the cover to the timing cover if required.

11

Ensure that the adjustment hole in the front of the camshaft front bearing journal corresponds with the hole in the camshaft cover. Install the fuel supply pump, operation 19A-03. Install the screw in the adjusting hole in the camshaft cover. Install the engine lifting brackets.

Valve clearance, check (12A-02)

Special tools: 885025, 885024



The valve clearance is measured between the camshaft and the upper side of the valve lifter (A). With a cold engine the correct valve clearance 0.25-0.35 mm for the inlet valves and 0.35 –0.45 mm for the exhaust valves. See B for the position for the inlet and exhaust cams.

Cam no.1 is at the camshaft pulley end.

1

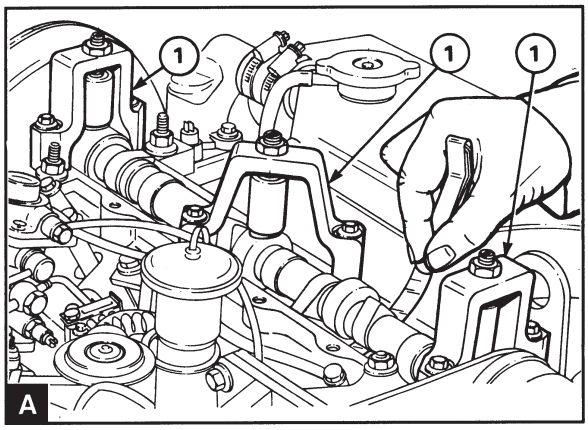
Disconnect the battery.

2

Remove the camshaft cover, operations 12A-01.

Dismantle the seawater pump, operation 20A-06 and install the camshaft lock 885025 before the cover is removed.

3



Install the camshaft mountings 885024 (A1) to hold the camshaft and mount the mountings with the relevant mounting screws for the cover. It is vital to move the rear camshaft stuffing box on the camshaft to secure sufficient clearance between the rear mounting and the stuffing box. Ensure that the sprung pads are correctly installed on the camshaft bearing journals and tighten the mounting screws for the mountings evenly.

4

Turn the crankshaft until the tips of cams 1 and 3 are both near their highest point. Use a feeler gauge with a bent blade to measure the valve clearance for valves 1 and 3. Make a note of the clearance.

5

Repeat point 4 for valves 2 and 5, 6 and 8 and 4 and 7.

6

Adjustment is only necessary if play lies outside the 0.20-0.40mm for the inlets valve or 0.30-0.50 for the exhaust valves. If adjustment is necessary see operation 12A-03.

7

When the clearance is correct remove the mountings for the camshaft bearing journals and install the camshaft cover, operation 12A-01.

8

Connect the battery.

Valve clearance, adjustment (12A–03)

Special tools: 885024, 885025, 885037

If when checking valve clearance, operation 12A-02, it appears that the adjustment is necessary carry on as follows:

1

Turn the crankshaft until the adjustment hole in the camshaft front bearing journal is at “12 o’clock”.

Install the adjustment drift 885037 through the rear plate or through the flywheel cover using the flywheel adjustment hole.

2

Remove the cap of the timing cover, operation 15A-01.

3

Remove the mounting screws for the camshaft pulley and the mounting screw for the pulley hub.

4

Install two screws (M6 x 50) to hold the fuel injection pump pulley.

5

Remove the timing belt, the camshaft pulley and the pulley hub see section 15.

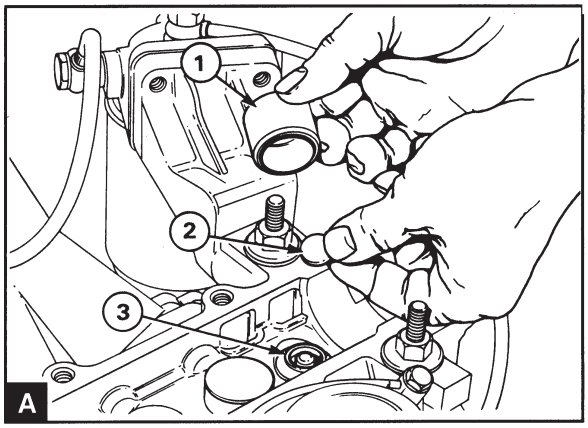
6

Remove the seawater pump, operation 20A-06 and the mounting bracket for the pump, operation 20A-08.

7

Remove the camshaft mountings and remove the camshaft (12A.07/A). Remove the stuffing boxes from the camshaft.

8



Adjust each valve lifter in the following order: Remove the valve lifter (A1) and remove the shim (A2), located on top of the valve spring washer (A3). Calculate the adjustment for each valve lifter using the notes from operation 12A-02 Measure the thickness of the existing shim. If the clearance must be increased insert a thinner shim of the thickness required. If the clearance must be decreased insert a thicker shim. Use the average clearance of 0.30 mm for the inlet 0.40 mm for the exhaust valves when calculating. Lubricate the valve lifter and insert it in the hole. Repeat the operation for each valve lifter requiring adjustment.

9

When all the shims requiring changing have been replaced, install the camshaft in position and install the temporary camshaft pulley hub. Remove the adjustment drift and the locking tool from the flywheel. Turn the crankshaft a quarter turn clockwise. Install the camshaft mountings and check that the valve clearance is correct, operation 12A-02.

10

If the play is correct, remove the camshaft pulley hub and the camshaft mountings. Turn the crankshaft a quarter turn counter-clockwise. Install the adjustment drift and the locking tool on the flywheel. Lubricate the valve lifters and the camshaft bearing journals and cams.

11

Install the camshaft cover, operations 12A-01.

12

Install the new front and rear stuffing box on the camshaft, operations 12A-04 and 12A-05.

13

Install the camshaft pulley and the timing belt, see section 15. Remove the locking drifts from the fuel injection pump pulley and adjust the belt tension, operation 15A-03.

14

Remove the adjustment drift. Check the fuel injection pump adjustment, operations 17A-03.

15

Install the cap of the timing cover, operation 15A-01.

16

Install the screw in the adjustment hole in the camshaft cover. Install the back plate for the camshaft cover.

Install the bracket for the seawater pump, operation 21A-08 and the seawater pump, operation 20A-06.

17

Turn the crankshaft two revolutions to ensure that there is nothing preventing free movement.

Front sealing ring, replacement (12A-04)

Special tools: 885026, 885018, 885037

1

Disconnect the battery

2

Remove the screw from the adjustment hole on the top of the front end of the camshaft cover (12A.03/A4). Turn the crankshaft until the adjustment hole in the front of the camshaft front bearing journal corresponds with the hole in the cover.

3

Install the adjustment drifts 885037 on the camshaft and flywheel.

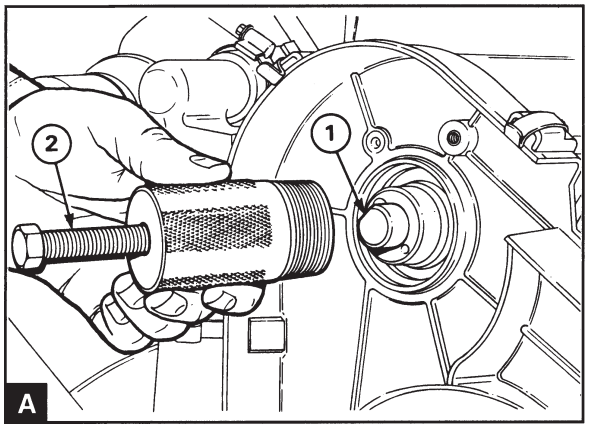
4

Remove the cap of the timing cover, operation 15A-01.

5

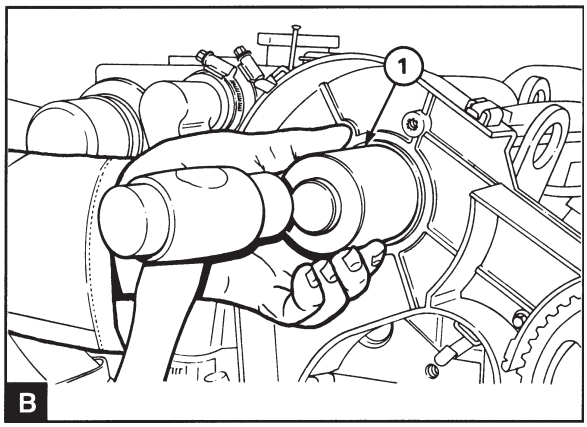
Remove the camshaft pulley, operation 15A-06.

6



Install the plug from the tool 885026 (A1) in the front end of the camshaft. Unscrew the center screw (A2) sufficiently to ensure that it does not reach the plug and insert the main tool into the stuffing box. Turn the tool clockwise to ensure that the it is secure in the stuffing box and tighten the center screw against the plug to remove the stuffing box.

7



Ensure that the stuffing box and the camshaft are clean and undamaged. Lubricate the new stuffing box with fresh engine oil and insert it into position with the seal lip inwards. Use installation tool 885026 (B1) and a hammer with a soft face to drive the stuffing box into the correct position.

8

Install the camshaft pulley and the timing belt, see section 15. Remove the locking drifts from the fuel injection pump pulley and adjust the timing belt tension, operation 15A-03.

9

Check the fuel injection pump adjustment, operations 17A-03.

10

Remove the adjustment drifts and turn the crankshaft two revolutions to ensure that there is nothing preventing free movement.

11

Install the screw in the adjustment hole in the camshaft cover. Connect the battery.

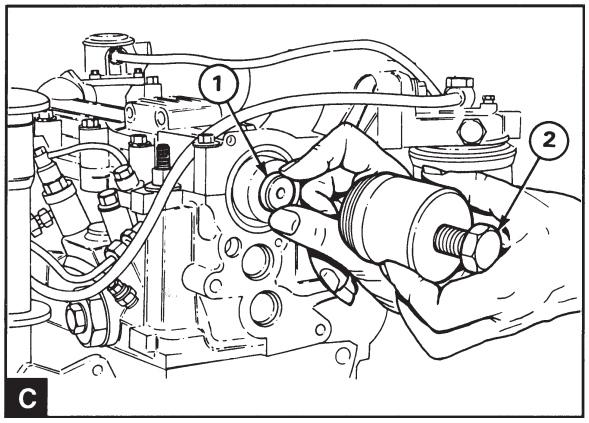
Rear sealing ring, replacement (12A-05)

Special tools: 885019, 885020, 885038

1

Remove the seawater pump and the drive housing and remove the drive adapter from the camshaft end, see section 20.

2

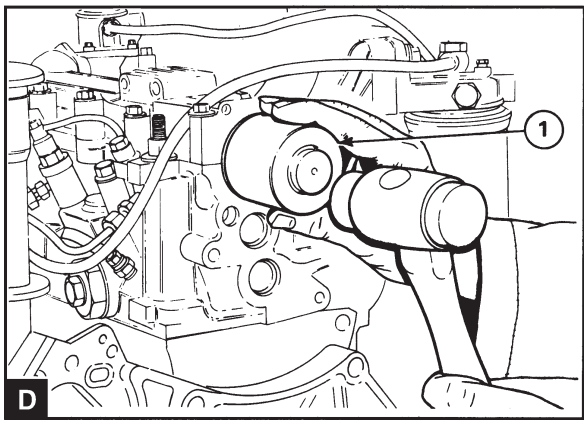


Install the plug from the tool 885019 (C1) in the rear end of the camshaft.

3

Unscrew the center screw (C2) sufficiently to ensure that it does not reach the plug and insert the main tool into the stuffing box. Turn the tool clockwise to ensure that the it is secure in the stuffing box and tighten the center screw against the plug to remove the stuffing box.

4



Ensure that the stuffing box and the camshaft are clean and undamaged. Lubricate the new stuffing box with fresh engine oil and insert it into position with the seal lip inwards. Use installation tool 885020 (D1) and a hammer with a soft face to drive the stuffing box into the correct position.

5

Install the seawater pump drive housing with the hole correctly aligned, operation 20A-08. Install the seawater pump drive adapter and tighten the domed screws to **9 Nm**. Install the seawater pump, operation 20A-06.

Camshaft, replacement (12A-06)

Special tools: 885037

1

Disconnect the battery

2

Remove the screw from the adjustment hole on the top of the front end of the camshaft cover (12A.03/A4). Turn the crankshaft until the adjustment hole in the front of the camshaft front bearing journal corresponds with the hole in the cover.

3

Install the adjustment drifts 885037 on the camshaft and flywheel.

4

Remove the cap of the timing cover, operation 15A-01.

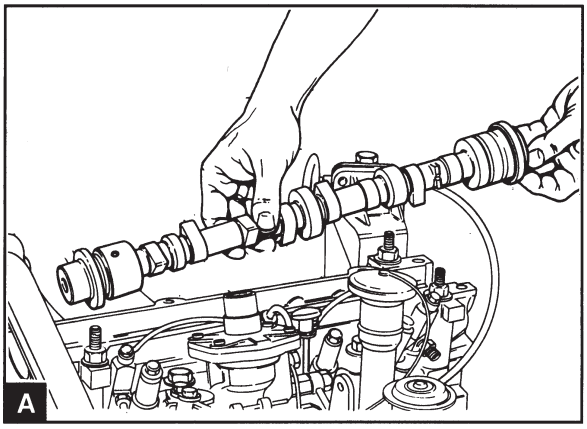
5

Remove the camshaft pulley, operation 15A-06.

6

Remove the camshaft cover, operations 12A-01.

7



Remove the camshaft (A) and remove the camshaft sealing rings.

8

Check the camshaft for wear and damage and replace it if required.

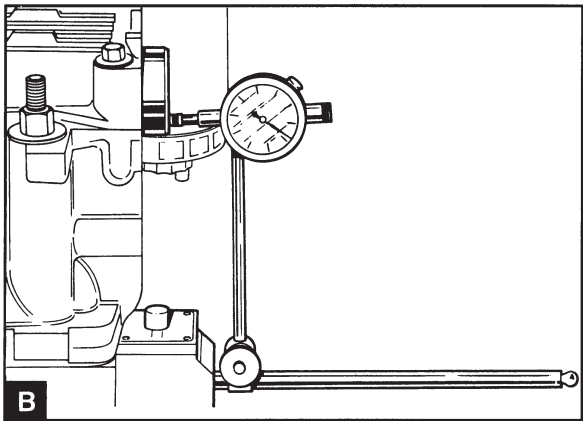
9

Ensure that the camshaft is clean and lubricated with fresh engine oil. Install the camshaft in position and check the valve clearance if necessary, see operation 12A-02.

10

Install the camshaft cover, operations 12A-01.

11



Check the camshaft axial clearance with a dial indicator (B). For tolerances see Workshop Manual “Technical data”.

12

Install the camshaft sealing rings, operations 12A-04 and 12A-05.

13

Install the rear camshaft cover.

Install the seawater pump, section 20.

14

Install the camshaft pulley and the timing belt and adjust the belt tension, section 15.

15

Check the fuel injection pump adjustment, operations 17A-03.

16

Install the cap of the timing cover, operation 15A-01. Install the screw in the adjustment hole on top of the camshaft cover front section.

17

Check that all adjustment drifts are removed. Turn the crankshaft two revolutions to ensure that there is nothing preventing free movement.

18

Connect the battery.

Cylinder head assembly, replacement (12A-07)

Special tools: 885037

1

Disconnect the battery.

2

Drain the cooling system.

3

Detach the engine coolant hose from the thermostat housing. If necessary remove the by-pass hose at the bottom of the thermostat housing.

4

Detach all wiring at the cylinder head and thermostat housing.

5

Detach the intake manifold and exhaust pipe.

6

If the cylinder head is being dismantled:

Remove the intake manifold and the heat exchanger / manifold / coolant tank assembly, operation 20A-12.

7

Detach the fuel supply pump.

8

Detach the fuel filter and remove it from the bracket.

9

Remove the delivery lines from the injectors and from the fuel pump (FP) – do not bend the pipes. When a pipe nut is removed at the pump, hold the output terminal from the pump with a wrench so that the connection does not move. Install the protective cover over the open terminals at the injectors and the pump.

10

Remove the injectors, operation 19A-02 and the glow plugs, operation 22C-01 to prevent any possible damage to the tips.

11

Remove the screw from the adjustment hole on the top of the front end of the camshaft cover 12A.03/A4. Turn the crankshaft until the adjustment hole in the front of the camshaft front bearing journal corresponds with the hole in the cover.

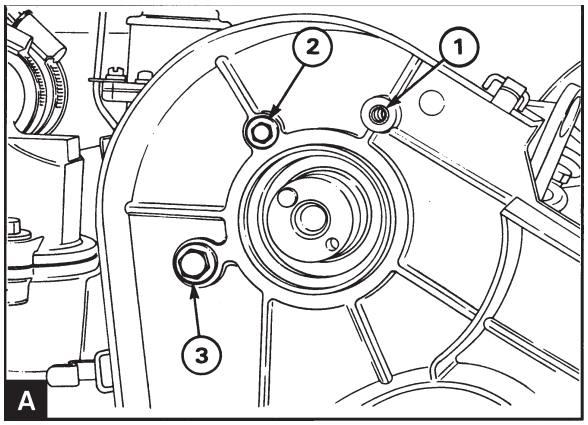
12

Install the adjusting drift on the flywheel.

13

Remove the cap of the timing cover, operation 15A-01 and remove the camshaft pulley, operation 15A-06.

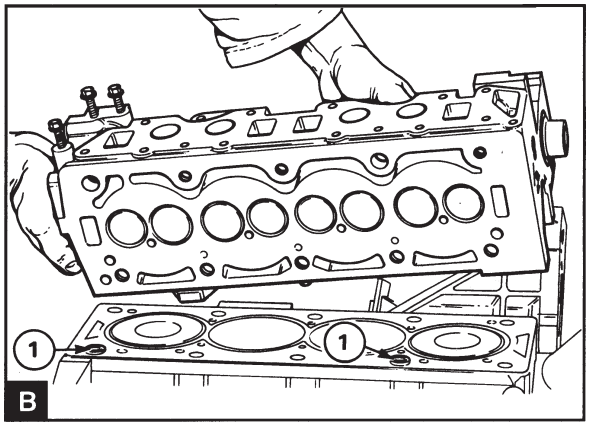
14



Remove the mounting screw which is installed through the camshaft cover into the timing cover (A1).

Remove the screw securing the timing cover to the cylinder head (A3).

15



Unscrew the screws for the cylinder head evenly in reverse order compared to the illustration 12A.09/A. Remove the screws and dismantle the cylinder head (B), ensure that the camshaft does not come into contact with the timing cover. Place the cylinder head on even surface that will not damage the cylinder head surface.

16

Check the upper side of each screw head for punch marks. If there are four punch marks on the screw heads it means that the screws have been post tightened four times and cannot be reused. Check the screws for deformation using a straight edged ruler held along the screw. If there is a visible decrease in shaft diameter or in the threaded section, which has not been not been threaded into the cylinder head, the screw must be discarded.

17

Remove the cylinder head gasket.

18

Clean the underside of the cylinder head and the surface of the cylinder block. Ensure that there is no debris in the cylinder bores.

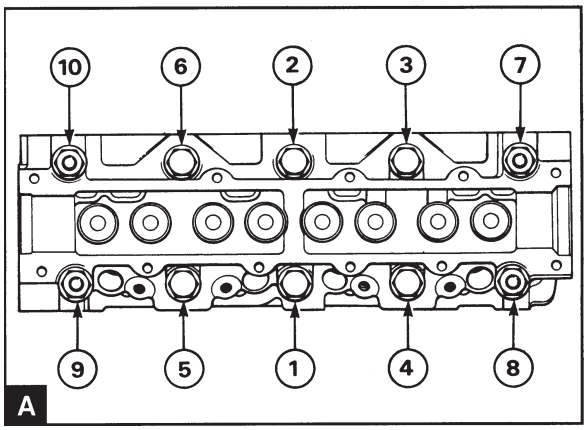
19

Ensure that the 1st and 4th pistons are at top dead center and that the adjustment drifts are installed through the back plate or through the flywheel cover in the flywheel adjustment hole.

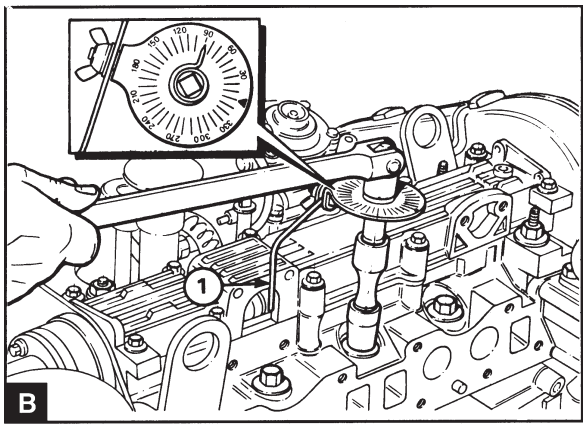
20

Ensure that the two guide sleeves (12A.08/B1) is in position in the cylinder block surface and install the cylinder head gasket without sealing compound. The gasket can only be installed in one position over the guide sleeves.

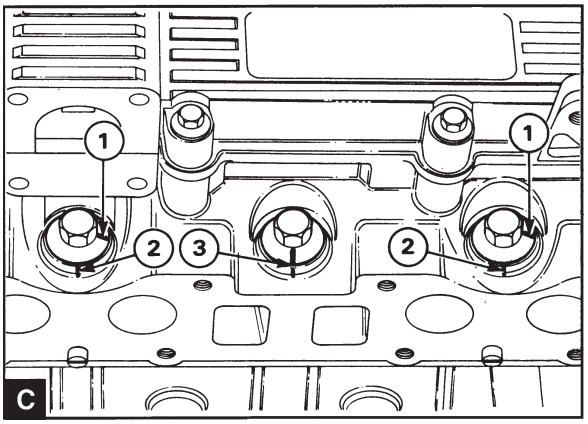
21



Ensure that the adjustment drifts are installed through the camshaft cover into the adjustment hole in the camshaft. Install the cylinder head in position over the guide sleeves. Screw in the cylinder head screws with the long screws located at the cylinder head ends. Tighten the screws evenly in the order shown in illustration (A) to a torque of **50 Nm.** Tighten the screws again, in the same order to a torque of **100 Nm.** Finally tighten the screws a further quarter turn (90°) in the same order. Install the tool between the socket and the handle. Apply the stop against a suitably extended part of the cylinder head to prevent the protractor turning clockwise. Turn the indicator so that it corresponds with the 90° marking on the protractor. Tighten the screw until the indicator points to zero.



If no tool is available make a suitable marking on each screw flange (C1). Make other markings on the cylinder head (C2) with 90° clockwise offset in relation to the markings on the screws. Tighten each screw in the correct order until the markings on the screw match the markings on the cylinder head (C3). The screws do not need to be post tightened with the engine at operating temperature or after a certain period of operation.



If the original screws have been reinstalled, mark the top of each screw with a punch mark to indicate that the screws have been tightened operationally. A maximum of four punch marks is permitted.

22

Install the heat exchanger / manifold / coolant tank assembly, operation 20A-10 and install the intake manifold.

23

Connect the air filter and the exhaust pipe.

24

Install the screws securing the timing cover to the cylinder head (12A.08/A1) and to the camshaft cover (12A.03/A1).

25

Install the camshaft pulley and the timing belt and check the belt tension, see section 15.

26

Check the fuel injection pump adjustment, operations 17A-03 and remove the adjustment drifts. Turn the crankshaft two revolutions to ensure that there is nothing preventing free movement.

27

Install the glow plugs, operation 22C-01.

28

Install the injectors, operation 19A-02.

29

Install the fuel delivery lines and tighten the connector nuts to **18 Nm**. Ensure that a separate wrench is used to prevent movement in the outgoing connections from the fuel injection pump.

30

Install the fuel filter and the low pressure fuel lines between the fuel injection pump and the fuel filter.

31

Install the fuel supply pump if necessary, operation 19A-03. Connect the wiring to the fuel supply pump.

32

Install the cap of the timing cover, operation 15A-01.

33

Connect the coolant by-pass hose and the outlet hose for the coolant.

Connect the sea water pipes to the heat exchanger and to the seawater pump.

34

Connect the wiring to the cylinder head and to the thermostat housing.

35

Fill the engine coolant system. See operation 20A-02.

36

Connect the battery.

37

Bleed the fuel injection system, operation 19A-08.

38

Start the engine and check for leaks.

Valves and valve springs, replacement (12A-08)

Special tools: 885023

1

Remove the cylinder head, operations 12A-07.

2

Remove the seawater pump, operation 20A-06.

3

Remove the camshaft cover, operations 12A-01.

4

Remove the valve lifters and shims and place each valve lifter and shim together in a numbered place, so that they can be returned to their original positions.

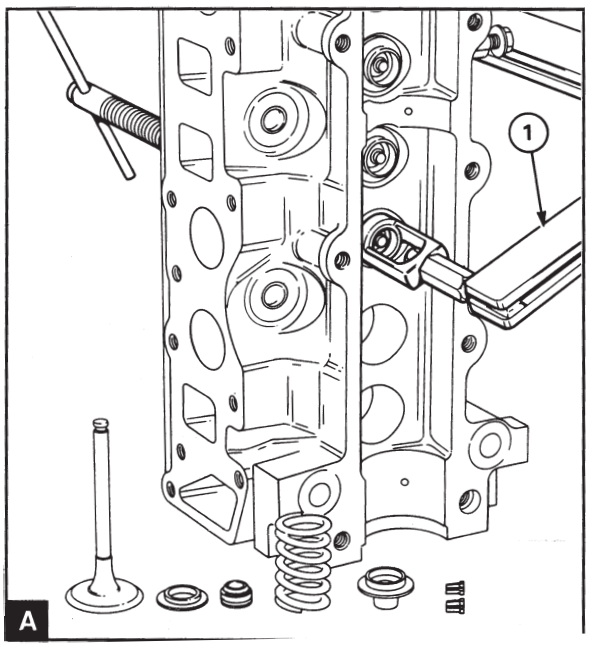
5

Clean the underside of the cylinder head and check how deep the valve crowns are under the cylinder head surface, see operation 12A-09.

6

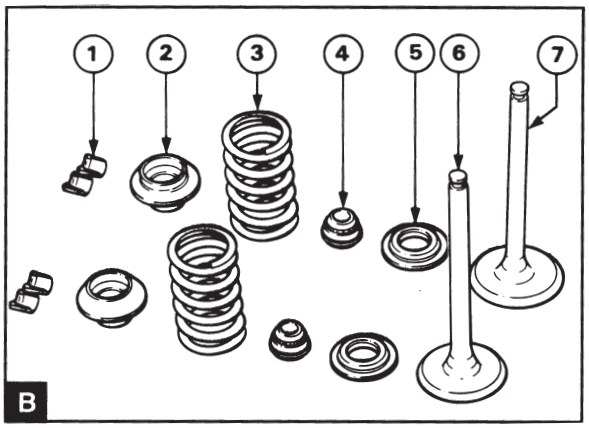
Make a suitable marking on the valve crowns so that the valves can be installed in their original positions if they are to be reused.

7



Press the valve springs together with the valve spring tensioners (A1). Ensure that the spring is pressed straight downwards so that the valve stem is not damaged. Remove the valve cotter (B1).

8



Take the load off the valve spring tensioner and remove the valve spring washer (B2), valve spring (B3), valve stem seal (B4) and the spring seat washer (B5). Remove the exhaust valve (B6) or the inlet valve (B7).

9

Repeat points 7 and 8 for the other valves.

10

Ensure that the components are clean.

The components in the valve assembly, as shown in illustration B.

11

Lubricate the valve stems with fresh engine oil and install the valves B6 / B7 in their respective guides. Ensure that the valve crown depth, see operation 12A-09.

12

Install the spring seat washers (B5). Install the new valve stem seals (B4) on the valve guides. Install the valve springs (B3) and the valve spring washers (B2).

13

Use the valve spring tensioner to compress the valve spring and the install the valve cotter (B1). Ensure that the valve spring is pressed straight down so that the valve stem is not damaged.

14

Lubricate the shims and valve lifters. Install each shim above the valve spring washer for each valve and install the valve lifter above each shim.

15

Install the camshaft in position and check valve clearance according to operation 12A-02. Adjust valve clearance as necessary.

16

Install the camshaft and the camshaft cover, operation 12A-02.

17

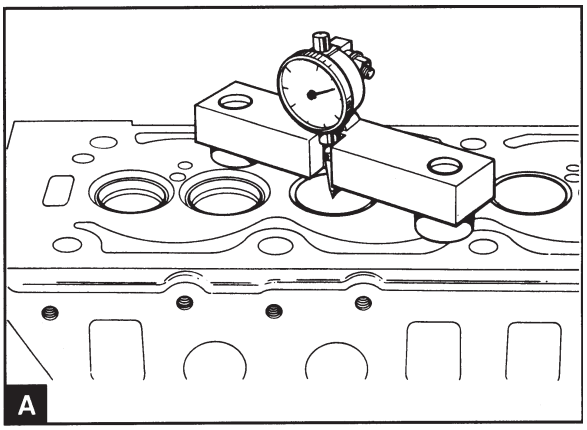
Install the seawater pump, operation 20A-06.

18

Install the cylinder head, operation 12A-07.

Valves and valve springs, inspection (12A-09)

1



Check the depth of the valve crowns under the cylinder head surface, before removing the valve springs. Ensure that the valve crowns and the cylinder head underside are clean. Install the valve depth gauge on the cylinder head surface and zero the gauge. Install the valve depth gauge carefully in position above each valve crown (A) and note the value. The parameter values for valve crown depth are given in the Workshop Manual “Technical Data”. If a valve is deeper than the maximum value, check the valve depth using a new valve. If the valve depth is still outside the permitted value, a new valve seat can be installed, operation 12A-14.

2

Check for the valves for cracks. Check the valve stems for wear and correct alignment in the valve guides.

3

Check that the valves mating surfaces to the seats are not badly burnt or damaged. Valves with damaged sealing surfaces can be reground in a special machine. Lightly damaged valves can be lapped in to the valve seats. When new valves are installed the valve depth must be checked.

4

Check that the spring loading is the correct at the installed length, see Workshop Manual “Technical data”.

Install the new valve springs at every complete engine reconditioning.

Valve guides, inspection (12A-10)

Special tools: 885021, 885022

Check the valve guides for wear. The maximum play between the valve stem and the hole in the guide is 0.13 mm. If the clearance is greater when a new valve is installed, a new valve guide must be installed.

Valve guides, replacement (12A-11)

1

Ensure that the surface of the cylinder head and the storage surface in a suitable press are clean.

2

Heat the whole cylinder head slowly and evenly to approximately 100°C and lay the head with the surface downwards. Ensure that the surface is not damaged during handling.

WARNING! Use suitable gloves as protection against the hot metal.

3

Install the thin end of tool 885021 in the guide and press it out. Repeat the procedure if several guides need to be replaced.

4

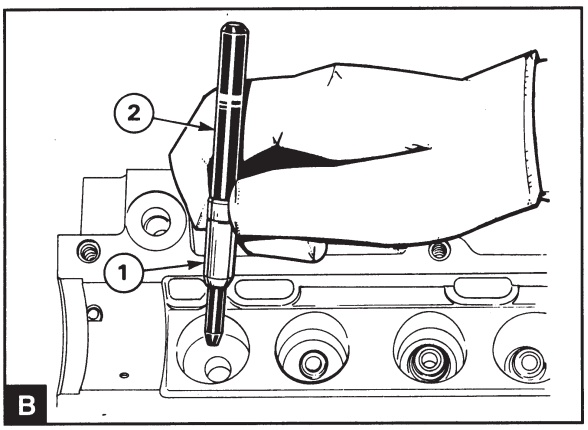
Clean the valve guide position and ensure that it is not damaged.

5

Heat the whole cylinder head slowly and evenly to approximately 100°C. Lay the head in the press with the surface downward with a flat surface located under the valve opening. Ensure that the head surface is not damaged during handling.

WARNING! Use suitable gloves as protection against the hot metal.

6

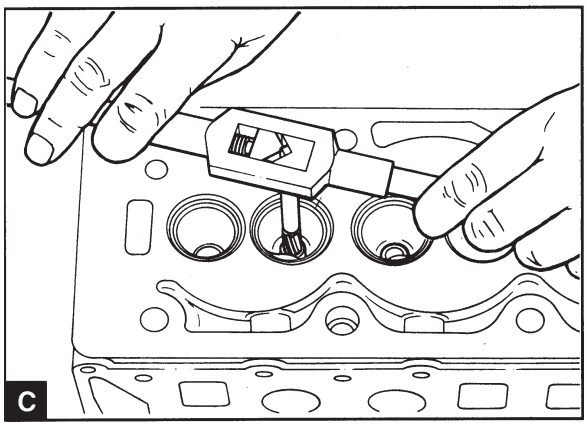


Install the guide B1 on the thin end of the tool 885021 (B2) with the bevel turned to the thin end of the tool (B). Insert the bevelled end of the guide into position in the cylinder head and press in the guide until the tool end comes into contact with the flat plate. Check that the guide protrudes 10 mm above the mating surface for the valve spring.

7

Allow the cylinder head to cool.

8



Ream the hole for the new guide using reamer 885022 (C).

Cylinder head, inspection (12A-12)

1

Remove the cylinder head assembly, operations 12A-07.

2

Remove the thermostat housing.

3

Remove the seawater pump, operation 20A-06.

4

Remove the camshaft cover, operation 12A-01 and the camshaft.

Remove the valve lifters and shims and place each valve lifter and shim together in a numbered place, so that they can be returned to their original positions.

5

Check the cylinder head for signs of gas or coolant leakage.

6

Remove the valve springs and valves, operation 12A-08.

7

Clean the cylinder head surface. Clean the coolant and lubrication channels. The water mantle can be cleaned with a special solvent which must be used according to the manufacturers instructions.

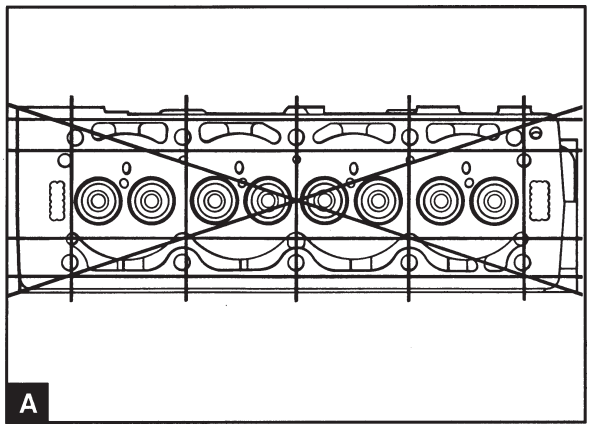
8

Check the cylinder head for leakage at the pressure specified in the Workshop Manual “Technical Data”.

9

When the cylinder head is completely clean, it should be checked for cracks. Carefully check the areas around the valve seats and the holes for injector nozzles.

10



Use a straight edged ruler and a feeler gauge to check the latitudinal, longitudinal and diagonal flatness of the bottom surface of the cylinder head (A). If deformation is greater than 0.10 mm the bottom surface can be machined. Remove the minimum amount of material and check that the cylinder head height will not be less than 119.85 mm after the cylinder head has been treated.

NOTE! After the cylinder head has been machined the valve seats must be corrected to give the correct valve depth. It is recommended to use the minimum value to allow for wear later.

11

Check the valve seats for damage and wear.

12

Before carrying out any work on the valve seats, check that the valve guides are not worn, see Workshop Manual “Technical Data”. If valve guide wear is above the parameter values the valve guides must be replaced, operation 12A-11.

13

If the damage is mild the valve and valve seat can be lapped in. When the valve seats are lapped keep the sealing area as thin as possible and ensure that all lapping paste used on the valve and seat is removed.

14

Valve seats with more serious damage can be corrected using a milling tool, operation 12A-13 or a new valve seats can be installed, operation 12A-14.

15

Install the valve springs and valves, operation 12A-08.

16

Install the camshaft cover, operation 12A-01 and the camshaft. Install the valve lifters and shims in their correct positions. Install the camshaft in position and check the valve clearance, operation 12A-02 and adjust as necessary, operation 12A-03.

17

Install the seawater pump, operation 20A-06.

18

Install the thermostat housing.

19

Install the cylinder head assembly, operation 12A-07.

Valve seat, grinding (12A-13)

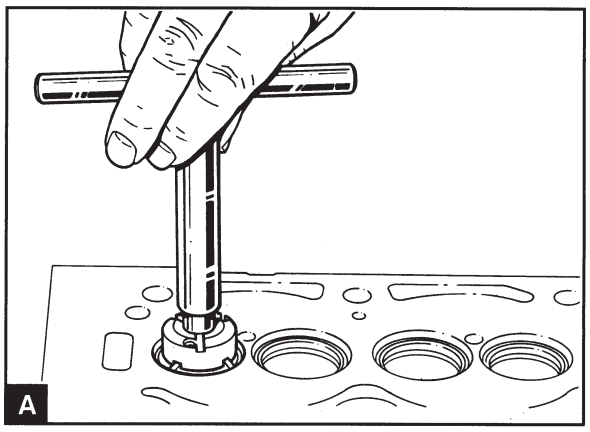
1

If the valve guide is worn it should be replaced, operation 12A-11.

2

Install the locating pin in the valve guide and tighten it.

3



Install the mill on the locating pin with 46° side against the valve seat and install the handle (A). Do not let the mill head fall down towards the seat, this can damage the blade.

4

Turn the mill carefully clockwise. Only remove as much material as is necessary to achieve a seal. Keep the sealing area as thin as possible.

5

Remove the mill and the locating pin when a satisfactory sealing area has been achieved. Remove all the work remnants from the area around the valve seat and valve opening.

6

Install the valve and lightly lap the valve and seat.

7

Check that valve depth lies within the permitted parameters, see Workshop Manual “Technical Data”.

If a valve seat has become too damaged or worn it must be replaced, operation 12A-14.

Valve seat, replacement (12A-14)

1

Install a new valve guide, operation 12A-11.

2

Work a small segment from the inside of one side of the valve seat to a depth of 8.25 mm from the surface of the cylinder head. Split the seat at the thinnest point and remove it from the cylinder block. Clean the seat position and check that there are no cracks.

3

The valve seat must be installed with the cylinder head hot and the seat cold. Heat the whole cylinder head slowly and evenly to approximately 100°C and if possible cool the seat with liquid nitrogen to –35°C. If liquid nitrogen is not accessible, cool the seat down as much as possible in a freezer. Install the seat with exterior bevel turned to the inside of the head. Ensure that the bottom of the seat has good contact with the bottom of the position in the cylinder head.

⚠ **WARNING!** Use suitable gloves as protection against the hot metal and the cold seat.

4

Mill the valve seat, 12A-13 and carefully lap the valve and valve seat. Ensure that the valve crown depth under the cylinder head surface is within the production parameters, see Workshop Manual “Technical Data”. Work as closely to the minimum value to allow for later valve seat wear.

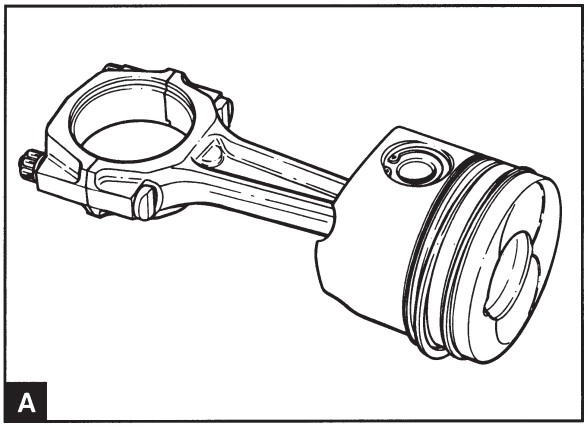
Piston and connecting rod

General

The combustion chamber on the upper side of the piston has a special ”swirl lip” to provide an effective fuel – air mixture. On the high effects the upper side of the piston is turned to ensure clearance between the valves and the glow plugs.

The pistons have two compression rings and one oil scavenger ring. The groove for the top ring is in a hard metal insert to minimize the groove wear. Axial guidance of the floating piston pins occurs using snap rings. There is a steel insert in the piston mantle to check the pistons dilation.

The connecting rods are H section forged steel. The bearing caps are located to the connecting rods using tight connecting rod screws with.



Big ends, replacement (13A-01)

1

Drain engine oil.

2

Remove the oil pan, operation 18A-03

3

Remove the oil screen and extractor pipe, operation 18A-04.

4

Turn the crankshaft until the relevant connecting rod is in its lowest position.

5

Unscrew the nuts and remove the bearing cap.

6

Remove the lower bearing shell from the bearing cap and put it together with the cap.

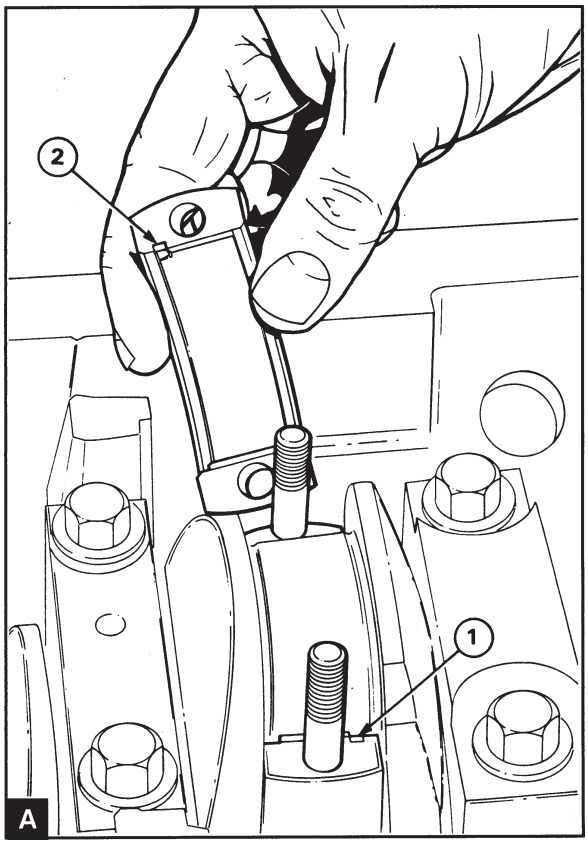
7

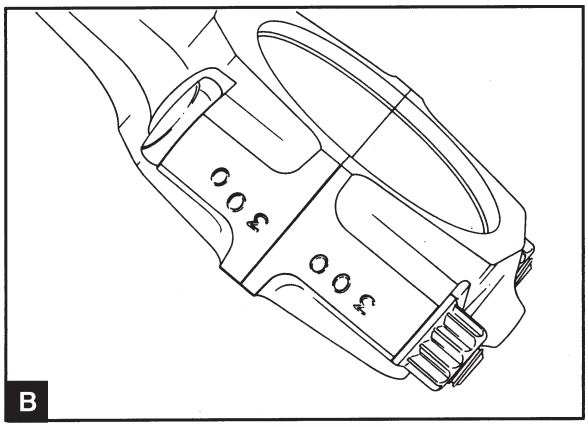
Install a plastic or rubber tube of suitable length on each respective connecting rod screw to protect the big end. Carefully slide the connecting rod up the cylinder, enough so that the upper bearing shell can be accessed. Remove the bearing shell from the connecting rod. Place the big end shells with the respective bearing caps.

8

Clean the bearing surfaces on the connecting rods and big end journals.

9





Clean the bearing shells and lubricate the bearing surfaces and big end journals. Install the upper bearing shell for the connecting rod with the locking lug well inserted in the cut out (A1). Install the connecting rod to the big end journal. Ensure that the marking on the connecting rod (B) lies in the same direction as the other connecting rods.

10

Clean, lubricate and install the lower bearing shell in the cap. Ensure that the guide lug is slid well into the cut out (A2). Remove the protective hosing from the connecting rod screws and check that the screws have not been damaged. Install the connecting rod cap. Ensure that the unit number on the cap is the same as on the connecting rod (B) and that both unit numbers are turned in the same direction.

11

Install new nuts for the connecting rod screws. Tighten them evenly and in stages to **47 Nm.**

12

Check that the crankshaft can be freely turned.

13

Install the oil screen and extractor pipe, operation 18A-04.

14

Install the oil pan, operations 18A-03 and fill it to the correct level with approved engine oil.

Big ends, inspection (13A-02)

Check the bearing shells and the big end journals for wear and other damage.

Piston and connecting rod assembly, replacement (13A-03)

1

Drain the engine oil and the engine coolant system.

2

Remove the cylinder head assembly, operations 12A-07.

3

Turn the crankshaft until the pistons are at the same height in the cylinder bores. Place a suitable clean rag over the piston to fill the cylinder bores. Remove all soot from the upper section of the cylinder bore with a coarse emery cloth. The emery cloth should be dampened with oil in order to retain the impurities. Polish the cleaned surface with a fine emery cloth. Clean the cylinder bore and remove the rag.

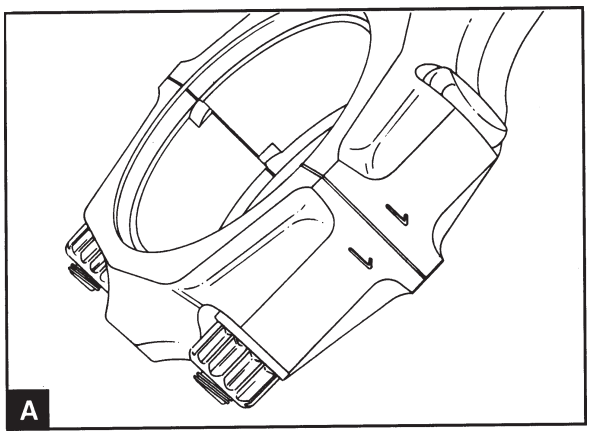
4

Remove the oil pan, operation 18A-03.

5

Remove the oil screen and extractor pipe if required, operation 18A-04.

6

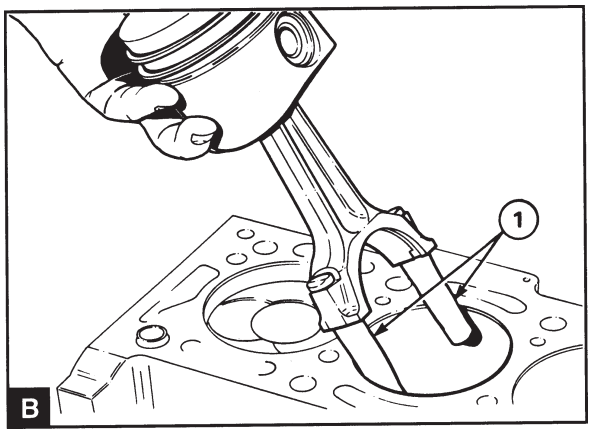


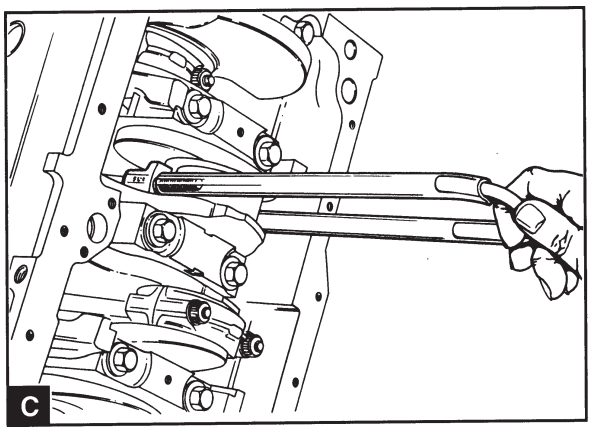
Check that all the connecting rods and the caps are marked with the correct cylinder number (A). If they are not marked, mark them from 1 to 4 with the number 1 at the timing belt cover end.

7

Remove the big end bearing cap and the connecting rod bearing caps, operation 13A-01. Keep the bearing shells with the relevant caps so that they can be returned to their original positions.

8





Install rubber or plastic protective tubes on the connecting rod screws (B1). Slide the piston and the connecting rod upwards in the cylinder bore A suitable tool for this job can be made from a (U) shaped pipe and two pieces of plastic hose (C).

9

Check the big end journal for damage.

10

Ensure that the piston, cylinder bore, big end journal and connecting rod big end are clean. Lubricate the piston and cylinder bore with fresh engine oil.

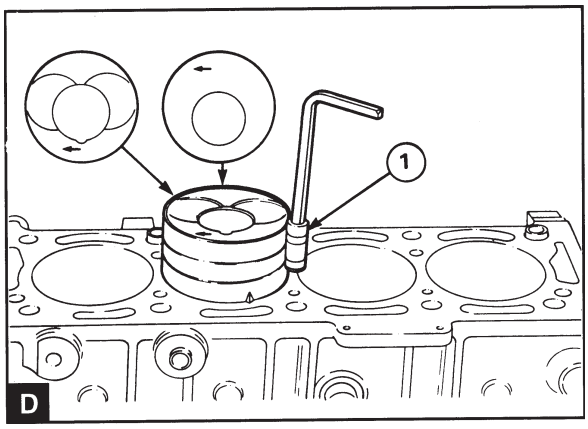
11

Turn the crankshaft until the relevant connecting rod is in its lowest position. Lubricate the big end journal with engine oil.

12

Install a plastic or rubber tube of suitable length on each respective connecting rod screw to protect the big end. Install the upper bearing shell on the connecting rod. Ensure that the locking lug is slid well into the cut out (A1). Lubricate the bearing with engine oil.

13



Ensure that the piston ring gaps are offset by 120° and press the rings together with a piston ring compressor (D1). Ensure that the protruberances pressed against one edge of the tool are bent downwards.

14

Install the piston unit in the correct cylinder bore. When the piston is installed the arrow on the upper side of the piston (D) must point towards the front end of the engine (timing cover end). In this position the combustion chamber on the top of the piston is turned towards the side of the engine on which the injection pump is installed. There is also a front end marking on the underside and on the connecting rod and these markings must be on the same side, see 13A.07/B.

15

Slide the piston and connecting rod through the cylinder bore and down to the big end journal. Turn the connecting rod so that the arrow on the upper side of the piston points towards the front end of the engine.

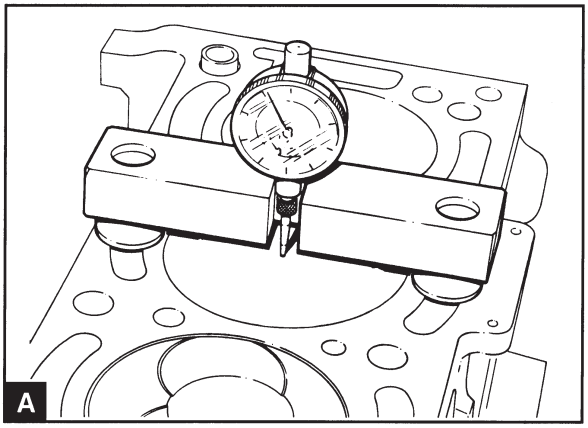
16

Remove the protective tubes from the connecting rod screws. Clean the connecting rod bearing cap and the lower bearing shell. Install the bearing shell in the cap with the locking lug slid well into the cut out. Lubricate the bearing with engine oil. Install the cap and ensure that the unit number is the same as on the connecting rod and that the numbers are on the same side. Install new nuts for the connecting rod screws. Tighten them evenly and in stages to **47 Nm.**

17

Check that the crankshaft can be freely turned.

18



Check the piston height above the cylinder block surface with the piston height measuring tool (A). Place the measuring tool on a flat surface and zero the measuring scale. Turn the crankshaft until the piston is approximately at top dead center. Locate the measuring tool over the cylinder bore with the dial gauge measuring point in contact with the piston. Turn the crankshaft so that the piston moves to its highest position and note the value. The correct value for the piston height is given in the Workshop manual “Technical data”. If a new service piston of a lower height class has been installed, see operation 13A-05, the piston height may be 0.10 mm lower than the lowest parameter. The piston may not be higher than the upper limit. Metal must not be removed from the upper side of the piston.

19

Install the oil screen and extractor pipe if required, operation 18A-04.

20

Install the oil pan, operation 18A-03.

21

Install the cylinder head assembly, operation 12A-07.

22

Fill the oil pan to the correct level with approved engine oil.

23

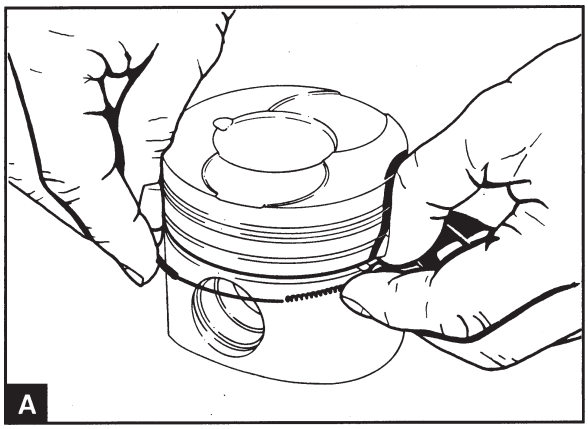
Fill the engine coolant system.

Piston rings, replacement (13A-04)

Remove the piston rings with an appropriate piston ring pliers Separate the ring gap just sufficiently that the ring ends do not damage the piston. Keep the rings together with the relevant piston.

Install the piston rings with an appropriate piston ring pliers Separate the ring gap just sufficiently that the ring ends do not damage the piston.

1

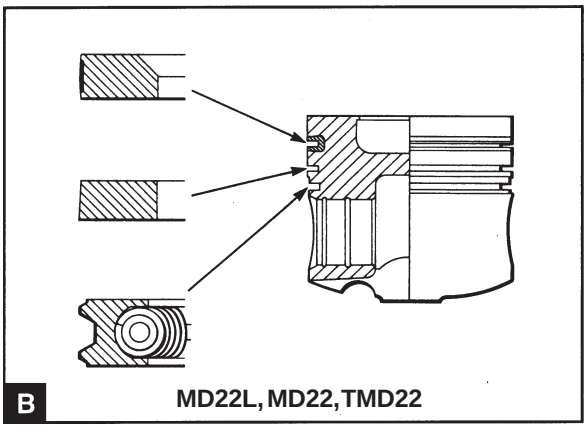


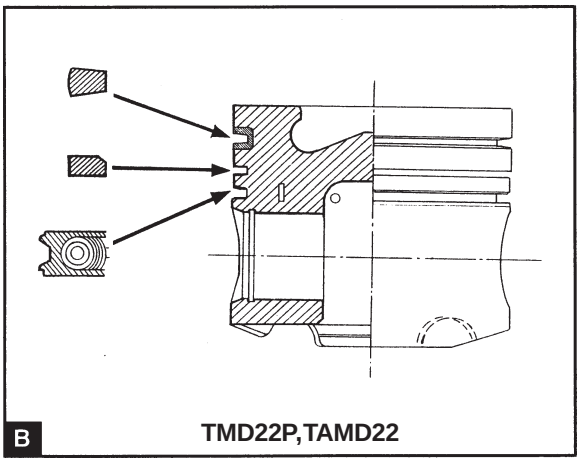
Insert the expander ring for the oil scraper ring in the lower piston ring groove with the catch through both end of the rings (A). Install the oil scraper ring over the spring (B). Ensure that the ring gap is located with a 180° offset to the catch.

2

Install the cast iron rings with the conical surface in the second piston ring groove with the word “TOP” or the manufacturers symbol towards the top. The new piston rings have a green identification mark. This must lie to the left of the ring gap when the ring is installed and the piston is raised.

3





Install the “barrel face” ring with the molybdenum insert in the upper piston ring groove (TMD22P, TAMD22 Keystone ring). The word “TOP”, the manufacturers mark or the internal milling must face the top of the piston. The new piston rings have a red identification mark. This must lie to the left of the ring gap when the ring is installed and the piston is raised.

4

Ensure that the ring gaps are offset 120° internally.

Piston and connecting rod, assembly / dismantling (13A-05)

1

Remove the piston rings, operation 13A-04.

2

Remove the snap rings holding the piston pins in position.

3

Make a temporary marking on the piston to display the cylinder number as given on the connecting rod. Make the marking on the piston on the same side as the marking on the connecting rod big end to ensure that they are correctly installed together.

4

Press out the piston bolt by hand. If the piston bolt is fixed, heat the piston to 40-50°C to allow the piston bolt to be removed.

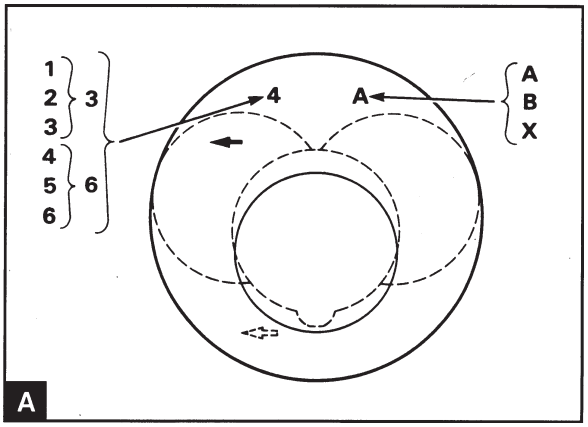
5

Clean the hole in the piston pin bushing and lubricate with fresh engine oil.

6

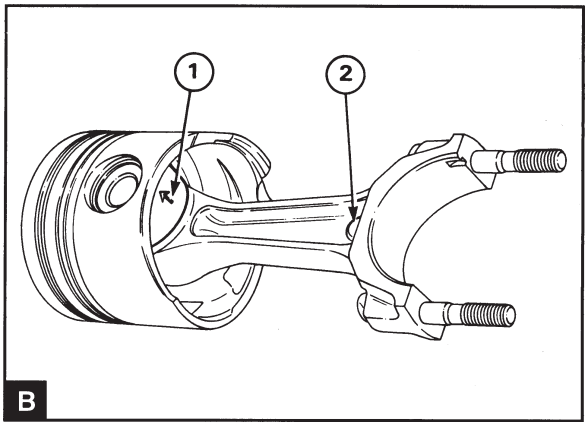
Install a new snap ring in one of the piston bolt positions on the piston.

7



If the original piston is used, ensure that it is installed on the correct connecting rod and the original cylinder. If a new piston is installed, ensure that it is the correct height class. There are six different height classes in production. The classes are designated with numbers which are stamped on the top of piston (A). Number 1 is the highest piston and number 6 the lowest. Only classes 3 and 6 are available for service purposes. Class 3 must be used if the original piston has the markings 1, 2 or 3. Class 6 must be used if the original piston has the markings 4, 5 or 6. Two different diameter classes ”A” and ”B” are also in production. Only piston A with the smaller diameter is available for the standard cylinder diameter for service purposes. A class (X) piston is accessible for cylinders which have been bored out by 0.50 mm oversize in connection with service repairs. The diameter classes are stamped on a machined plate in the right upper rear edge of the cylinder block (16A-04/C). If a cylinder bore has been bored out to oversize in a service repair, the letter for the original class should be stamped with an (X).

8



Place the connecting rod with piston upside down. The locating lug (B2) on the connecting rod must be on the same side as the arrow (B1) on the underside of the piston.

9

Lubricate the piston bolt position in the piston with fresh engine oil and slide in the piston bolt towards the snap ring. If the piston bolt has difficult to insert, heat the piston to 40°-50°C before the piston bolt is installed.

10

Install a new snap ring in the other piston bolt position on the piston. Ensure that it goes into the groove correctly.

11

Install the piston rings, operation 13A-04.

Piston and piston rings, inspection (13A-06)

1

Check the piston for wear and damage.

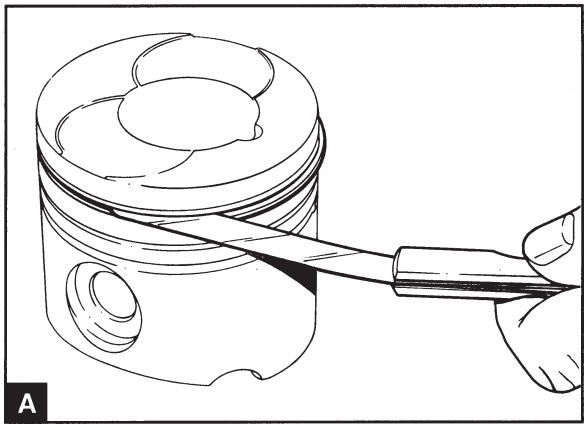
2

Check that the piston rings can move freely in its groove and that no ring is broken.

3

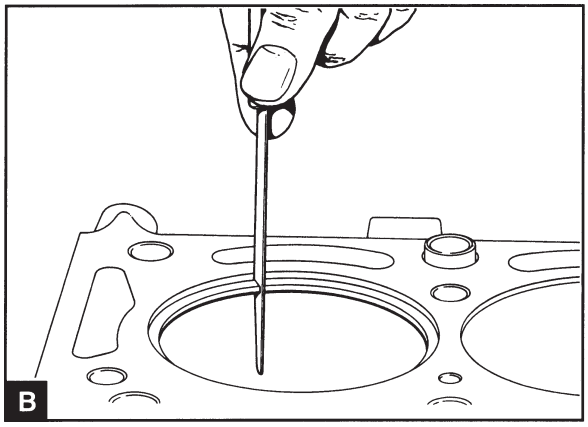
Remove the piston rings, operation 13A-04. Clean the piston ring and the piston ring grooves.

4



Install the new piston rings in the piston ring groove and check the ring groove wear using the feeler gauge (A). Compare the piston ring play in the groove to the values that apply to new components in the Workshop Manual “Technical Data”. Replace the cylinder if necessary.

5



Check that all the soot has been removed from the upper section of the cylinder bore. Install the piston rings in the upper section of the cylinder bore and measure the ring gap with a feeler gauge (B). The expander ring must be installed on the oil scraper ring when the ring gap is measured. The ring gap for the new components is given in the Workshop manual “Technical data”.

Connecting rod, inspection (13A-07)

1

Check the connecting rods for deformation, see Workshop Manual “Technical Data”.

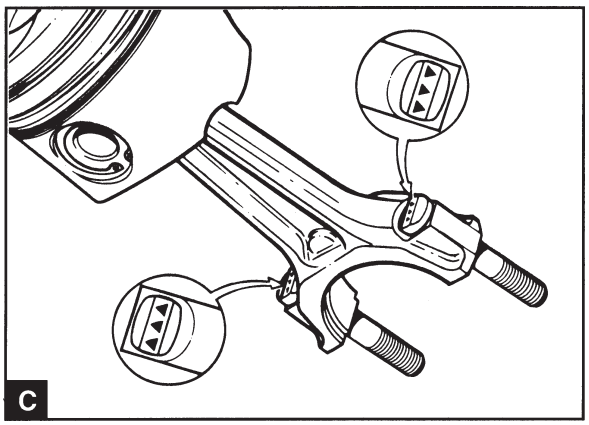
2

Check the connecting rod bushing for wear or other damage and replace it as necessary.

3

Check the piston bolt alignment in the connector rod bushing and check the piston bolt for wear, see Workshop Manual “Technical Data”.

4



Check the condition of the connecting rod screws. If the thread is sealed or if there are signs of stretching, the screw must be removed from the connecting rod and replaced. The new screw must be installed with the locating arrows (or recognition marks) on the screw head turned to the outside of the connecting rod big end (C). Ensure that the screw head has good contact with the connecting rod.

Connecting rod bushing, replacement (13A-08)

1

Press out the old bushing with an appropriate drift.

2

Clean the bearing recess in the connecting rod and remove any sharp edges.

3

Press in the new bushing. Ensure that the lubrication in the bushing is on the same side and is pointed towards the hole in the top of the connecting rod.

4

Ream the bushing in order to obtain the correct clearance between the piston bolt and the bushing, see Workshop Manual “Technical Data”.

Crankshaft assembly

General

The crankshaft is made of ductile cast iron. It has integral balancing weights and five main bearing journals.

The axial play is controlled by two sectioned thrust washers on each side of the central main bearing.

The main bearings have a steel plate mantel and a surface bearing of tin-aluminum. The main bearing cap is made of ductile cast iron.

The front and rear stuffing boxes have lip seals made of Viton and oil return grooves on the inside of the lip. The front stuffing box is installed on the front side of the lubricating oil pump. On most engines the rear stuffing box is located directly in the flywheel cover or the back plate.

The crankshaft front end has two separate keygrooves. The rear keygroove is for the lubricating oil pump, which is installed around the crankhaft. The front keygroove is for the belt pulley, which drives the timing belt.

The crankshaft pulley is fastened to the belt pulley with four domed screws and fastened to the crankshaft with a center screw.

A vibration damper is integrated into the pulley.

Crankshaft pulley, replacement (14A-01)

1

Disconnect the battery.

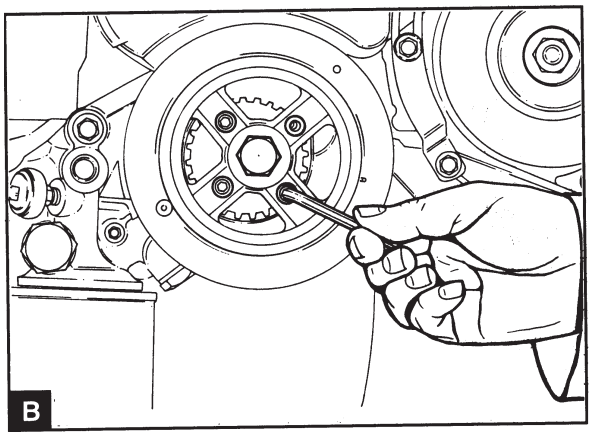
2

Remove the generator (GEN) drive belt, operation 22A-02.

3

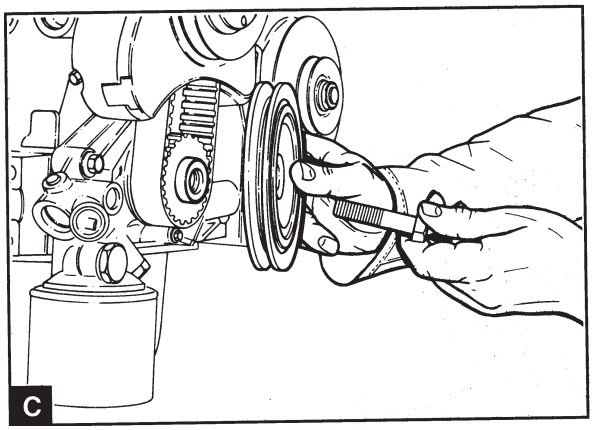
Remove the starter motor, operation 22B-01.

4



Unscrew and remove the four mounting screws (B) which secures the pulley to the belt pulley.

5



Slacken off the pulley center screw and remove the pulley (C). Use a large screwdriver or similar tool as a counterhold at the flywheel ring gear.

NOTE! The belt pulley is locked to the front end of the crankshaft using Loctite 648 and can only be removed using a puller.

6

Clean the components and check them for damage. Replace damaged components as necessary.

7

Install the pulley to the belt drive and tighten and finger tighten the four mounting screws.

8

Install the center screw (black), P/N 3581332 and tighten to **180 Nm**. Use a large screwdriver or similar tool as a counterhold at the flywheel ring gear.

9

Tighten the four mounting screws to:

Flanged screw **22 Nm**

Domed screws **36 Nm**

10

Remove the counterhold and install the starter motor, operation 22B-01.

11

Remove the generator (GEN) drive belt, operation 22A-01.

12

Connect the battery.

Front sealing ring, replacement (14A-02)

Special tools: 885031, 885032, 885033, 885037

1

Disconnect the battery

2

Remove the screw from the adjustment hole on the top of the front end of the camshaft cover (12A.03/A4). Turn the crankshaft until the adjustment hole in the front of the camshaft front bearing journal corresponds with the hole in the cover.

3

Install the adjustment drifts 885037 on the camshaft and flywheel. Remove the starter motor, operation 22B-01.

4

Remove the generator (GEN) drive belt, operation 22A-03 and the pulley for the water pump.

5

Remove the crankshaft pulley, operation 14A-01A or 14A-01B and remove the cap for the transmission cover, operation 15A-01.

6

Install two screws (M6 x 50) to secure the pulley to the injection pump and remove the timing belt, operation 15A-04.

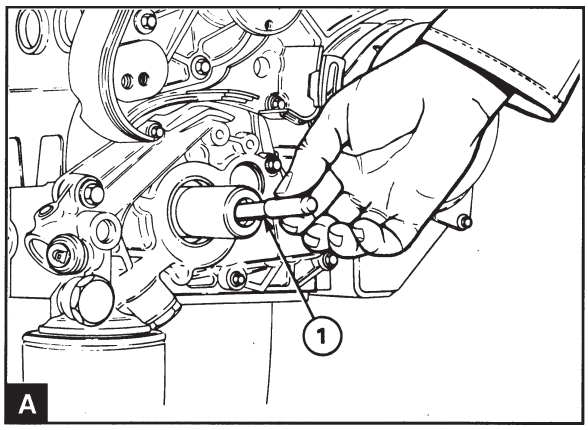
7

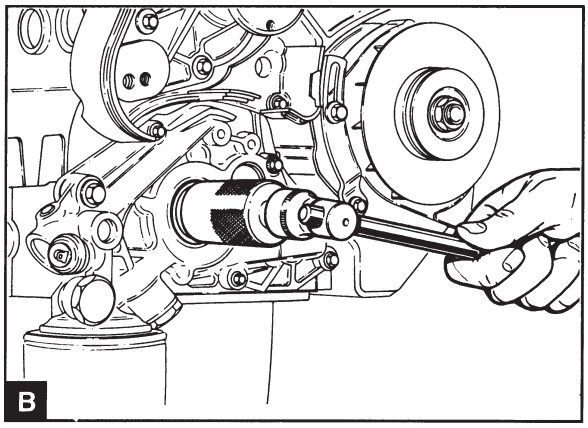
Remove the drive pulley from the crankshaft, operation 15A-07.

8

Remove the front key from the crankshaft.

9



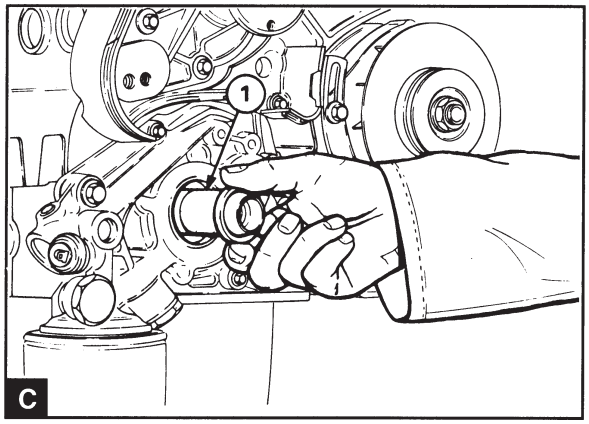


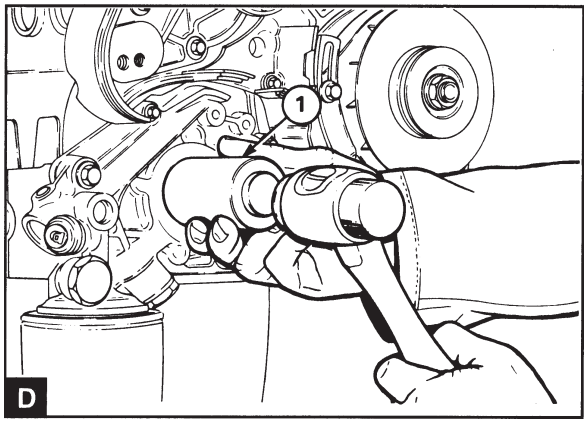
Install the adapter (A1) from the tool 885031 at the front end of the crankshaft. Slacken off the center screw so that it does not reach the adapter and insert the main tool in the sealing ring. Turn the tool clockwise to ensure that it is secure in the sealing ring and tighten the center screw against the adapter to remove the sealing ring (B). Remove the adapter.

10

Check that the position for the sealing ring and the crankshaft is clean and undamaged.

11





Install protective socket 885032 (C1) on the crankshaft. Lubricate the new sealing ring with fresh engine oil. Insert the sealing ring in position over the protective socket with the seal lip turned towards the engine. Remove the protective sleeve. Use installation tool 885033 (D1) and a hammer with a soft face to drive the sealing ring into the correct position. The correct position for the sealing ring is when the sealing ring front surface is 0.5 mm inside the housing.

12

Install the key in the crankshaft and install the drive pulley on the crankshaft, operation 15A-07. If the brush seal is not installed in the cap for the timing cover, install the crankshaft pulley, operation 14A-01 or 14A-01B.

13

Install the timing belt and adjust the belt tension, see section 15.

14

Remove the adjustment drifts and the pulley drifts. Check the fuel injection pump adjustment, operations 17A-03.

15

Turn the crankshaft two revolutions to ensure that there is nothing preventing free movement.

16

Install the cap for the timing cover, operation 15A-01. If the brush seal is installed in the cap install the crankshaft pulley, operation 14A-01A or 14A-01B.

17

Install the pulley for the water pump and the drive belt for the generator, operation 22A-03.

18

Install the starter motor and connect the battery.

Rear sealing ring, replacement (14A-03)

Special tools: 885030, 885034, 885035

1

Disconnect the battery

2

Remove the drive components from the rear end of the engine.

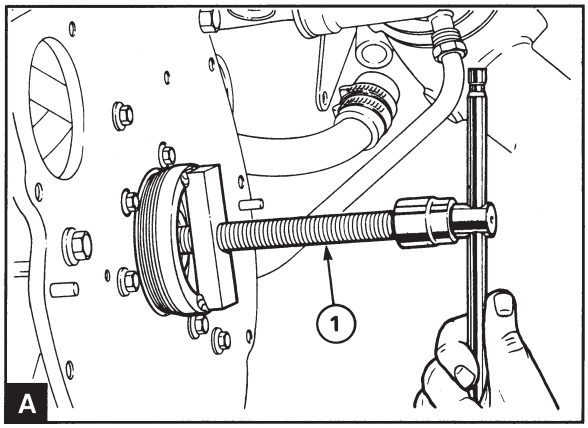
3

Remove the flywheel, operation 21A-01.

4

Check the sealing ring position in the flywheel housing, in the separate sealing ring housing or in the back plate. If the sealing ring rear surface is edge to edge with the rear housing surface, the new sealing ring can be pressed further into the housing, thus displacing the sealing rings sealing position on the crankshaft flange. This is not possible if a 10 mm thick back plate is installed. If the crankshaft flange is worn and a new sealing position is not possible, remove the crankshaft and machine the flange, see Workshop Manual “Technical Data”.

5



Slacken off the screw (A1) in the puller tool so that it does not reach the crankshaft. Insert the tool in the sealing ring and turn it clockwise so that it fastens in the sealing ring. Use an adjustable spanner to turn the tool body so that it fastens securely in the sealing ring. Tighten the screw against the rear end of the crankshaft in order to remove the sealing ring.

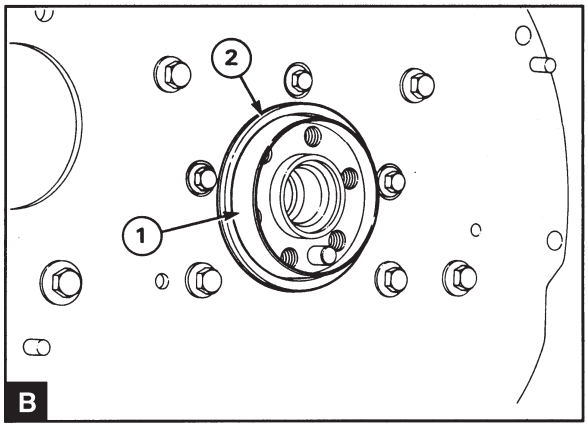
6

Clean the sealing ring housing and the flange on the crankshaft.

7

Lightly the sealing ring housing, the flange on the crankshaft and the sealing ring seal lip with fresh engine oil.

8

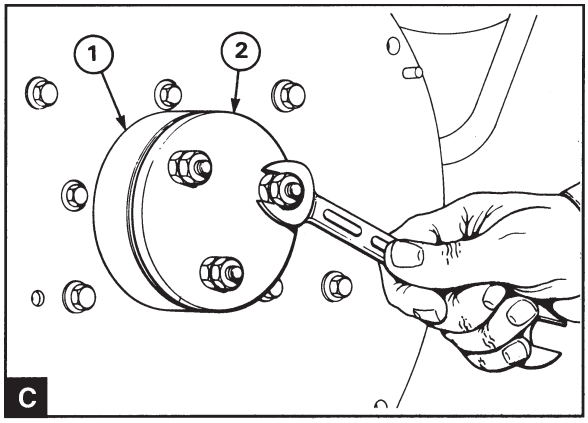


Clean and lubricate the protective socket 885030 (B1) and install it on the end of the crankshaft flange.

9

Insert the sealing ring (B2) over the socket with the seal lip turned towards the engine and slide it up the flange until it enters the sealing ring housing. Remove the protective sleeve.

10



Locate the ring (C1) from tool 885035 on the crankshaft flange with the correct side of the ring towards the sealing ring. If the sealing ring is to be installed in the front position (see paragraph 4), install the socket with the end with diameter markings turned to the sealing ring. Install the plate (C2) from the tool 885035 and use the locknuts to tighten the studs in the crankshaft flange. Slacken off the locknuts, ensure that the plate is installed perpendicular to the crankshaft and use the front nuts to press the sealing ring into position. The nuts must be tightened in stages and evenly.

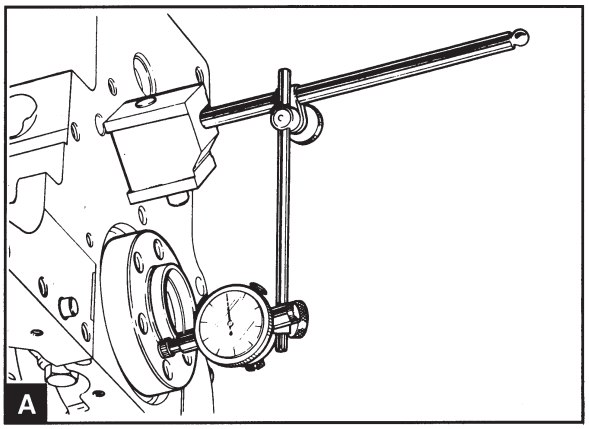
11

Remove the tools and install the flywheel, operation 21A-01.

12

Install the drive components on the rear end of the engine and connect the battery.

Crankshaft axial clearance, checking (14A-04)



The axial play of the crankshaft is controlled by two sectioned thrust washers on each side of the central main bearing (B). The axial clearance can be checked with a feeler gauge between a thrust washer and the crankshaft. A better method is to use a dial indicator and measure axial clearance against one of the crankshaft ends (A). For the correct axial clearance, see Workshop Manual, “Technical data”.

Thrust bearing, replacement (14A-05)

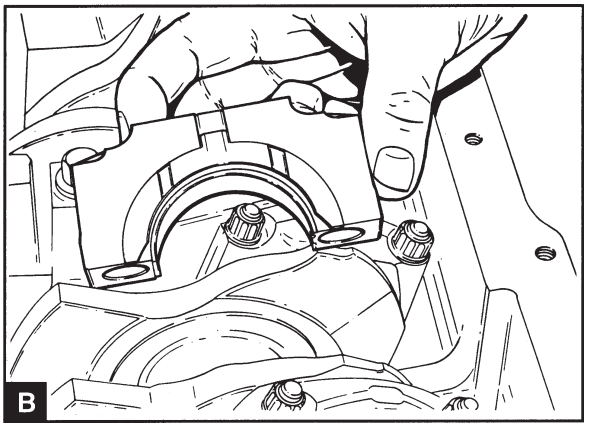
1

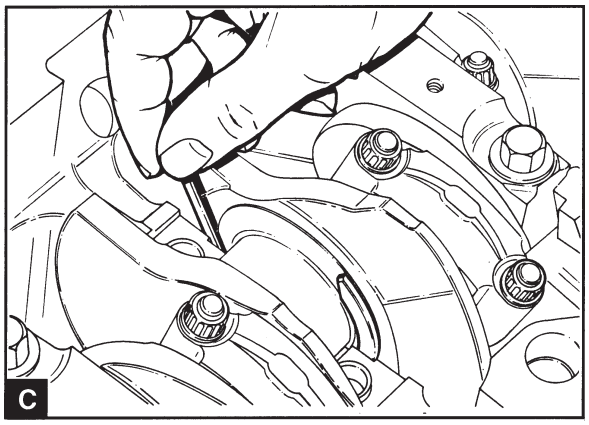
Drain the engine oil and remove the oil pan, operation 18A-03.

2

Remove the oil screen and extractor pipe if necessary, operation 18A-04.

3





Remove the screws for the central main bearing and remove the bearing cap assembly with the three lower thrust washer halves (B). Press down one end of each and every one of the upper thrust washers with a suitable tool, made of soft material so that the relevant thrust washer slides out of its groove (C). If necessary move the crankshaft forwards or backwards to take the load off a thrust washer which is trapped.

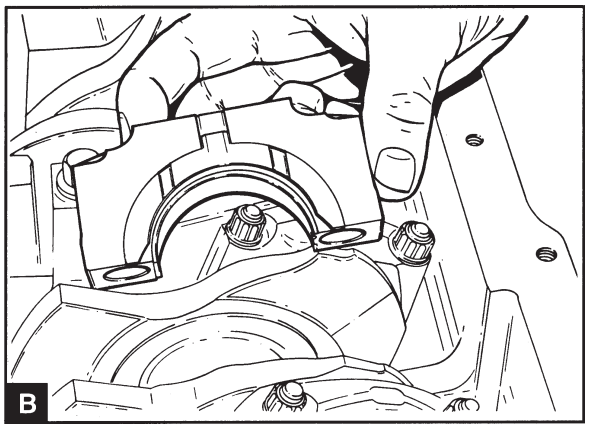
4

Lubricate the thrust washers with fresh engine oil.

5

Insert the upper thrust washer halves in their grooves in the cylinder block. Check that the side of thrust washer with the lubrication groove is turned towards the crankshaft.

6



Install the lower thrust washer halves in the main bearings with the lugs in their respective cut outs. Check that the lubrication grooves in the thrust washers are turned away from the bearing cap (B).

7

Check that the guide sleeves are correctly installed in the bearing cap or in the cylinder block.

8

Check that the bearing shell is correctly installed in the cap and that the main bearing journals are clean. Lubricate the bearing shell with fresh engine oil.

9

Install the bearing cap with the lugs for both bearing shells turned in the same direction (14A.07/B1 and B2). Tighten the screws for the main bearings in stages and evenly to **112 Nm**.

10

Check the axial clearance of the crankshaft. For the correct axial clearance, see Workshop Manual, “Technical data”

11

Install the oil screen and extractor pipe if required, operation 18A-04.

12

Install the oil pan, operation 18A-03 and fill it to the correct level with approved engine oil.

Main bearings, replacement (14A-06)

(with crankshaft installed)

If the front bearing is to be removed the oil pump must also be removed. Removing the main bearing cap with the pump in position damages the pump joint.

If the rear bearing cap is removed with the flywheel installed, sealant must be applied to the underside of the bearing cap rear surface before it is reinstalled.

1

Drain the engine oil and remove the oil pan, operation 18A-03.

2

Remove the oil screen and extractor pipe if required, operation 18A-04.

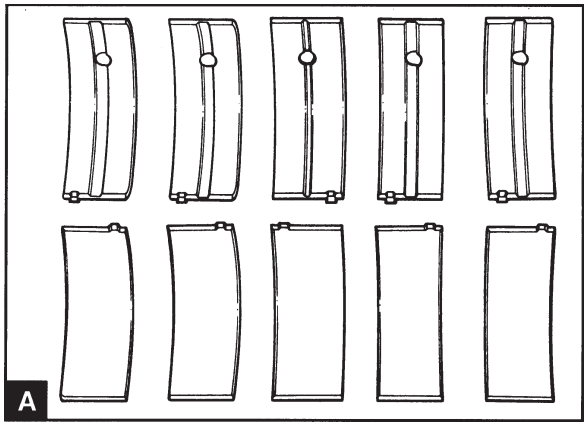
3

Remove the screws for the bearing cap and remove the cap. Remove the lower bearing shell from the cap.

4

Press the upper bearing shell on with a suitable tool on the opposite side to the lug. This presses the lug out of the cut out in the bearing housing. Turn the crankshaft carefully to feed the bearing shell out of the housing. Make a note of the respective bearing shell locations.

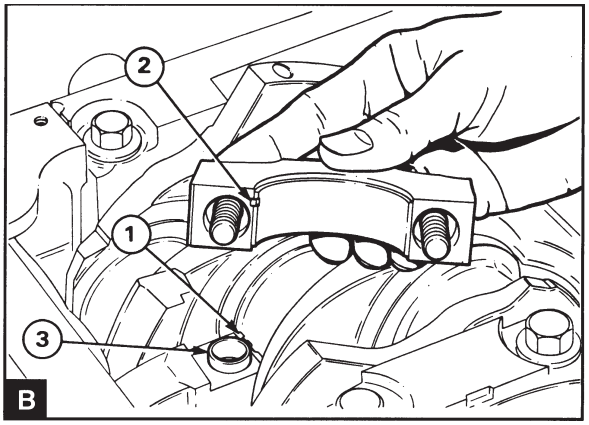
5



Clean the upper bearing shell and lubricate the bearing surface with fresh engine oil.

NOTE! There is only a lubrication hole in the upper bearing shell and it must therefore be placed against the cylinder block. The bearing shells for the central main bearing are wider than the other bearing shells (A). The bearing shells for the central main bearing also have differently located lugs.

6



Insert the flat edge of the upper bearing shell between the main bearing journals and the side of the bearing housing which has a cut out for the lug. Slide the bearing shell into the bearing housing until the lug on the bearing shell is well inside the cut out in the bearing housing (B1).

7

Clean the lower bearing shell and lubricate the bearing surface with fresh engine oil.

8

Install the bearing shell in the cap with the lug slid well into the cut out in the cap (B2).

9

Check that the guide sleeves (B3) are correctly installed in the bearing cap or in the cylinder block. Install the bearing cap so that both the bearing shells lugs are turned in the same direction.

10

Check the mounting screws for wear and deformation and replace them if required. Lightly lubricate the threads with engine oil. Install the screws and washers and tighten the screws in stages and evenly to **112 Nm**.

11

Check that the crankshaft can be freely turned. If the thrust washers have been removed and reinstalled, check crankshaft axial clearance, operation 14A-03.

12

Install the oil screen and extractor pipe if required, operation 18A-04.

13

Install the oil pan, operation 18A-03 and fill it to the correct level with approved engine oil.

Main bearings, inspection (14A-07)

Check the bearings for wear and damage. If a bearing is worn or damaged, replace both the bearing shells and check the condition of the other bearings.

Crankshaft, replacement (14A-08)

1

Drain the engine oil and the engine coolant system.

2

Remove the oil pan, operation 18A-03. Remove the oil screen and extractor pipe 18A-04.

3

Remove the crankshaft pulley, operation 14A-01. Remove the water pump pulley.

4

Remove the cap of the timing cover, operation 15A-01.

5

Remove the flywheel and flywheel cover, section 21.

6

Turn the crankshaft until the pistons are at the same height in the cylinder bores.

7

Temporarily mark the timing belt and the appropriate teeth on the crankshaft pulley, camshaft pulley and the injection pump pulley. This is to ensure that the belt can be reinstalled in the correct position.

8

Remove the timing belt, pulleys and timing cover, section 15.

9

Remove the oil pump, operation 18A-06.

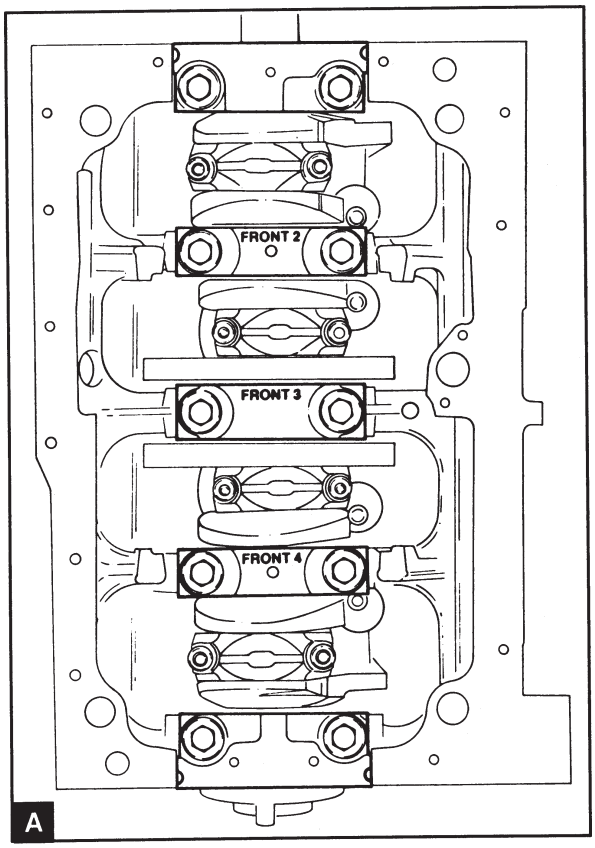
10

Measure the crankshaft axial clearance to determine if new thrust washers are required.

11

Check that all the big end caps are marked with the number of the relevant cylinder. Remove the caps and the lower big end shells, operation 13A-01.

12



The inner main bearing caps are marked with 2, 3 and 4 and the word “FRONT” to mark the correct installation position (A). Remove the main bearing caps, the lower main bearing shells and the thrust washers. Keep the bearings with their respective caps. Press out the upper halves of the thrust washers.

13

Remove the crankshaft.

14

Remove the upper bearing shells of the main bearings and big ends and keep them together with their respective caps.

15

Ensure that the oilways are clean and unobstructed. Clean the sealing grooves in the sides of the front and rear main bearing caps.

16

Clean the main bearing housing and the bearing shells. Install the bearing shells with the lugs well into the cut outs. The upper main bearing shells have oil holes and grooves and the center bearing is wider than the others. Lubricate the bearings with fresh engine oil.

17

Check that the crankshaft bearing journals are clean and lubricate them with fresh engine oil. Carefully lower the crankshaft into position above the bearings.

18

Clean and lubricate the upper halves of the thrust washer and slide them in on their grooves on both sides of the bearing housing. Ensure that the thrust washer lubricating grooves are turned towards the crankshaft.

19

Clean the bearing caps and the lower bearing shells. Install the bearings in the caps with the lugs correctly installed in their cut outs. Lubricate the bearings with fresh engine oil.

20

Check that the guide sleeves for the main bearing caps are correctly installed in the bearing cap or in the cylinder block.

21

Clean the lower halves of the thrust washers and lubricate them with fresh engine oil. Install the thrust washers against the central main bearing cap with the oil grooves turned away from the cap. Check that the guide sleeves of the cap are in the correct position. Install the cap on the cylinder block with the word “FRONT” turned towards the timing cover end of the engine. Tighten the screws for the cap in stages and evenly to **112 Nm**.

22

Install the other caps in their correct positions. Caps number 2 and 4 are stamped with the position number and the word “FRONT”. The word “FRONT” must be turned towards the timing cover end of the engine. The front and rear caps have no stamped number. The front cap has a threaded hole in the underside, the rear cap has two threaded holes on the underside. Tighten the screws for the cap in stages and evenly to **112 Nm**.

23

Check the axial clearance of the crankshaft and replace the thrust washer if necessary.

24

Remove the protective tubes from the connecting rod screws.

25

Install the big end caps, see operation 13A-03.

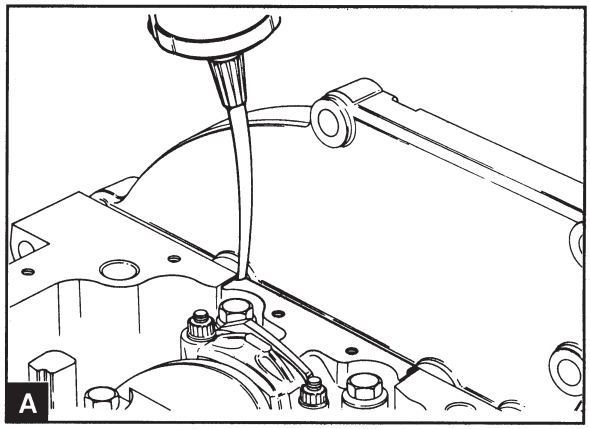
26

Install the oil extractor pipe, oil screen and oil pan, section 18.

27

Install the flywheel cover and the flywheel, see section 21.

28



Apply sealing compound in the groove on each side of the front and rear main bearing cap (A). Apply the sealing compound until it fills the groove completely and is pressed into the column between the cap and the cylinder block. Remove the sealant from the areas around the oil pan mounting holes. Install the oil pan, operation 18A-03 within five minutes of applying the sealing compound.

29

Install the timing cover and the timing pulleys, see section 15. Install the timing belt, operation 15A-04, with the temporary markings on the belt aligned to the marked teeth on the pulleys. Remove the temporary markings and adjust the belt tension, operation 15A-03.

30

Check the fuel injection pump adjustment, operations 17A-03.

31

Install the cap of the timing cover, operation 15A-01.

32

Install the crankshaft pulley, operation 14A-01.

33

Install the pulley for the water pump.

34

Install the starter motor, operation 22B-01.

35

After the engine is installed fill the oil pan to the correct level with an approved engine oil. Fill the engine coolant system.

Crankshaft, inspection (14A-09)

Check the crankshaft for wear and damage. The maximum permitted wear and ovality in the main bearing journals and crankshaft journals is 0.03 mm.

Main bearing journals and crankshaft journals can be worked to 0.3 mm undersize in diameter, see Workshop Manual “Technical Data”. Special bearings for under size are available.

The mating surface on the rear flange can be worked to remove wear marks, if the seal has been installed in both positions see Workshop handbook “Technical data”.

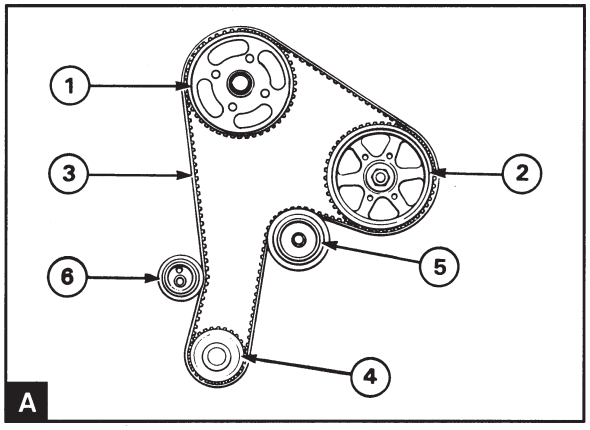
Timing cover and sprocket

General

The drive pulleys are installed on the camshaft (A1) and the fuel injection pump (A2). These pulleys are driven by a toothed belt (A3) from one toothed pulley mounted on the crankshaft (A4). The pulleys are made of sintered iron with 2% copper and the belt is made of neoprene and glass fibre. A flat idler pulley (A5) ensures good belt position and an adjustable tension pulley controls the belt tension.

The pulley for the fuel injection pump has two key grooves, one for turbo charged engines and the other for naturally aspirated engines.

The pulleys and belt are covered by a timing cover and a cap which is made of fibreglass reinforced polypropylene.



Timing cover outer, replacement (15A-01)

1

Disconnect the battery.

2

Remove the generator (GEN) drive belt, operation 22A-03.

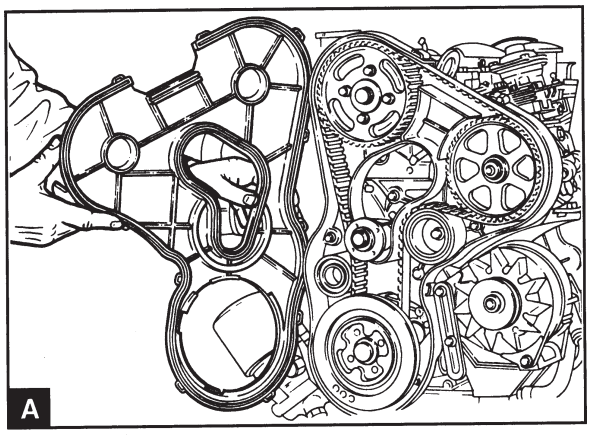
3

Remove the pulley for the water pump.

4

Remove the inspection hatch from the timing cover (15A.04/A).

5



Remove the clips for the cover and remove the cap (A).

6

Check that the cap is clean and that all the spring clips are fastened at the timing cover.

7

Install the cap on the timing cover and ensure that all the clips are in position.

8

Install the inspection hatch on the timing cover and the cap.

9

Install the water pump belt.

10

Install the generator (GEN) belt, operation 22A-03.

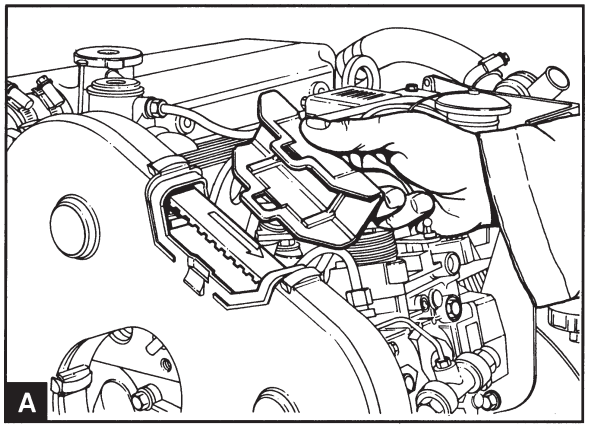
11

Connect the battery.

Timing belt, inspection (15A-02)

Special tools: 885036

1

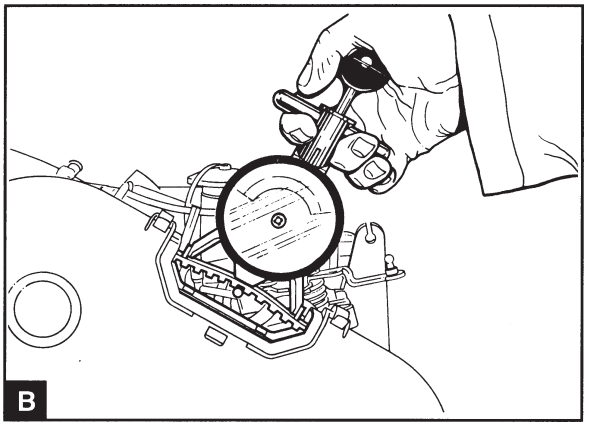


Remove the inspection hatch from the upper side of the timing cover (A).

2

Make a temporary mark on the belt to ensure that the whole belt is checked. Check the belt for wear and damage and check that the belt is not split or contaminated by oil. Turn the crankshaft so that all the teeth on the belt can be checked. Replace the belt if necessary, operation 15A-04. Remove the temporary mark.

3



Press the ball end of the belt tension gauge and install the gauge over the belt. Ensure that the gauge foot is located under the belt and between two teeth (B). Slowly release the ball end and read off the gauge. Turn the crankshaft slightly in each direction until a stable read off is obtained. The correct value for a new belt is 425-465 N and for a used belt 340-370 N. If the tension of a used belt has fallen to 270 N or below, adjust the belt tension to 340-370 N, operation 15A-03.

4

If belt tension is correct, install the inspection hatch on the timing cover.

Timing belt, tension (15A-03)

Special tools: 885036, 885037

1

Install the adjustment drifts on the camshaft and flywheel, operation 17A-01.

2

Remove the cap of the timing cover, operation 15A-01.

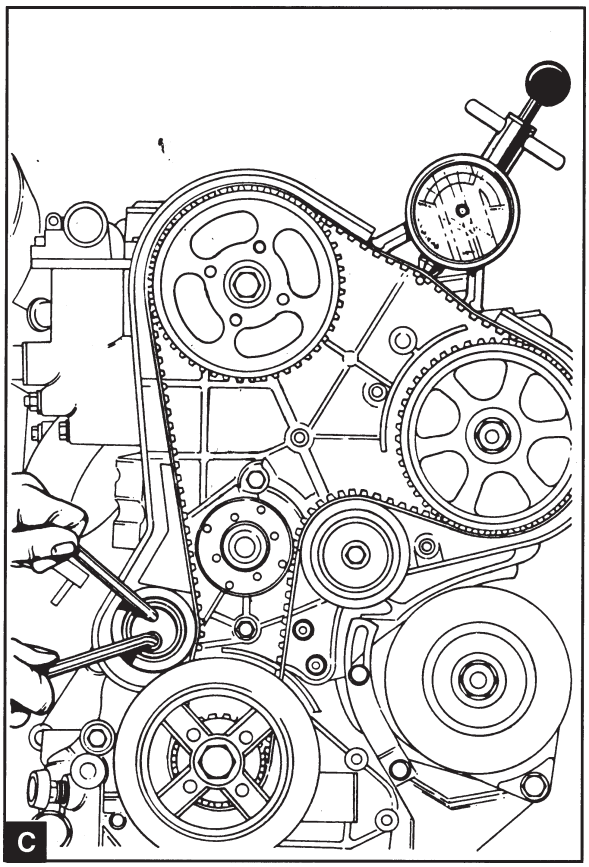
3

Install the belt tension gauge between the belts for the injection pump and the camshaft.

4

Remove the four mounting for the camshaft pulley, so that the pulley can turn on its hub.

5



Unscrew the domed screws holding the belt tensioner roller. Adjust the belt tension using a hexagonal key in the hexagonal socket in the roller (C). The correct tension for a new belt is 425-465 N and for a used belt 340-370 N. When the tension is correct, tighten the domed screws to **45 Nm** and then recheck the belt tension.

6

Tighten the mounting screws for the camshaft pulley to the correct torque, see Workshop manual “Technical data” and check that the belt tension is still correct.

7

Remove the adjustment drifts from the camshaft and the flywheel.

8

Turn the crankshaft two revolutions and check the belt tension again.

9

Check the fuel injection pump adjustment, operations 17A-03.

10

Install the cap of the timing cover, operation 15A-01.

Timing belt, replacement (15A-04)

Special tools: 885037

1

Disconnect the battery.

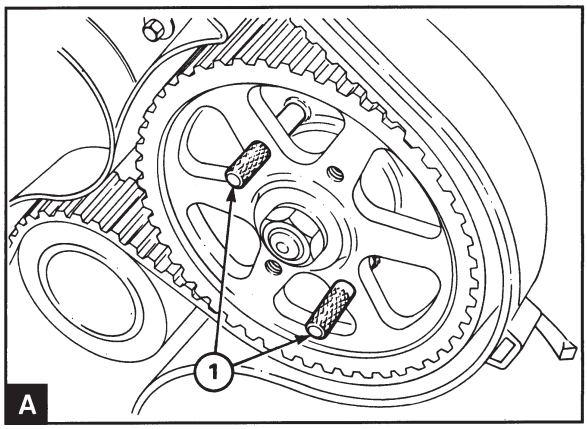
2

Remove the screw over the adjustment hole in the camshaft cover. Turn the crankshaft until the adjustment hole in the front of the camshaft corresponds with the hole in the cover. Install the adjustment drifts 885037 in the camshaft and the flywheel.

3

Remove the cap of the timing cover, operation 15A-01.

4



Install the two screws (M6 x 50) (A1) through the smooth holes in the fuel injection pump pulley and in the pump bracket.

5

Remove the tension pulley and idler pulley.

6

Remove the timing belt. Do not bend the belt at an angle, this can damage the belt and could cause engine seizure. Lay the belt on its edge in a circle on a flat surface. Do not hang the belt.

7

Check the belt teeth for wear. Check the belt for oil contamination, cracks and other damage. Replace the belt if any fault is found.

8

Install the timing belt over the crankshaft, camshaft and fuel injection pump pulleys. Ensure that the direction arrows show a clockwise direction of rotation when seen from the front (15A.04/A).

9

Install the idler pulley and tighten to **43 Nm**.

10

Install the tension pulley in position and install the roller domed screw. There are two threaded holes for the domed screw and it must be placed in the hole which makes real belt tension adjustment possible. Tighten the domed screw so that the pulley is held in position, but do not tighten completely.

11

Remove the fixing screws from the fuel injection pump pulley and adjust the belt tension, operation 15A-03.

12

Tighten the mounting screws for the camshaft pulley to the correct torque, see Workshop manual “Technical Data” and remove the rotation locking tool.

13

Remove the adjustment drifts from the camshaft and the flywheel.

14

Check the fuel injection pump adjustment, operations 17A-03.

15

Turn the crankshaft two revolutions to ensure that there is nothing preventing free movement

16

Install the cap of the timing cover, operation 15A-01 and install the inspection hatch.

17

Install the mounting screw in the adjustment hole in the camshaft cover.

18

Connect the battery.

Fuel injection pump pulley, replacement (15A-05)

Special tools: 885037, 885027, 885029

1

Disconnect the battery.

2

Remove the screw over the adjustment hole in the camshaft cover. Turn the crankshaft until the adjustment hole in the front of the camshaft corresponds with the hole in the cover. Install the adjustment drifts 885037 in the camshaft and the flywheel.

3

Remove the cap of the timing cover, operation 15A-01.

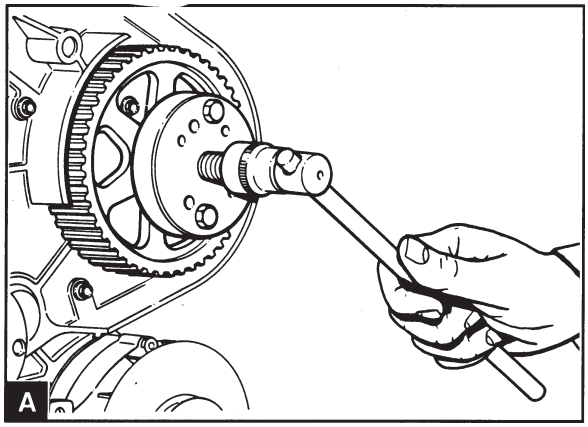
4

Slacken off and remove the nut for the fuel injection pump pulley. Unscrew the mounting screws for the camshaft pulley.

5

Remove the timing belt, operation 15A-04.

6



Remove the pulley with pulley puller 885027 and adapters 885029. Take care not to lose the key.

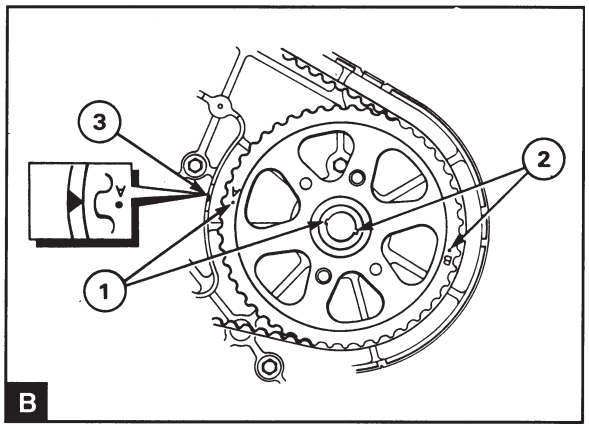
7

Check the pulley for wear, cracks and other damage. Replace it if required.

8

Check that the key is correctly installed in the fuel injection pump shaft.

9



Install the pulley in position on the shaft with the correct keygroove in contact with the key. There are two keygrooves and two marked teeth, “A” and “B”, on the pulley. On engines types MD22 and MD22L use the keygroove lying on the same side as the tooth marked “A”. On engines types TMD22 and TAMD22 use the keygroove lying on the same side as the tooth marked “B”. Ensure that the marking on the pulley is turned to the front end of the engine.

10

Install the spring washer and the pulley nut, hold the pulley so that it does not move and tighten the nut to press the pulley into position.

11

Check that the tooth with the correct marking (see paragraph 2) is closest to the arrow on the timing cover (B3). Install the two screws (M6 x 50) through the smooth holes in the pulley and in the pump bracket.

12

Install the timing belt, operation 15A-04. Remove the fixing pin for the pulley and adjust the belt tension, operation 15A-03.

13

Tighten the pump pulley to **60 Nm** and remove the locking tool.

14

Remove the adjustment drifts from the camshaft and the flywheel.

15

Check the fuel injection pump adjustment, operations 17A-03.

16

Turn the crankshaft two revolutions to ensure that there is nothing preventing free movement

17

Install the cap of the timing cover, operation 15A-01 and install the inspection hatch.

18

Install the mounting screw in the adjustment hole in the camshaft cover.

19

Connect the battery.

Camshaft pulley, replacement (15A-06)

Special tools: 885027, 885029, 885037

1

Disconnect the battery.

2

Remove the screw over the adjustment hole in the camshaft cover. Turn the crankshaft until the adjustment hole in the front of the camshaft corresponds with the hole in the cover. Install the adjustment drifts 885037 in the camshaft and the flywheel.

3

Remove the cap of the timing cover, operation 15A-01.

4

Install the two screws (M6 x 50) through the smooth holes in the fuel injection pump pulley and in the pump bracket.

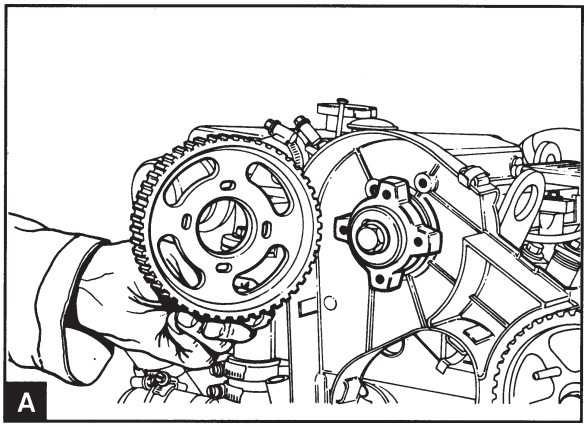
5

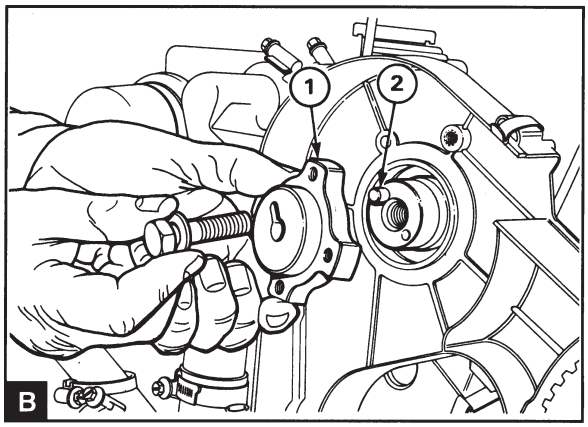
Unscrew the screws securing the pulley to the hub.

6

Remove the timing belt, operation 15A-04.

7





Remove the mounting screws for the pulley and remove the pulley. Remove the pulley hub (B1) and the guide pin (B2).

8

Check the pulley for wear, cracks and other damage. Replace it if required.

9

Check that the guide pin (B2) is in position on the camshaft. Install the hub and the mounting screws, but do not tighten the screw completely. Install the pulley on the hub if necessary, but do not tighten the screws completely.

10

Install the timing belt, operation 15A-04. Remove the fixing pin for the fuel injection pump pulley and adjust the belt tension, operation 15A-03.

11

Tighten the central mounting screw to **85 Nm** and/or tighten the screws which secure the pulley to the hub to **22 Nm.** Remove locking tool.

12

Remove the adjustment drifts from the camshaft and the flywheel.

13

Check the fuel injection pump adjustment, operations 17A-03.

14

Turn the crankshaft two revolutions to ensure that there is nothing preventing free movement

15

Install the cap of the timing cover, operation 15A-01 and install the inspection hatch.

16

Install the mounting screw in the adjustment hole in the camshaft cover.

17

Connect the battery.

Crankshaft pulley, replacement (15A-07)

Special tools: 885029, 885027, 885037

1

Disconnect the battery.

2

Remove the screw over the adjustment hole in the camshaft cover. Turn the crankshaft until the adjustment hole in the front of the camshaft corresponds with the hole in the cover. Install the adjustment drifts 885037 in the camshaft and the flywheel.

3

Remove the starter motor.

4

Remove the crankshaft pulley, operation 14A-01.

5

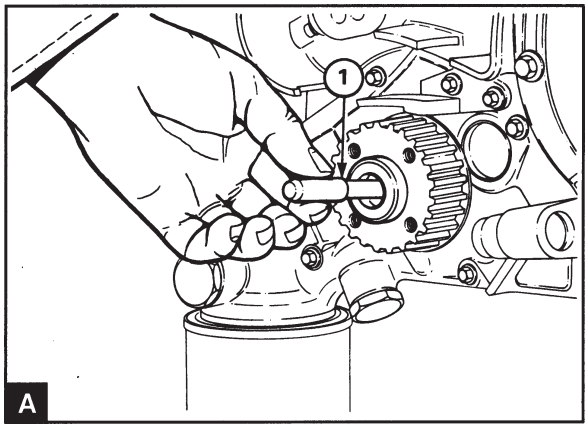
Remove the cap of the timing cover, operation 15A-01.

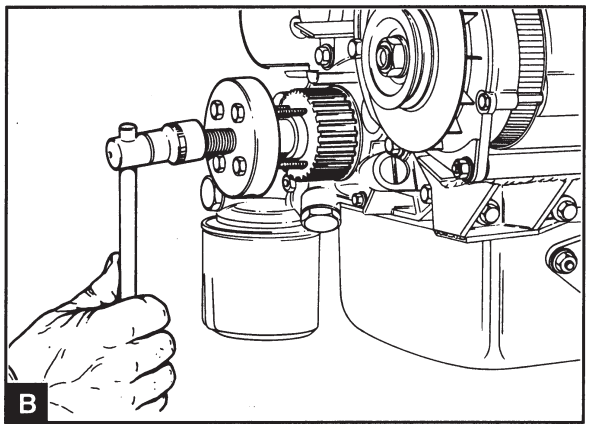
6

Remove the timing belt, operation 15 A-04.

NOTE! The belt pulley is locked to the front end of the crankshaft using Loctite 648 and can only be removed using a puller.

7





Insert the thin end spacer piece in the crankshaft (A1). Install the main tool 885027 (B) on the pulley using the mounting screws and tighten the center screws against the spacer piece to remove the pulley.

8

Check the pulley for wear, cracks and other damage. Replace it if necessary.

9

If the pulley is to be reused, the old Loctite 648 must be removed from the crankshaft, pulley and key using Loctite 8151 according to the manufacturers instructions.

NOTE! It is acceptable for some of the old Loctite 648 to remain on the components, if the pulley can be mounted correctly New Loctite can bond to old Loctite if it is clean, dry and free of any cleaning agent.

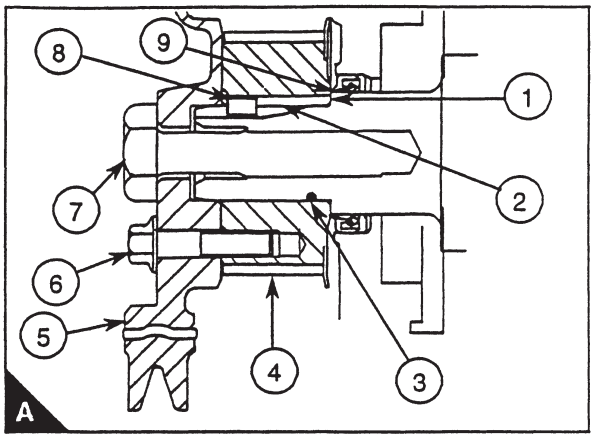
10

If old Loctite remains on the components and the pulley cannot be correctly installed extra working with the Loctite tool is needed.

11

Ensure that the hole in the pulley, the keygroove and the front end of the crankshaft are dry and free of grease, cleaning agent and external inhibitors.

12



Apply a bead of Loctite 648 (A3) in a complete circle internally in the hole in the pulley (A4), 6.5 mm from the rear end panel.

13

Install the pulley on the crankshaft, but do not align the keygroove.

14

Spray Loctite 648 into the keygroove (A2) in the pulley. Ensure that the pulley is pressed against the projection (A1) on the crankshaft during this operation. This prevents the oil seal (A9) being contaminated by the Loctite.

NOTE! If too much Loctite is sprayed into the keygroove it can contaminate the oil seal (A9) behind the pulley. If this occurs the oil seal must be replaced.

15

Turn the pulley through 360° to spread the Loctite over the surface of the hole in the pulley and on the front end of the crankshaft.

16

Align the keygroove in the crankshaft and the pulley and carefully spray Loctite 648 into keygroove until one can see Loctite fully and evenly at the front end of the keygroove. Ensure that the pulley is pressed against the projection on the crankshaft during this operation.

17

Slide the (A8) into the keygroove to a depth of 5 mm measured from the pulley front end plate.

NOTE! It is important that all excess Loctite is wiped off from the front end of the crankshaft and from the pulley before the pulley is installed.

18

Install the damper pulley (A5) on the pulley using the four mounting screws (A6). Finger tighten the mounting screws.

19

Install the center screw (A7) and tighten to **180 Nm**.

20

Tighten the four mounting screws to:

Flanged screw **22 Nm**

Domed screws **36 Nm**

NOTE! Loctite 648 starts to cure after seven minutes at 22° C. It is important to tighten the these mounting screws within the given time limit.

21

Install the timing belt, operation 15A-04. Remove the fixing pin for the fuel injection pump pulley and adjust the belt tension, operation 15A-03.

22

Check the fuel injection pump adjustment, operations 17A-03.

23

Carefully turn the crankshaft two revolutions to ensure that there is nothing preventing free movement.

24

Install the cap of the timing cover, operation 15A-01 and install the inspection hatch.

25

Install the screw in the adjustment hole in the camshaft cover.

26

Install the starter motor, operation 23B-01.

27

Connect the battery.

Timing cover inner, replacement (15A-08)

Special tools: 885037, 885027, 885029

1

Disconnect the battery.

2

Remove the screw over the adjustment hole in the camshaft cover. Turn the crankshaft until the adjustment hole in the front of the camshaft corresponds with the hole in the cover. Install the adjustment drifts 885037 in the camshaft and the flywheel.

3

Remove the starter motor.

4

Remove the crankshaft pulley, operation 14A-01A.

5

Remove the cap of the timing cover, operation 15A-01.

6

Install the two screws (M6 x 50) through the smooth holes in the fuel injection pump pulley and in the pump bracket.

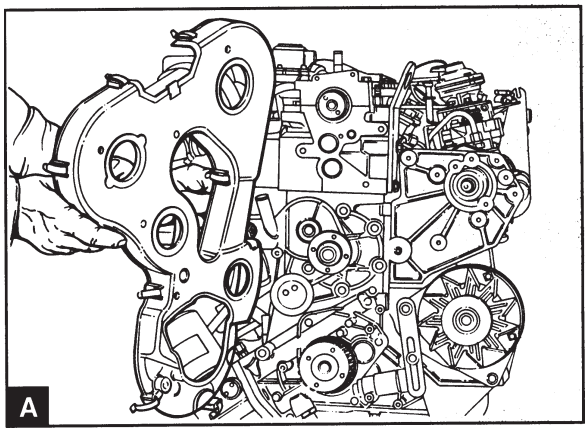
7

Remove the timing belt, operation 15A-04.

8

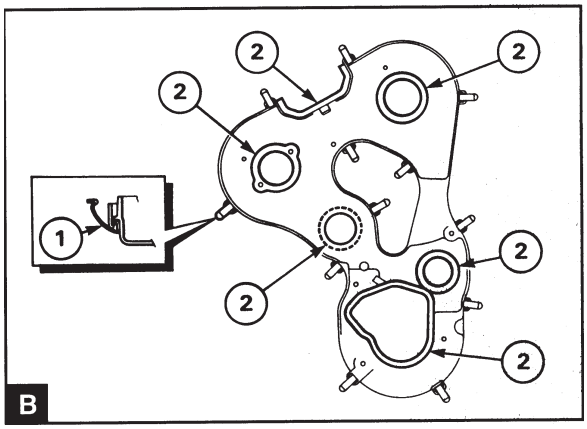
Remove the fuel injection pump pulley, operation 15A-05 and the camshaft pulley, operation 15A-06.

9



Unscrew the screws securing the timing cover to the cylinder head, the cylinder block, the fuel injection pump bracket and the oil pump. Remove the timing cover (A).

10



Check the timing cover for cracks and damage and replace it if required. Check that all the clips are correctly installed in the timing cover (B1).

11

Check that the mating surfaces of the timing cover and engine are clean. Install the cover in position and tighten with the mounting screws. Tighten the screws to the correct torque in relation to the thread dimension, see Workshop Manual “Technical Data”.

12

Remove the fuel injection pump pulley, operation 15A-05 and the camshaft pulley, operation 15A-06.

13

Install the crankshaft pulley if required, operation 14A-01A.

14

Install the timing belt, operation 15A-04. Remove the fixing pin for the fuel injection pump pulley and adjust the belt tension, operation 15A-03.

15

Remove the adjustment drifts from the camshaft and the flywheel.

16

Check the fuel injection pump adjustment, operations 17A-03.

17

Turn the crankshaft two revolutions to ensure that there is nothing preventing free movement

18

Install the cap of the timing cover, operation 15A-01 and install the inspection hatch.

19

Install the screw in the adjustment hole in the camshaft cover.

20

Install the starter motor, operation 22B-01.

21

Connect the battery.

Cylinder block

General

The cylinder block is made of cast iron with sides which extend below the crankshaft for maximum support. The cylinder bore is machined directly into the block and is specially honed to minimize wear and oil consumption.

Repair instructions

Cylinder block, replacement (16A.01)

1

Drain the engine oil and the engine coolant system.

2

Remove the generator (GEN) drive belt, the generator (GEN) and the mounting brackets, see 22.

3

Remove the starter motor, operation 22B-01.

4

Remove the crankshaft pulley, operation 14A-01A.

5

Remove the cap for the timing cover, the timing belt, belt pulleys and timing cover, see section 15.

6

Remove the oil pump and filter unit, operation 18A-06.

7

Remove the fuel filter, injectors and fuel injection pump, see section 19.

8

Remove the reverse gear.

9

Remove the flywheel and the flywheel cover.

10

Remove the cylinder head assembly, operations 12A-07.

11

Remove the oil pump, operation 20A-11.

12

Remove the oil filter/ separator unit.

13

Remove the oil pan, operation 18A-03.

14

Remove the pistons and connecting rods assembly, operation 13A-03.

15

Remove the crankshaft pulley, operation 14A-09.

16

Remove the mounting bracket for the fuel injection pump (A).

17

Remove the mounting screws and washers if the cooler nozzle is not installed.

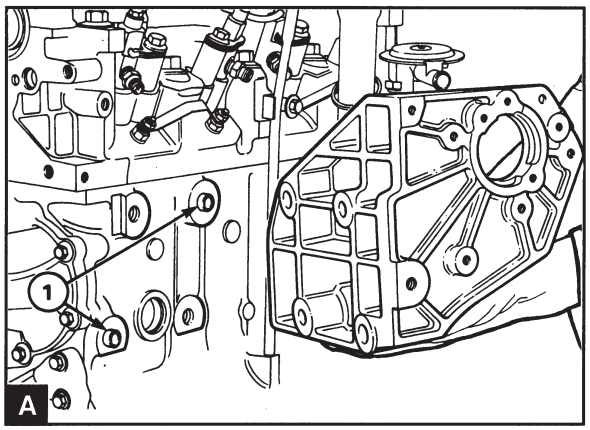
18

Clean the new cylinder block carefully. Check that all the oilways are clear and clean. Ensure that the plug is installed in the rear end of the pressure channel.

19

If the cooler nozzle is not used, install the mounting screws and washers to drain the oil hole and tighten the screws to **22 Nm**.

20



Install the fuel injection pump bracket. Check that the guide pins (A1) is correctly installed. Tighten the mounting screws to **43 Nm**.

21

Install the crankshaft and if necessary, the separate housing oil stuffing box, see section 14.

22

Install the pistons and connecting rods assembly, operation 13A-03.

23

Install the oil pan, operation 18A-03.

24

Install the oil filter/ separator unit.

25

Install the flywheel cover and the flywheel, see section 21.

26

Install the oil cooler if necessary, operation 20A-11.

27

Install the cylinder head assembly, operation 12A-07.

28

Install the fuel filter, injectors and fuel injection pump, see section 19.

29

Install the oil pump and filter unit, operation 18A-06.

30

Install the timing cover, belt pulleys and the timing belt, see section 15. Install the crankshaft pulley, operation 14A-01A. Adjust the timing belt tension, operation 15A-01.

31

Remove the adjustment drifts and turn the crankshaft two revolutions. Check the fuel injection pump setting, operation 17A-03. Install the cap of the timing cover, operation 15A-01.

32

Install the starter motor, operation 22B-01.

33

Install the generator (GEN) drive belt, the generator (GEN) and the mounting brackets, see 22.

34

Install the engine.

35

Fill the engine coolant system.

36

Fill the oil pump to the correct level with an approved engine oil.

37

Bleed the fuel injection system, operation 19A-08.

Cylinder block, inspection (16A-02)

1

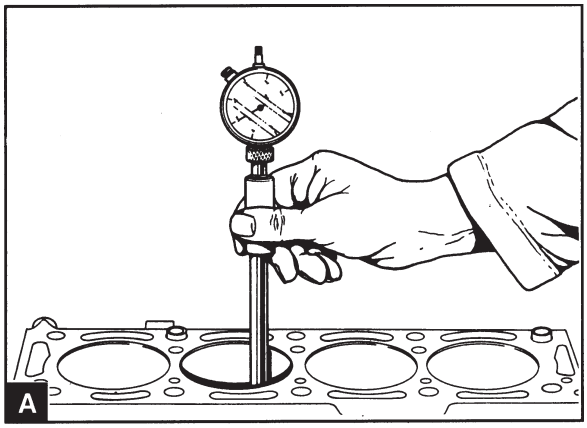
Clean the coolant and lubrication channels.

2

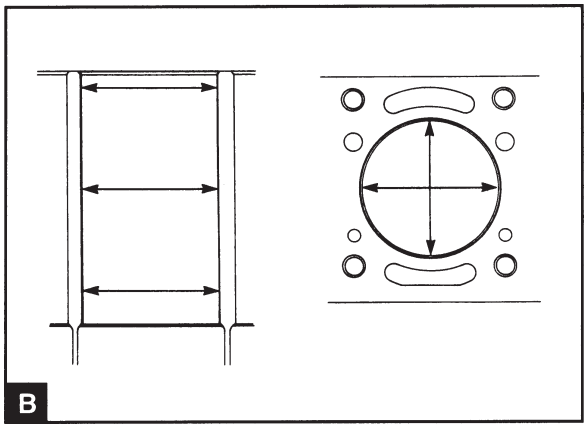
Check the cylinder block for cracks and other damage.

The upper surface of the cylinder block cannot normally be machined, because it affects the height of the pistons above the cylinder block surface. If high pistons (height class 1) are installed in all cylinders it is possible to machine a maximum of 0.26 mm from the upper surface of the cylinder block and install low pistons (height class 6). If the block is machined the piston height must be checked to ensure that the pistons do not reach further than the maximum permitted limit, otherwise the pistons may hit the valves and damage the engine.

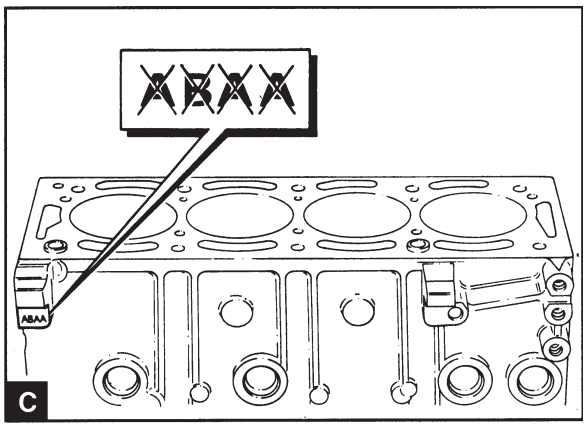
3



Check the cylinder bore for wear (A) and damage. The top, bottom and center of the cylinder bore should be inspected in both the vertical and lateral planes (B).



If the cylinder bores are damaged or worn more than 0.15 mm, measured in the diameter, the bore can be bored out and honed to 0.50 mm, diametrically oversize, and oversized pistons can be installed. For best results the cylinder bore should be honed with a total angle of 30° to 35° with a silicon carbide honing element which gives clean scoring. Coarse hone with a surface evenness of 1.5-2.0 mm (micrometer) and then fine hone to an mean



evenness of 0.7-1.4 mm.

After the cylinder has been bored out to oversize, an “X” should be stamped over the bore classes on the cast lug on the rear of the right hand size of the cylinder block (C).

If the cylinder bore surface is glazed the engine may have high oil consumption with very low cylinder bore wear.

Cylinder bore, honing (16A-03)

A tool, called Flex-Hone is accessible for adjusting the cylinder bore surface. This tool can be used together with an electric drill at low speeds. The pistons and connecting rods must be removed. Use covers to protect all the engine components from swarf that occurs during the machining.

1

An 80SC Flex-Hone with the grade 3 1/2 can be used.

2

A new Flex-Hone must be used on an old cylinder bore first in order to remove any loose material and sharp edges.

3

Lubricate the cylinder head and Flex-Hone lightly with fresh engine oil.

4

Install the tool in position at the top of the cylinder bore, but do not push the tool down into the cylinder bore until it has begun to operate.

5

Allow the tool to operate and move it up and down in the cylinder bore once a second for 30-50 seconds. Pull the tool up while it is rotating.

6

Clean the cylinder bore carefully to remove all dirt from the machining, use a hard brush and kerosene.

7

Dry the cylinder bore and carefully remove all the covers used to protect the components. Carefully clean all the engine components exposed to machining particles.

8

Ensure that new piston rings are installed when the engine is reassembled.

NOTE! After honing, we recommend that the following instructions are followed for the first 5 hours of operational use:

- Do not run the engine at maximum load.
- Do not run the engine at high engine speeds (RPM).
- Do not run the engine at low idling speed for long periods of time.

Engine settings

General

The installation holes for the adjustment drifts are in the flywheel and in the front camshaft bearing journal. When these holes are aligned to the adjustment holes in the flywheel cover and the camshaft cover the cylinder 1 piston should be in the Top dead center (TDC) position of the compression stroke.

The fuel injection pump pulley has two adjustment marks (A and B) and two keygrooves. The keygroove on the same side as the relevant adjustment mark must always be used.

Setting the fuel injection pump must always be checked after the timing belt tension has been adjusted.

Setting the 1st piston at top dead center of the compression stroke (17A-01)

Special tools: 885037

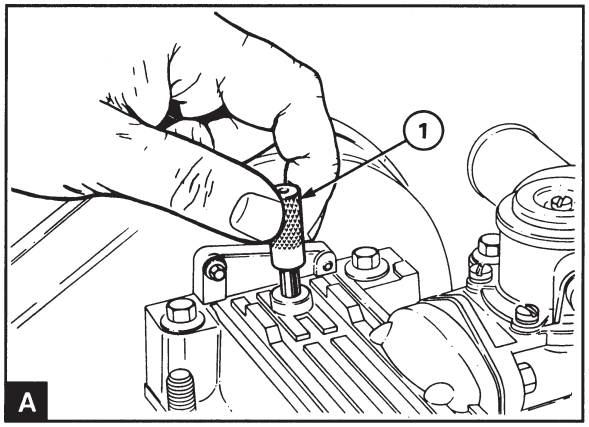
1

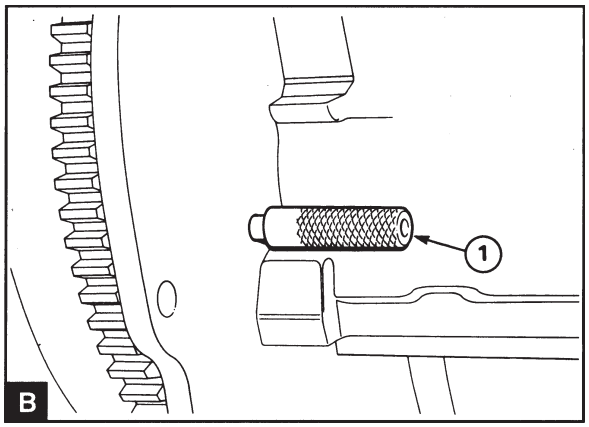
Disconnect the battery and remove the screw over the adjustment hole at the top of the front end of the camshaft cover.

2

Turn the crankshaft (in the normal direction of rotation – clockwise as seen from the front) until the adjusting hole in the crankshaft front bearing journal corresponds to the hole in the camshaft cover.

3





Install the adjustment drifts through the camshaft cover in the camshaft (A1) and through the flywheel cover in the flywheel (B1).

Valve timings, checking/ adjustment (17A-02)

Special tools: 885037

Position the piston in cylinder 1 at TDC in the compression stroke, operation 17A-01 If both the adjustment drifts can be installed, the valve timing is correct. If only one of the drifts can be installed, adjust the valve timings as follows:

1

If necessary remove the drift from the flywheel, turn the crankshaft to align the adjustment hole in the crankshaft to the hole in the camshaft cover and install the adjustment drift for the camshaft.

2

Remove the cap of the timing cover, operation 15A-01.

3

Slacken off the screws securing the camshaft pulley to the hub, so that the pulley can move on the hub.

4

Unscrew the dome screw for the tension pulley and loosen the timing belt tension.

5

Turn the crankshaft to align the adjustment hole in the flywheel to the hole in the flywheel cover or back plate. Install the adjusting drift on the flywheel.

6

Adjust the timing belt tension, operation 12A-03.

7

Tighten the mounting screws for the camshaft pulley to the correct torque, see Workshop manual “Technical Data”.

8

Check the fuel injection pump adjustment, operations 17A-03.

9

Remove the adjustment drifts and turn the engine two revolutions to ensure that there is nothing preventing free movement.

10

Install the cap of the timing cover, operation 12A-01 and install the screw in the adjustment hole in the camshaft cover.

11

Connect the battery.

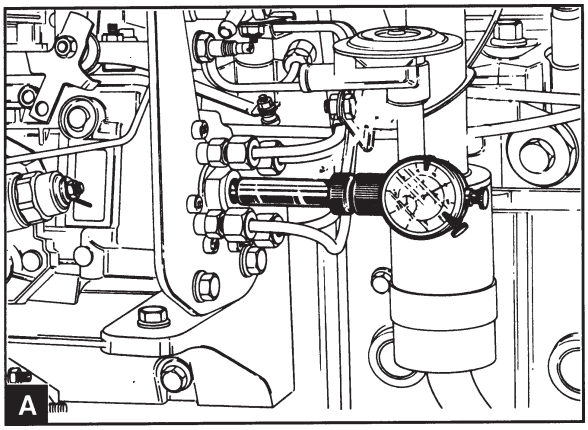
Injection timing, checking/adjustment (17A-03)

Special tools: 884955, 885139 (TMD22P, TAMD22), 885037

1

Position the piston in cylinder 1 at TDC in the compression stroke, operation 17A-01. Remove the adjustment drifts.

2



Remove the plug and the washer from the center of the fuel injection pump rear plate and install the gauge. Set the gauge so that it reads approximately 3.0 mm. Ensure that there is sufficient play between the gauge and the oil filler pipe, to allow for any radial movement in the pump.

3

Turn the crankshaft slowly (counter-clockwise seen from the front of the engine) until the gauge displays the pump element at the bottom of the stroke. Set the gauge to zero.

4

Slowly turn the crankshaft clockwise, until the adjustment drift goes into the adjustment hole in the flywheel. In this position the gauge should indicate the correct lift height for the pump element, see Workshop Manual “Technical Data”.

5

If the read out is not within 0.05 mm of the correct setting, disconnect the fuel delivery lines from the pump. Use a wrench to prevent the output terminals on the fuel pump (FP) from moving when the delivery lines are removed or installed. Remove the nuts for the pump flange and mounting screws for the rear support bracket.

If the read off value is too low, turn the pump clockwise as seen from the rear, until the correct value is reached and then tighten the flange nuts and the screws for the bracket.

If the read off value is too high, turn the pump counter-clockwise as seen from the rear, past the correct setting and then back clockwise to the correct position. Tighten the flange nuts and the screws for the bracket.

Remove the adjustment drift from the flywheel and turn the crankshaft counter-clockwise approximately 45°. Check that the gauge still displays zero and check the setting again. When the setting is correct, connect the fuel delivery lines.

6

Remove the gauge and the adapter and reinstall the plug and the washer. Tighten to **10 Nm**.

7

Remove the adjustment drift from the flywheel and install the adjustment screw in the camshaft cover.

8

Connect the battery.

Lubrication system

General

The oil pump is located around the front end of the crankshaft, the pumps inner rotor is driven by a key in the crankshaft. The pump has an inner and an outer rotor which are located eccentrically in relation to each other. The inner rotor has ten teeth which mesh with the outer rotors eleven teeth. When the pump turns the space between the teeth, which are meshed with each other, increases so that a vacuum occurs, or decreases so that pressure increases.

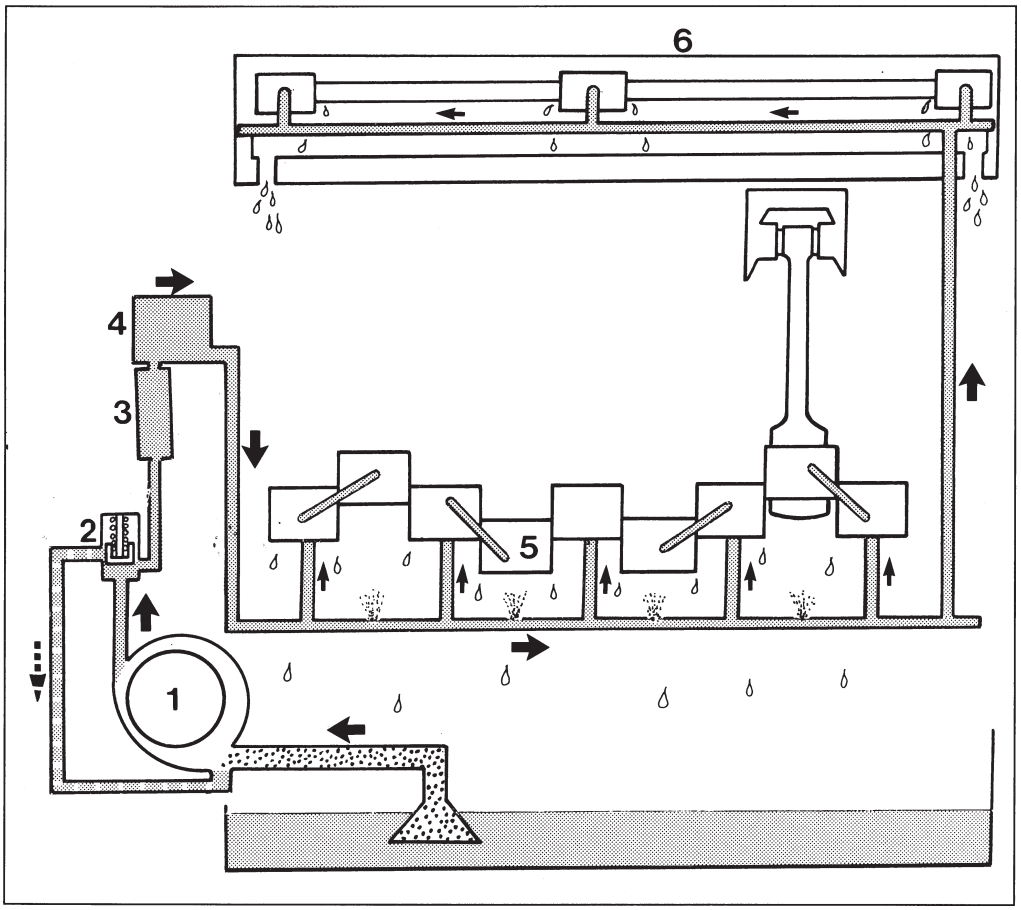
The lubricating oil from the oil pan is routed through an oil screen and a pipe to a passage in the cylinder block and from there on to the suction side of the pump.

A relief valve (mounted in the pump housing) opens if the pressure is too high. This allows a certain amount of the oil on the output side to be returned to the intake side of the pump.

From the pump the oil passes through a filter mounted on the pump housing. After the filter the oil passes into the pressure channel which is drilled the length of the cylinder block.

From the pressure channel the oil passe to the crankshaft main bearings and through the channels in the crankshaft to the big ends. The pistons and the cylinder bores are lubricated by oil mist and splash lubrication.

Oil passes (through the channels in the block and cylinder block) from the rear section in the cylinder block to the pressure channel in the cylinder head. From the pressure channel in the head the oil passes to each of the camshaft bearing journals. The valves and the valve lifters are lubricated by oil mist and splash lubrication.



1. Oil pump
2. Relief valve
3. Oil cooler
4. Oil filter
5. Crankshaft
6. Camshaft

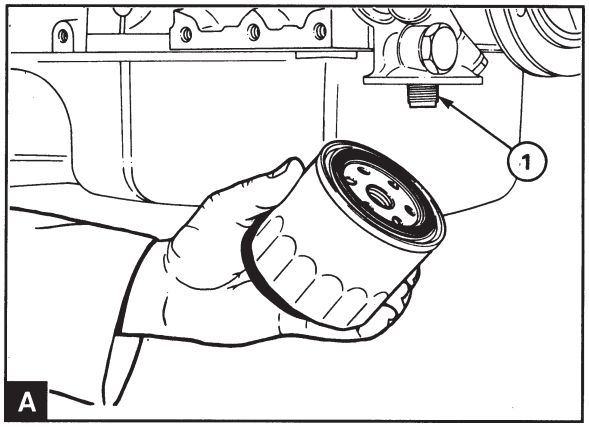
Repair Instructions

Oil filter, replacement (18A-01)

1

Place a container under the filter to collect any spilled fluid.

2



Remove the filter holder with a strap wrench or a similar tool. Ensure that the adapter (A1) remains in the filter head and discard the holder.

3

Clean the filter head.

4

Fill the new reservoir with fresh engine oil. Give the oil time to fill the holder through the filter element.

5

Lubricate the upper side of the filter holder gasket with fresh engine oil.

6

Install the new filter holder, hand tighten only. Do not use a strap wrench.

7

Check that there is lubricating oil in the oil pan.

8

Start the engine and check the filter for leaks. Check the oil level on the dipstick when the engine has cooled and top up the oil in the oil pan if necessary.

NOTE! The filter holder contains a valve and a special pipe which ensures that the filter is not drained of oil. Ensure that the correct type of filter holder is used.

Oil filter adapter, replacement (18A-02)

1

Place a container under the filter to collect any spilled fluid.

2

Remove the oil filter, operation 18A-01.

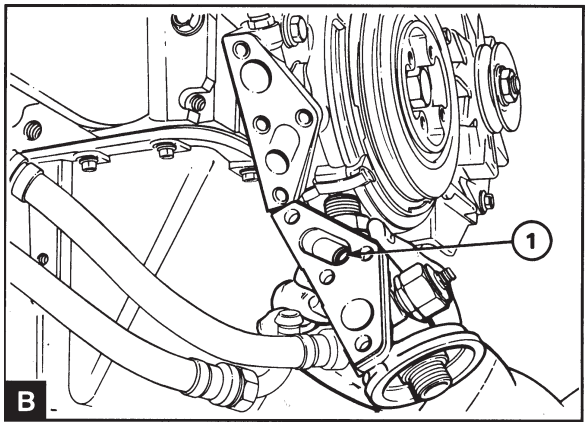
3

Install the pipe to the oil cooler if required.

4

Unscrew the mounting screws and remove the oil filter adapter from the oil pump. Discard the gasket.

5



Clean the sealing surfaces on the oil filter adapter and the oil pump.

If an oil cooler is used ensure that a plug is installed in the oil filter adapter (B1).

6

Install the oil filter adapter with a new gasket against the oil pump and tighten the mounting screws to **22 Nm**.

7

Connect to the oil cooler pipe and /or the pipe to the turbocharger if required.

8

Install a new oil filter, operation 18A-01.

Oil pan, replacement (18A-03)

1

Drain the oil. Remove the dip stick. Disconnect the crankcase ventilation return pipe.

2

Arrange a support for the oil pan if required. Remove the screws holding the oil pan against the cylinder block. Lower the oil pan and remove the gasket.

3

Clean the oil pan with fresh kerosene and ensure that all kerosene is removed. Clean the flange surfaces on the oil pan and the cylinder block.

4

If the front or rear main bearing caps have been removed, apply sealing compound according to the instructions under point 14 in operation 14A-08.

5

Apply a new oil pan gasket in position on the pan or the cylinder block. If a two piece gasket is used, apply the sealing compound on the ends of the respective gasket halves and ensure that the ends are correctly mounted on each other. Install the oil pan and ensure correct positioning using a mounting screw on each side. Install the remaining screws and tighten all the screws to **22 Nm.** Install the drain plug and washer if required and tighten the plug to **43 Nm**.

6

Install the dipstick. Connect the crankcase ventilation return tube.

7

Fill the oil pan to “MAX” level on the dipstick with an approved engine oil.

Oil screen and suction pipe, replacement (18A-04)

The oil screen is an integrated part of the suction pipe. No regular service is required, but clean the oil screen when it is dismantled.

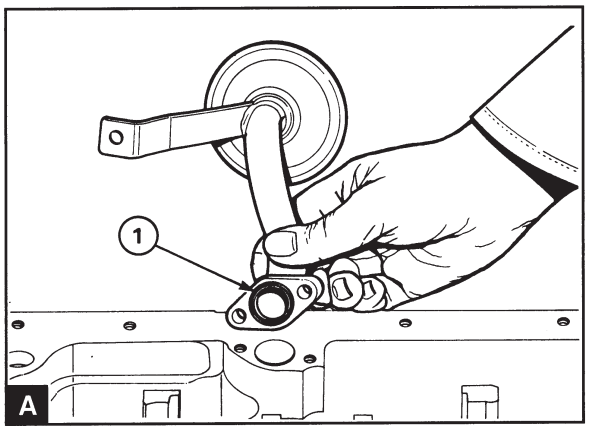
1

Remove the oil pan, operation 18A-03.

2

Remove the screw securing the bracket to the main bearing cap.

3



Remove the screws at the suction pipe flange and remove the suction pipe and screen. Remove the O-ring (A1). Clean the flange surface on the cylinder block and the suction pipe.

4

Install the suction pipe bracket loosely to the correct main bearing cap. Install the suction pipe to the oil pump with a new O ring. Tighten the screws. Tighten the mounting screws for the suction pipe bracket, ensure that the suction pipe is not subjected to tension.

5

Install the oil pan, operation 18A-03 and fill it to ”MAX” on the dipstick with an approved engine oil.

Oil screen and suction pipe, inspection (18A-05)

1

Clean the unit in kerosene and dry it carefully.

2

Check the pipe, screen and welded joints for cracks and other damage. Check that the mounting bracket is well tightened.

3

If a damaged component cannot be welded correctly the whole unit should be replaced.

Oil pump, replacement (18A-06)

Special tools: 885032, 885037

1

Disconnect the battery

2

Remove the screw from the adjustment hole on the top of the front end of the camshaft cover. Turn the crankshaft until the adjustment hole in the front of the camshaft front bearing journal corresponds with the hole in the cover.

3

Install the adjustment drifts in the camshaft and the flywheel, see section 17.

4

Remove the generator (GEN) drive belt, operation 22A-03 and remove the water pump pulley.

5

Remove the crankshaft pulley, operation 14A-01A.

6

Remove the cap of the timing cover, operation 15A-01.

7

Remove the timing belt, pulleys and timing cover, section 15.

8

Remove the front key in the crankshaft.

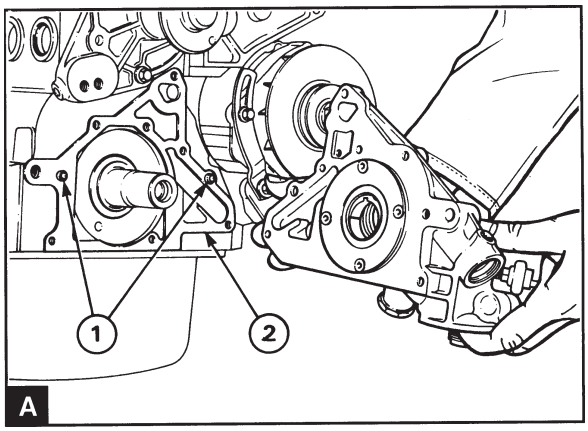
9

Unscrew the mounting screws for the oil pump in stages and evenly and in reverse order to that shown in the illustration D.

10

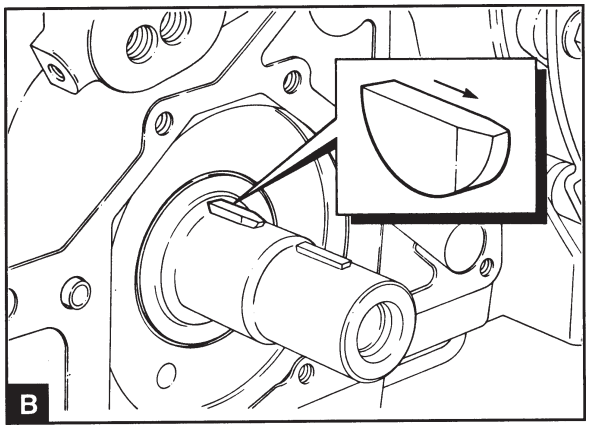
Remove the oil pump (A).

11



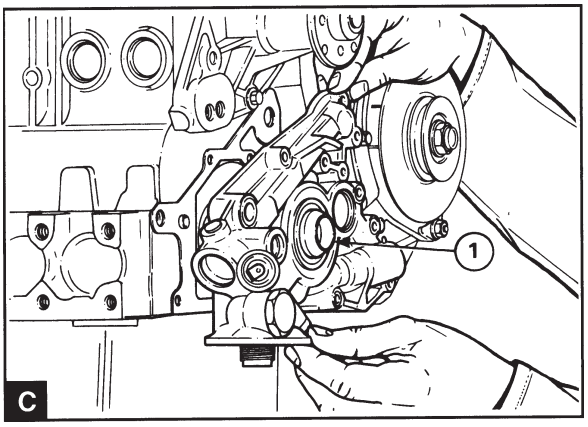
Check that the mating surfaces of the oil pump, cylinder block and main bearing cap are clean. Check that the two guide pins (A1) are in position and install a new gasket (A2).

12



Ensure that the rear key is in position and that the bevelled end of the key is turned forwards (B). If the front key is still in position, remove it from the crankshaft.

13

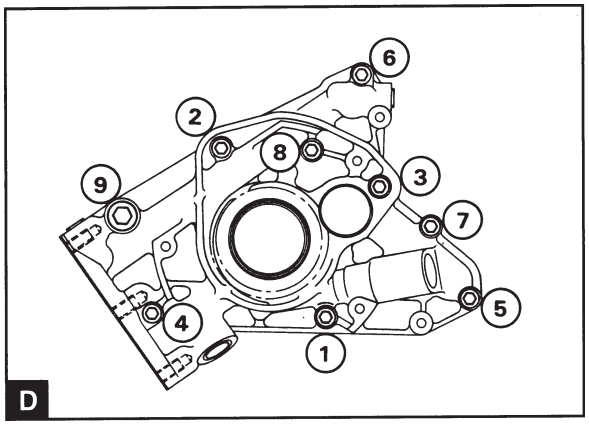


Clean the crankshaft and the protective socket 885032-3 and lightly lubricate with fresh engine oil. Install the protective socket (C1) on the crankshaft.

14

Turn the oil pump rotor until the keygroove in the inner rotor corresponds to the key on the crankshaft. If the stuffing box is installed in the front end of the pump, lubricate it lightly with fresh engine oil. Carefully install the pump in position with the keygroove over the key and with the guide pin inserted in the pump housing. Remove the protective sleeve.

15



Install the pump mounting screws in position with a suitable sealing compound applied to the mounting screw which passes into the main bearing (D1). The sealing compound is already applied to new mounting screws. Tighten the screws in stages and evenly to the correct tightening torques, see Workshop Manual “Technical Data”, in the correct order (D).

16

Install the front stuffing box in the pump if necessary, see operation 14A-02.

17

Install a new front key on the crankshaft.

18

Install the timing cover, operation 15A-08.

19

Remove the pulleys and timing belt, see section 15.

Check the fuel injection pump adjustment, operations 17A-03.

20

Install the cap of the timing cover, operation 15A-01.

21

Install the crankshaft pulley, operation 14A-01A.

22

Install the pulley for the water pump and the drive belt for the generator, operation 22A-03.

23

Check that the adjustment drifts have been removed and install the screw in the adjustment hole on the top of the front of the camshaft cover.

24

Connect the battery.

25

Ensure that the engine cannot be started and turn the starter motor until the oil pressure gauge reacts or the oil pressure warning lamp goes out.

26

Start the engine and check for leaks.

Oil pump, inspection (18A-07)

If the rotors are so damaged that it affects the oil pump capacity, the whole oil pump must be replaced.

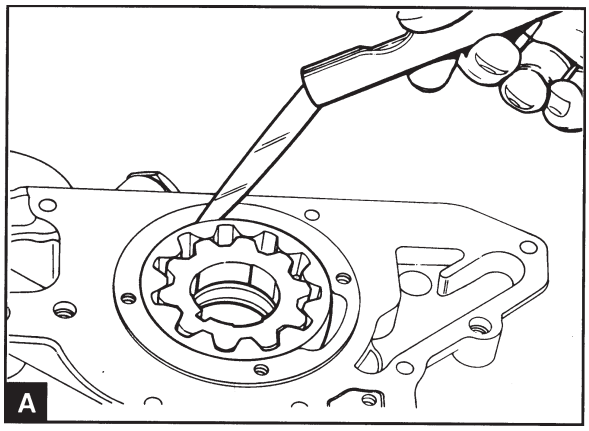
1

Unscrew the screws and remove the oil pump back plate.

2

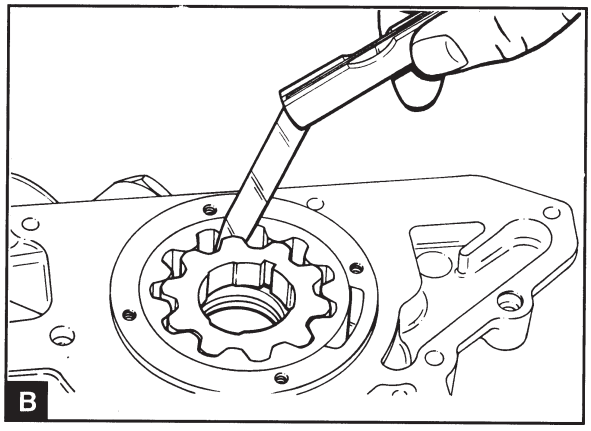
Remove the rotors and check the all the components thoroughly. Check for cracks and other damage.

3



Install the rotors in the pump housing and check the outer rotor play against the housing (A).

4

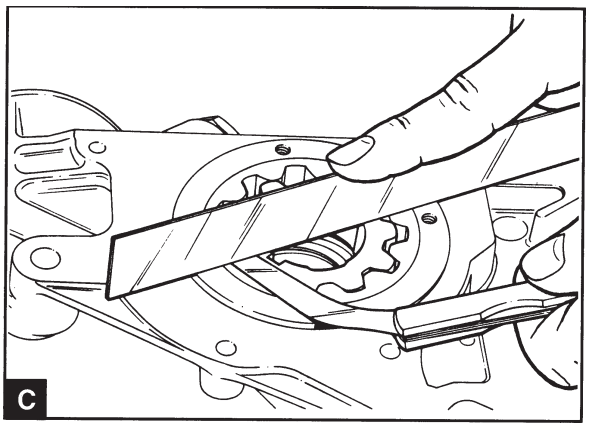


Check the inner rotor clearance against the outer rotor (B).

5

Check the rotor axial clearance using a ruler and a feeler gauge (C). For size and all clearances, see Workshop Manual “Technical Data”.

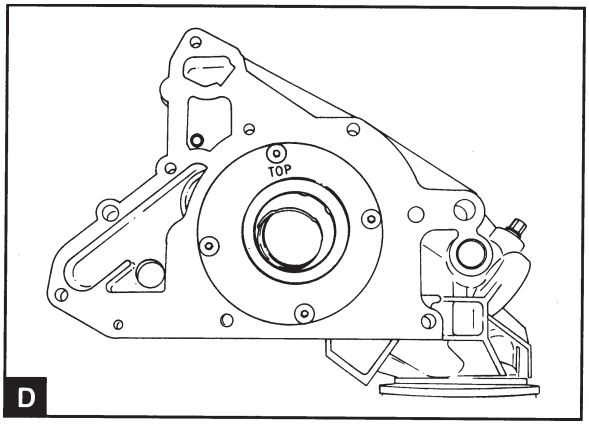
6



If the sealing ring needs changing, remove the rotors and press the sealing ring out of the housing. The pump is easier to install on the engine with the sealing ring uninstalled and the sealing ring can be installed on the installed pump, see operation 14A-02.

If necessary the sealing ring can be installed on the dismantled pump. Ensure that the sealing lip is turned in towards the pump and that the sealing is inserted flat to the pump. Use a suitable adapter and press in the sealing ring in the pump until the sealing ring front surface is 0.5 mm lower than the housing surface.

7

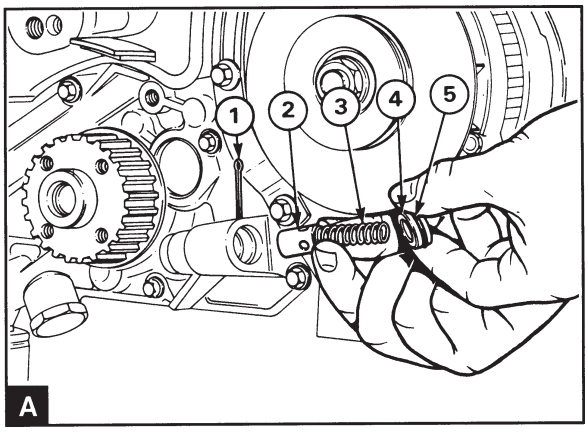


Lightly apply fresh engine oil to the rotors and insert them in the pump. The inner rotor has a lug in one end and this tap must be turned towards the sealing ring housing. Install the back plate with the word “TOP” turned from the pump housing straight edge (D). Install and tighten the screws for the back plate to **4 Nm**.

Relief valve, replacement (18A-08)

The relief valve is installed on the left side of the pump and can be replaced as a unit. The pressure setting cannot be adjusted in any other way than by installing new components.

1



Bend the shafts of the split pin together (A1). Press the end plug (A4) and remove the split pin from the pump housing.

2

Take the weight off the plug and if possible remove the plug and the spring (A3). If the plug will not come loose, tap it carefully inwards to see if the spring tension can force it out of the housing. If the plug still does not come loose, drill a small hole in the center of the plug, use a self tapping screw to remove the plug.

3

Remove the spring and piston (A2). A small magnet can be used to remove the piston.

4

Replace the split pin, the O ring (A5) and the end plug (if a hole has been drilled in it.)

5

Check that all the components are clean and lubricate them with fresh engine oil. Install a new O ring on the end plug.

6

Install the piston in the sleeve with the open end of the piston turned inwards. Install the spring over the lug on the end of the piston. Install the end plug with the sprung end inserted in the cutout in the plug.

7

Press in the end plug and install the split pin through the upper hole in the housing and down through the lower hole. Bend the split pin shafts apart.

Relief valve, inspection (18A-09)

1

Check the spring for wear and other damage and if possible check what pressure is required to compress a spring to its installed length, see Workshop manual “Technical Data”.

2

Check the piston for wear and other damage and check that it travels smoothly in the socket in the housing.

3

Check the housing and the end plug for wear and other damage.

4

Replace worn or damaged seals.

Fuel system

General

All engines are equipped with Bosch fuel injection pump. These pumps have mechanical engine speed regulator.

The injectors are supplied with fuel under high pressure from the fuel injection pump and spray the fuel into the combustion chamber in the form of a finely misted jet. The pressure under which the injector operates can be adjusted by replacing the shims above the spring.

The fuel injection equipment may only be checked and adjusted by personnel who have the necessary training.

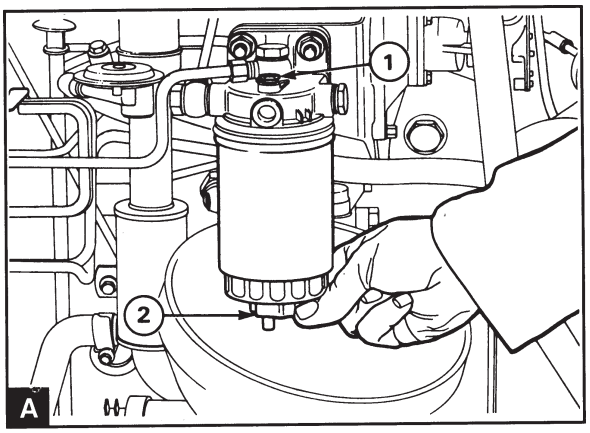
The supply pump is the membrane type and is mechanically driven. It is mounted on the right side of the camshaft cover and is driven by an eccentric cam on the camshaft. The pump is equipped with a lever for hand pumping.

It is important that no contaminants enter the fuel system. Before a connector is slackened off, clean thoroughly around the connector. After a component has been slackened, position suitable protection over all open terminals.

Repair Instructions

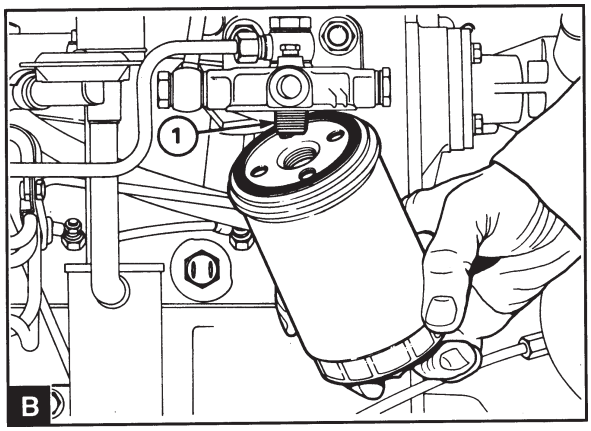
Fuel filter, replacement (19A-01)

1



Carefully clean the outside of the fuel filter unit. Slacken off the bleed screw (A1) located above the filter, two or three turns. Slacken off the drain arrangement (A2) at the bottom of the holder and drain the fuel into a suitable container.

2



Use a strap wrench or similar to remove the filter (B).

3

Ensure that the threaded adapter (B1) is steady in the filter head and that the inside of the head is clean.

4

Lightly lubricate the new holder top gasket with fresh fuel. Install the new filter holder onto the filter head, hand tighten only.

5

Bleed the air from the fuel filter, see operation 19A-10.

NOTE! It is extremely important that only original Volvo Penta filter holders are used. Using the wrong type of holder can damage the fuel injection pump.

Injectors, fault-tracing

A faulty injector can cause engine misfires.

To find the faulty injector, run the engine at high idling speed. Slacken off and tighten the connector nut for the delivery line for each injector. When the connector nut for the faulty injector is slackened off it has little or no effect on the engine speed (RPM).

⚠ **WARNING!** Ensure that fuel is not sprayed onto your skin.

Injectors, replacement (19A-02)

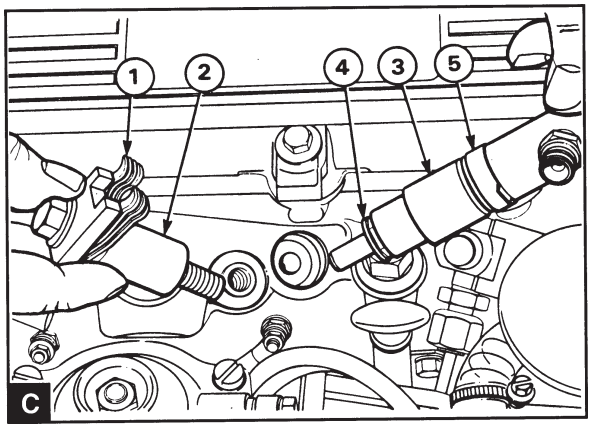
1

Remove the leak fuel line.

2

Remove the connector nuts for the delivery lines from the injectors and from the fuel injection pump. Hold the pump outlet with a wrench to prevent the join from moving when the terminal is slackened off. Do not bend the pipe. Replace the pipe clamps if required.

3



Slacken off the mounting screws for the injector holders. The spacer piece (C2) should either be 31.5mm or 7 mm long, depending on which type of injector is used. If a short spacer is used, lift the spring unit when the mounting screw is removed. This ensures that the mounting screw threads do not go in the hole in the lower spring. Remove the holder (C1) and the spacer washer. Remove the injector (C3) and the seat gasket (A4).

4

Check the holder unit for wear and deformation and replace the unit if required. Replace the injector seat gasket.

5

Check that the injector guide ring (C5) is in position in the cylinder head and install the new injector and seat gasket. Check that the injector is not crooked. Install the holder unit and the spacer with holder arms placed at right angles on the injector's projection. Tighten the holder mounting screws to **43 Nm**.

6

Install the delivery lines and tighten the connector nuts to **18 Nm**. Hold the pump outlet with a wrench to prevent the join from moving when the nut is tightened. Install the pipe clamps if required.

7

Install the leak fuel line.

8

Start the engine and check that there are no air and fuel leaks.

Feed pump, replacement (19A-03)

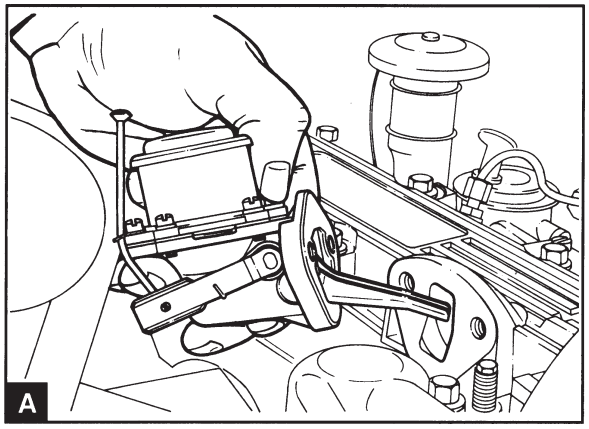
1

Remove the fuel lines from the supply pump.

2

Remove the screw from the adjustment hole on the top of the front end of the camshaft cover. Turn the crankshaft until the adjustment hole in the camshaft front bearing journal corresponds with the hole in the camshaft cover. This ensures that the highest point of the eccentric drive cam is turned away from the pump lever.

3



Unscrew the mounting screws and remove the supply pump (A).

4

Clean the sealing surfaces on the supply pump and camshaft cover and install the pump with a new gasket. Install the mounting screws and tighten in stages and evenly to **22 Nm**.

5

Connect the fuel lines.

6

Slacken off the bleed screw in the fuel filter head. Hand pump with the lever on the supply pump to eliminate any air between the supply ball and the fuel filter. Pump with the lever until air free fuel comes out of the bleed screw. Tighten the bleed screw.

7

Start the engine and check that there are no air and fuel leaks.

Feed pump, reconditioning (19A-04)

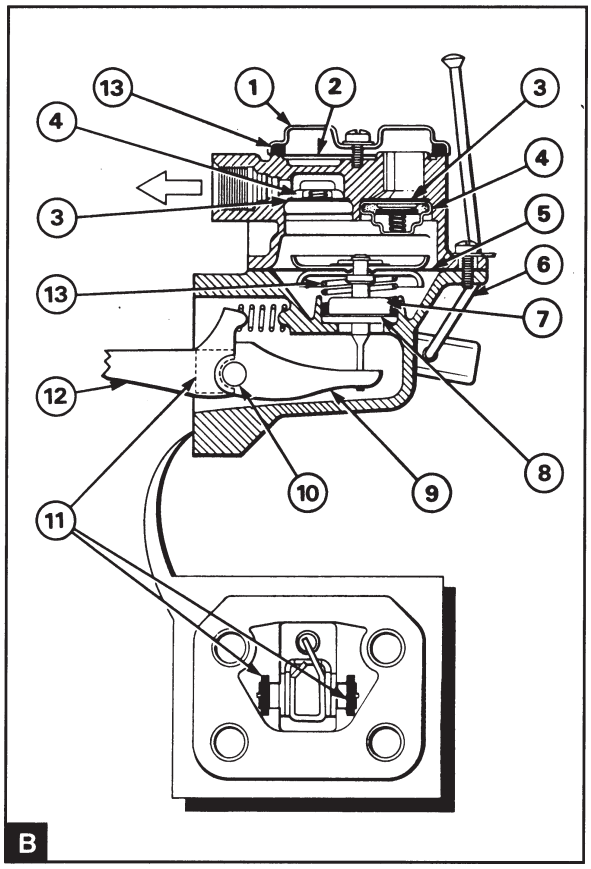
1

Clean the outside of the supply pump.

2

Make a mark straight across the flanges on both the pump halves to ensure correct reinstallation.

3



Remove the cap of the supply pump (B1) and the metal screen (B2). Remove the screws and separate the pump halves.

4

Turn the diaphragm unit (B5) 90° to remove the diaphragm connecting rod from the control arm (B9) and remove the diaphragm unit. Remove the shaft seal (B7), spring seat washer (B8) and the spring (B13) from the connecting rod. The diaphragm and the connecting rod unit are replaced as a unit and service remedies for the diaphragm are not possible.

5

The valves (B4) are jammed in the housing and can be removed with a suitable jimmy tool. Part of the flattened metal must be removed before the valves can be removed.

6

Disconnecting the control arm: secure the rocker (B12) with a vise and hit the pump housing with a soft faced hammer to release the two holders (B11). Take care not to damage the pump housing mating surface. Remove the rocker arm, the journal (B10), the control arm and the return spring. Check the components for wear and other damage.

7

Clean the valve housing thoroughly. Install new seat washers (B3) and slide the new valves (B4) into position. Because the valves are similar, but one valve is installed in the opposite direction in relation to the others, it is possible to install the valves upside down. To ensure that the valves are installed correctly, follow illustration B. When the valves are correctly installed flatten the valve housing edge in six places equally spaced over the perimeter to hold the valves in position.

8

Place the rocker arm (B12), the journal B10 and the connecting rod unit (B9) in the lower section of the supply pump. Install the return spring and check that the spring ends are in the correct position.

9

Install two new holders (19A.04/B11) in the grooves in the housing until the lock the journal. Use a light hammer and a suitable adapter. Flatten the open ends of the groove to hold the holders in position.

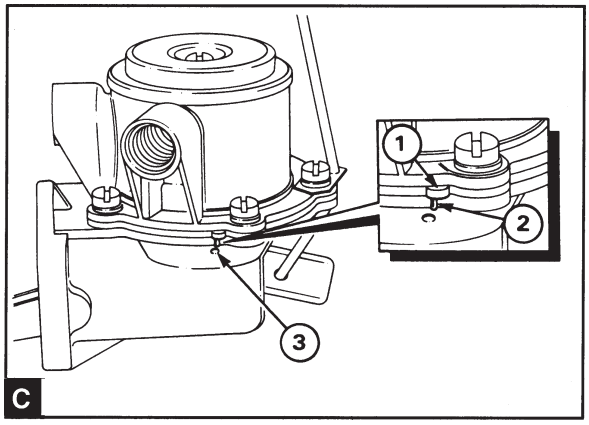
10

Install the diaphragm spring (19A.04/B13) in the correct position under the diaphragm (19A.04/B5.) Install the valve seat washer (19A. 04/B8) and a new shaft seal (19A.04/B7) in position on the connecting rod. Check that the small diameter on the upper side of the seal is against the round section of the connecting rod.

11

Install the diaphragm in position above the bottom pump half with the connecting arm fin upwards towards the slit in the control arm. Ensure that the small bulge in the edge of the diaphragm (19A.04/C1) is at a 90° angle to the similar bulge on the pump housing (19A.04/C2). Press the diaphragm lightly down until the notch in the connecting rod is in the slit in the control arm. Turn the diaphragm 90° to ensure that the bulge on the edge of the diaphragm corresponds with the bulge on the pump housing. This ensures that the connecting rod goes into and remains in the slit in the control arm.

12



Press the rocker arm upwards in the diaphragm until the diaphragm lies at the level of the pump housing flange. Install the upper half of the pump housing in position with the marks on the flanges lined up. Keep pressure on the rocker arm and install the spring washers and screws. Remove the pressure from the rocker arm and tighten the screws evenly. After installation the edge of the membrane should lie along at the level of the edge of the pump housing.

13

Install the metal screen (19A.04/B2) and the cap (19A.04/B1) with the rubber seal (19A.04/B14) correctly installed. Install the screw of the cap and the sealing washer and tighten the screw.

Fuel supply pressure, checking (19A-05)

If there is fuel leakage through the hole in the pump housing (19A.04/C3), it means that the diaphragm is damaged. If there is an oil leakage it means that the seal is damaged.

1

Remove the outlet pipe for the fuel at the supply pump. Install a manometer for 0-70 kPa to the output side of the pump. Slacken off the connection of the gauge and pump the lever by hand to eliminate air in the line. Tighten the connection when air free fuel comes out of the line. Check that there is no leakage at the terminals between the pump and the manometer.

2

Turn the starter motor for 10 seconds and note the highest pressure that the manometer displays. The pump should be repaired or replaced if the displayed pressure is lower than 75% of the minimum static pressure permitted in production, see Workshop Manual “Technical Data”. Check after the engine has stopped, the time it takes for the pressure to drop to half the measured value. If the time is less than 30 seconds the pump should be repaired or replaced.

3

Remove the manometer and connect the outlet line to the supply pump. Slacken off the bleed screw on the fuel filter head and the hand pump until the air free fuel flows out of the bleed screw. Tighten the bleed screw.

Fuel injection pump, replacement (19A-06)

Special tools: 885027, 885029, 885037

1

Disconnect the battery.

2

Position the piston in cylinder 1 at TDC in the compression stroke, operation 17A-01 and install the adjustment drifts 885037.

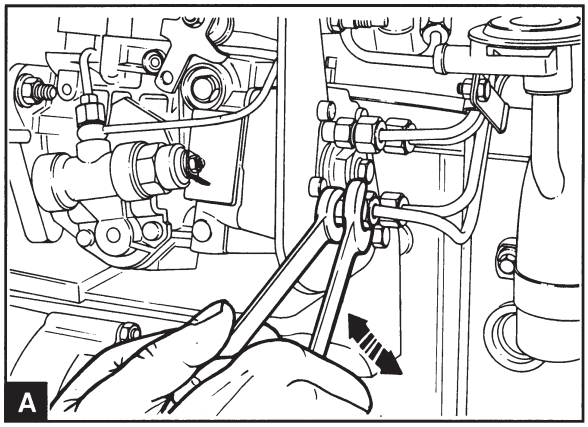
3

Remove the cap for the timing cover, the timing belt and the fuel injection pump pulley, see section 15.

4

Disconnect the fuel injection pump engine speed regulator and, if necessary, the stop control. Detach the cable from the stop solenoid on the pump. Mark the cables in a suitable way to facilitate reinstallation.

5

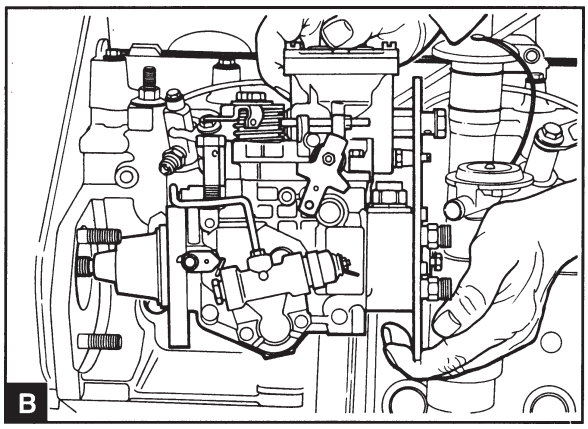


Remove all the necessary pipes from the pump. Use a wrench as a counterhold at the pump outlets side (A) to prevent the joint moving when the nuts for the delivery lines are slackened off.

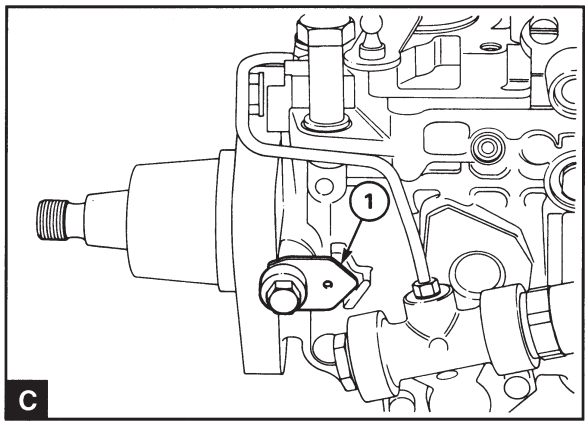
6

Remove the screws holding the support bracket at the rear of the pump against the installation bracket.

7



Remove the locknuts and remove the pump (B) – ensure that the key does not fall out of the drive shaft.



NOTE! If a new or repaired pump is to be installed, the pump shaft should be installed in the correct position in relation to the engine with cylinder 1 at top dead center on the compression stroke. If this is to happen the spacer in the form of an arrow (C1) should be removed from its position under mounting screw, which is located on the pumps front left hand side. Fasten the spacer to the pump loosely using metal wire. The pump can be installed and the timing belt tension adjusted with the pump in this condition, but **neither the pump shaft nor the crankshaft should be turned if the spacer is not in position under the mounting screw.**

8

Check that the adjustment drifts are installed in the camshaft and the flywheel.

9

Check that the key is correctly installed on the pump shaft. Install the fuel injection pump in position with the locknuts sufficiently tightened to hold the pump secure, but not so much that it prevents radial movement in the housing. Install the screws holding the support bracket against the rear end of the pump and finger tighten them.

10

Install the pulley on the shaft with the key in the correct keygroove, see operation 15A-05. Hold the belt so that it does not move and install the pulley nut and washer. Tighten the nut so that the pulley is pressed up on the shaft, do not tighten the nut to the final torque.

11

If the pump shaft is installed in top dead center position (see “Note!” above): Ensure that the tooth with the correct marking turned towards the arrow on the timing cover and install the timing belt, see operation 15A-04. Check the position of the journals in the cut out in the pump mounting flange. Check that the fuel injection pump can be turned clockwise seen from the rear when the belt tension is adjusted. If there is not sufficient room for movement change the position of the belt on the pulley. Adjust the timing belt tension, operation 15A-03. Check that the journals are not in the end of the groove in the pump mounting flange and tighten the locknuts. Unscrew the mounting screw on the side of the pump and install the spacer under the screw.

Tighten the mounting screw to **12 Nm**. Tighten the nut for pump pulley to **60 Nm**. Check the fuel injection pump adjustment, operations 17A-03.

If the pump shaft is not secure: Ensure that the tooth with the correct marking turned towards the arrow on the timing cover and install the adjustment drifts through the smooth holes in the pump pulley. Install the timing belt, see operation 15A-04 and remove the adjustment drifts. Adjust the belt tension, operation 15A-03. Tighten the nut for pump pulley to **60 Nm**. Adjust the pump setting, operation 17A-03 and tighten the pump flanged nuts.

12

Tighten the screws holding the support bracket at the rear of the pump against the installation bracket.

13

Check that the adjustment drifts are removed.

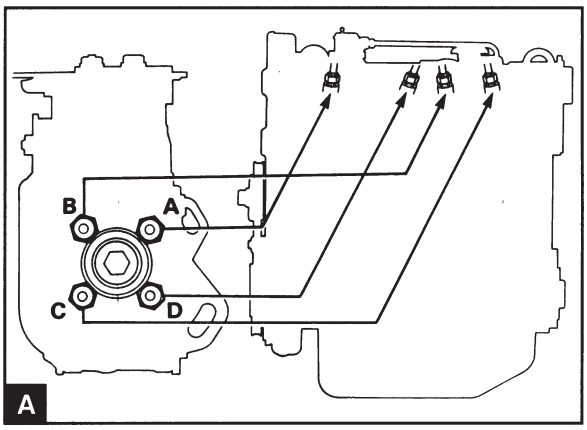
14

Install the cap of the timing cover, operation 15A-01.

15

Install the low pressure lines. Certain pumps have a banjo screw, which is marked “OUT” and this must be installed at the fuel return connection at the tank.

16



Install the delivery pipes to the pump. Use a wrench to prevent the output terminals on the fuel pump (FP) from moving when the delivery lines are installed. The connections to the pump are as displayed in illustration A. Do not tighten the connector to the injectors until the system has been bled.

17

Connect the engine speed regulator to the fuel pump (FP) and connect the stop control if required. Connect the cables for the stop solenoid on the pump. Connect the battery.

18

Bleed the fuel injection system, operation 19A-08.

19

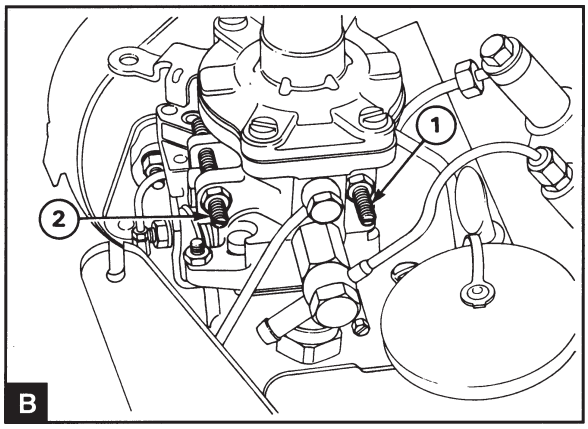
Run the engine and check for any leakage. Check that the idle speed is correct, operation 19A-07.

20

If a new fuel injection pump has been installed, check that maximum idling speed, operation 19A-07.

Idling speed, adjustment (19A-07)

1



Run the engine to operating temperature and check the idling speed. If required adjustment can be carried out using the inner adjustment screw (B1). Slacken off the locknut and turn the screw clockwise to increase and counter-clockwise to decrease the engine speed (RPM). Tighten the locknut when the engine speed (RPM) is correct.

2

Check the maximum idling speed with the engine at operating temperature. The maximum idling speed is taken from the last section of the fuel injection pump setting code. The setting code can be found on the type plate on the side of the fuel injection pump. A typical setting code is 2643H000CE/1/3200. In this example the maximum idle speed is 3200 rpm. If necessary this speed can be adjusted with the outer adjuster screw (B2). Slacken off the locknut and turn the screw counter-clockwise to increase and clockwise to decrease the engine speed (RPM). When the engine speed (RPM) is correct, tighten the locknut and seal the screw. The person who installs the pump must check that the adjustment screw is sealed in a suitable manner so that the setting cannot be changed later.

On new pumps the adjustment screw is set and sealed by the manufacturer. The setting may not be changed, if it is changed the engine's guarantee can be affected.

Fuel injection system, bleeding (19A-08)

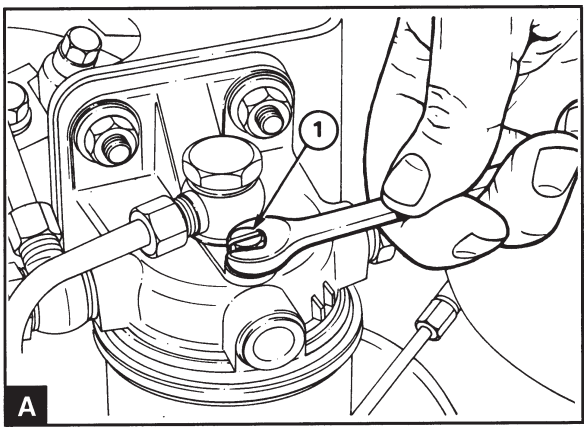
If air has entered the fuel injection system it must be removed before the engine is started.

Air can enter the fuel injection system if:

- The fuel tank is run dry during normal operation.
- The low pressure fuel lines are loosened.
- Any section of the low pressure system leaks while in operation.

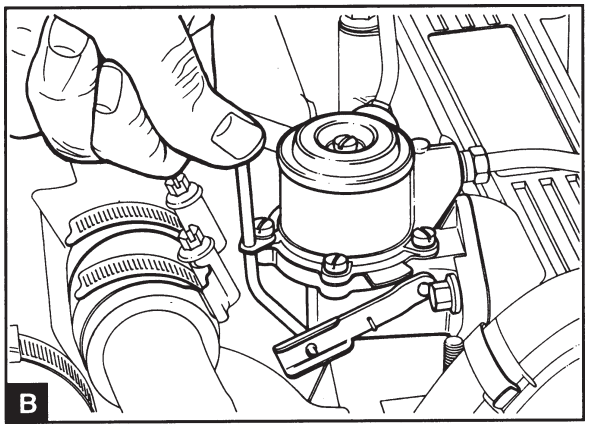
Carry out the following to bleed the system:

1



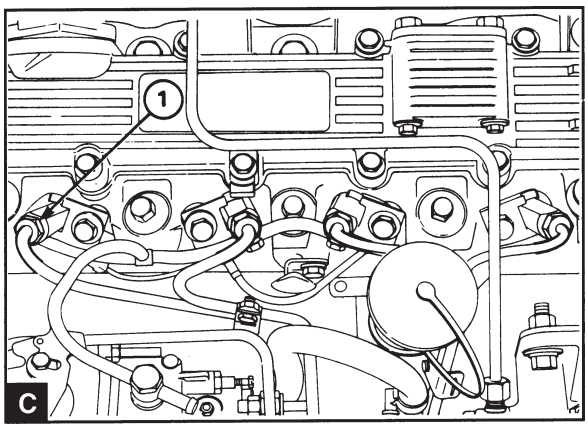
Slacken off the bleed screw (A1) located above the fuel filter, two or three turns.

2



Pump the supply pump (B) with the lever until air free fuel comes out of the bleed screw. Tighten the bleed screw on the filter. If the supply pump drive cam is in position for maximum cam lift it is not possible to pump by hand. In this situation the crankshaft must be turned one revolution.

3



Slacken off the connector nuts for the delivery lines at the injectors (C). Depending on the type of injectors the connector nuts can be located above or beside the injectors.

4

Operate the starter motor until air free fuel is forced out of the delivery line connectors. If a separate switch is used for the starter motor, ensure that the switch for the engine electrical system is in the “ON” position at this moment.

5

Tighten the delivery lines connections.

6

The engine is now ready to be started.

If the engine runs as it should for a short period of time and then stops or runs unevenly, check if there is air in the fuel system. If there is air in the fuel system, there is probably a leak in the low-pressure side of the system.

Cooling system

General

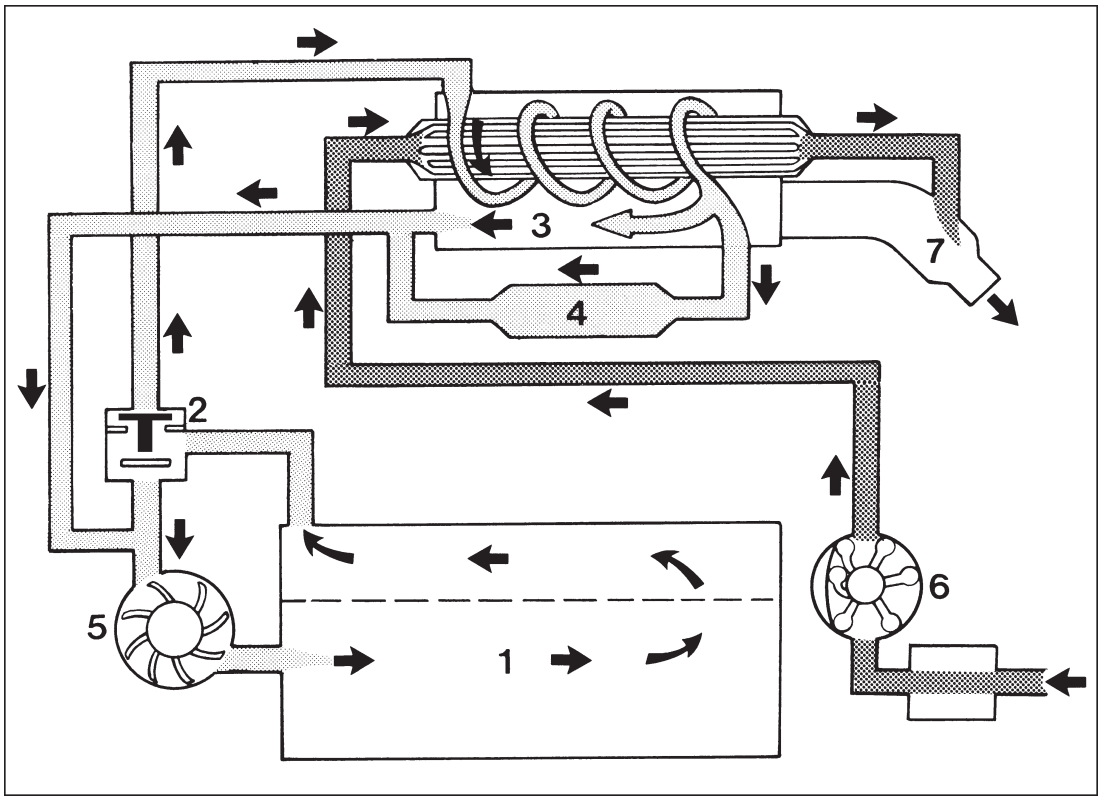
The engine has two cooling circuits. The closed circuit is filled with coolant which is used for cooling the cylinder block and cylinder head. This coolant is also used to cool the exhaust manifold. The sea water circuit uses sea water, which is drawn directly from the outside of the boat, to cool the coolant in the closed circuit and to cool the engine oil (only A-engines).

The heat exchanger, exhaust manifold and coolant tank for the coolant in the closed circuit are combined in one unit. This is installed on the right of the engine. On B-engines the oil cooler is also built into the heat exchanger (MD22L-B has no oil cooler).

The coolant in the closed circuit passes from the coolant tank to the intake side of the pump. From the pump the coolant passes through the cylinder block and cylinder head to the thermostat housing. If the coolant is cold, it passes through the by-pass connection directly to the intake side of the pump.

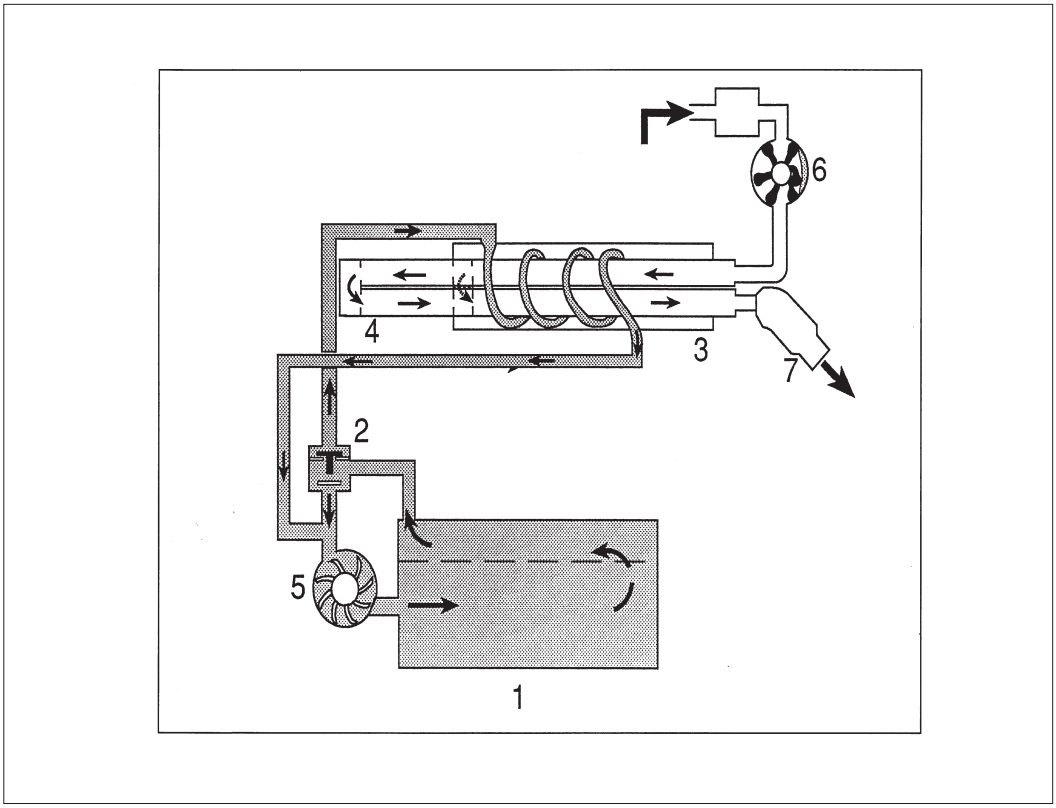
When the coolant temperature increases, the thermostat valve opens, the by-pass connection closes and the coolant passes through the heat exchanger. In the heat exchanger the coolant passes along the outside of the pipes and is cooled by the sea water in the pipes. The coolant then leaves the heat exchanger and enters the tank unit, where it cools the exhaust manifold which forms an integral part of the unit. The coolant then moves to the intake side of the water pump. Some of the coolant passes through an outlet in the rear of the unit to an oil cooler and then to the intake side of the pump (only A-engines).

The sea water is circulated by the sea water pump which is directly driven from the rear end of the camshaft on A-engines and belt-driven from the rear end of the camshaft on B-engines. From the pump the sea water passes through the heat exchanger pipes and is then expelled through the outlet.



Outline diagram MD22A, MD22L-A, TMD22A

1. Cylinder block
2. Thermostat
3. The combined coolant tank, heat exchanger and exhaust manifold
4. Engine oil cooler
5. Freshwater pump
6. Sea water pump
7. Outlet bend



MD22L-B, MD22P-B, TMD22-B, TMD22P-C, TAMD22P-B

1. Cylinder block
2. Thermostat
3. The combined coolant tank, heat exchanger and exhaust manifold
4. Engine oil cooler (MD22P, TMD22, TAMD22)
5. Freshwater pump
6. Sea water pump
7. Outlet bend
8. Charge air cooler (only TAMD22)

Repair Instructions

Coolant, draining (20A-01)

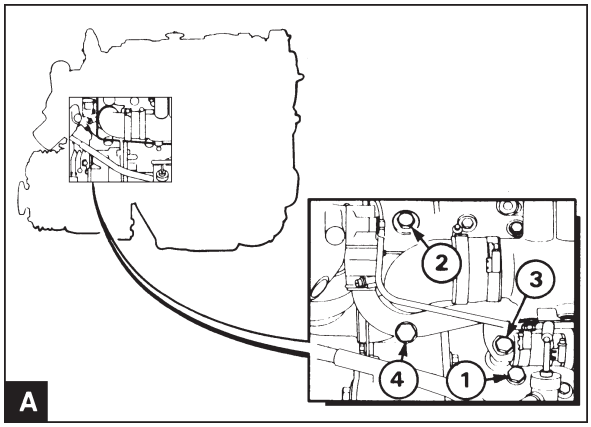
Applies to MD22A, MD22L-A, TMD22A

⚠ **WARNING!** Do not drain coolant when the engine is still warm and the system is pressurized, as dangerous hot coolant may spray out.

1

Remove the coolant tank filler cap.

2



Drain the coolant by removing the plug (A1) on the starboard side of the engine block. Ensure that the drain hole is not blocked by contaminants.

3

Drain the heat exchanger / manifold / coolant tank assembly by removing the drain plug (A2). Ensure that the drain hole is not blocked by contaminants.

4

Drain the oil cooler by opening the drain plug (A3). Ensure that the drain hole is not blocked by contaminants.

5

Install the drain plugs and the filler cap.

6

Place a suitable label on the engine control panel stating that the coolant has been drained.

Coolant, draining (20A-01)

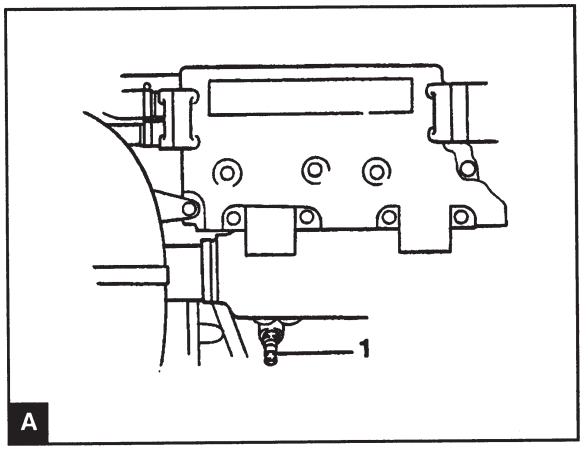
Applies to MD22L-B, MD22P-B, TMD22-B, TMD22P-C, TAMD22P-B

⚠ **WARNING!** Do not drain coolant when the engine is still warm and the system is pressurized, as dangerous hot coolant may spray out.

1

Remove the coolant tank filler cap.

2



Drain the coolant using the cock (A1) on the starboard side of the engine block.

3

Install the drain plug and the filler cap.

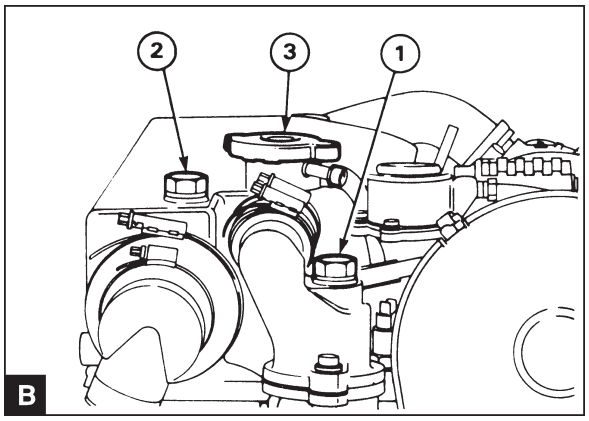
4

Place a suitable label on the engine control panel stating that the coolant has been drained.

Coolant, filling (20A-2)

Applies to MD22A, MD22L-A, TMD22A

1



Remove the bleed plug from the hot water connection (B1) or the plug (B2) on the heat exchanger.

2

Remove the filler cap (B3) from the coolant tank and fill the tank with coolant to the level of the filler pipe.

3

Install the ventilation plug and the filler cap.

4

Start the engine. Stop it when it has reached normal operating temperature and let it cool.

5

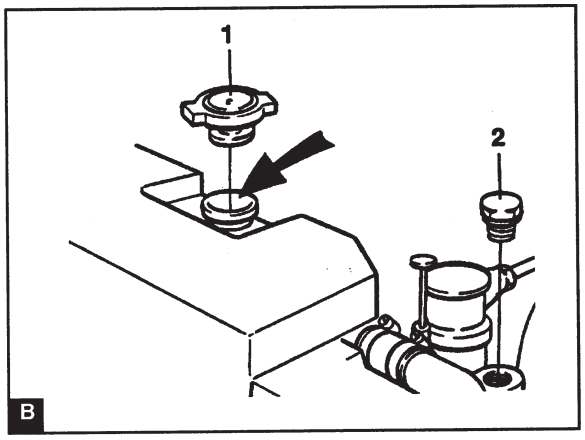
Remove the filler cap from the coolant tank and fill with coolant to the level of the filler pipe. Install the filler cap.

NOTE! If the circuit is topped up with coolant, it must have the same composition as the coolant already being used in the system.

Coolant, filling (20A-2)

Applies to MD22L-B, MD22P-B, TMD22-B, TMD22P-C, TAMD22P-B

1



Remove the bleed plug from the outlet connection for the coolant (B2).

2

Remove the filler cap (B1) from the coolant tank and fill the tank with coolant to the level of the filler pipe.

3

Install the ventilation plug and the filler cap.

4

Start the engine. Stop it when it has reached normal operating temperature and let it cool.

5

Remove the filler cap from the coolant tank and fill with coolant to the level of the filler pipe. Install the filler cap.

NOTE! If the circuit is topped up with coolant, it must have the same composition as the coolant already being used in the system.

Sea water circuit, draining (20A-03)

Applies to MD22A, MD22L-A, TMD22A

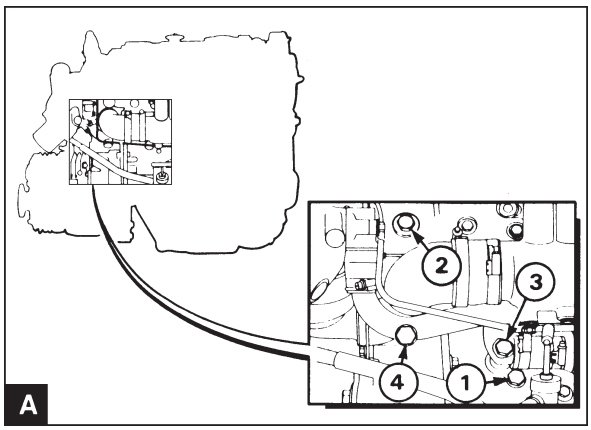
1

Check that the seacock is closed.

2

Disconnect both hoses from the sea water pump.

3



Drain the water from the heat exchanger through the cock (A4). Ensure that the drain hole is not blocked by contaminants.

4

Turn over the engine to check that the sea water pump is empty.

5

Connect the hoses and close the cock.

Sea water circuit, draining (20A-03)

Applies to MD22L-B, MD22P-B, TMD22-B, TMD22P-C, TAMD22P-B

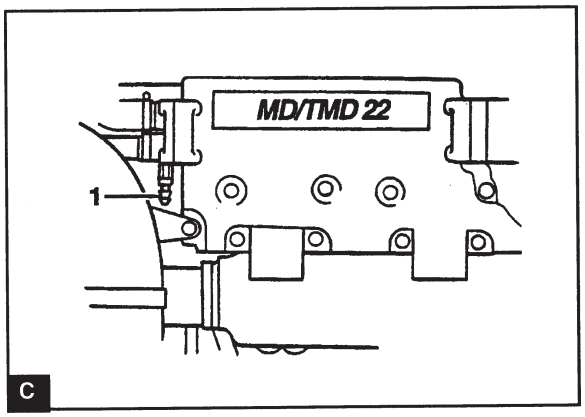
1

Check that the seacock is closed.

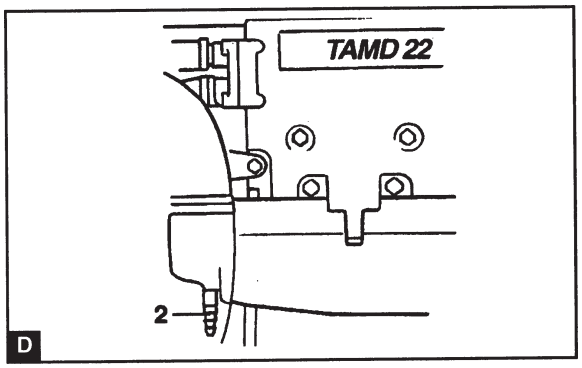
2

Disconnect both hoses from the sea water pump.

3



Drain the water from the heat exchanger (MD, TMD) through the cock (C1).



On the TAMD22 the water is drained through the cock (D2) on the charge air cooler (CAC).

4

Turn over the engine to check that the sea water pump is empty.

5

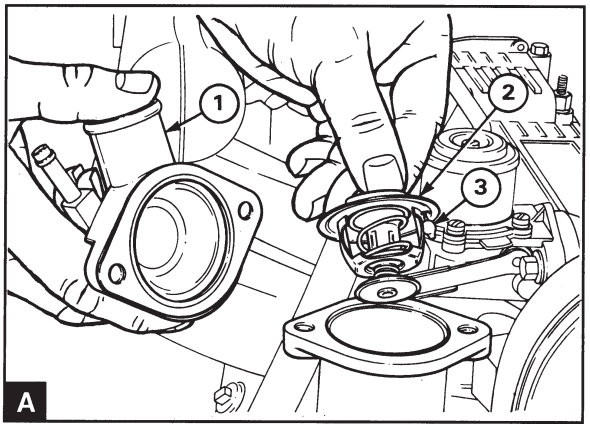
Connect the hoses and close the cock.

Thermostat, replacement (20A-04)

1

Drain the cooing system so that the coolant level is below the position of the thermostat and disconnect the upper hose from the coolant outlet connection.

2



Remove the mounting screws and remove the coolant outlet connection (A1).

3

Remove the thermostat (A2).

4

Check that the sealing surfaces of the housing and the outlet are clean and the tilt pin (A3) in the thermostat can move freely.

5

Install the new thermostat in position in the housing.

6

Install the coolant outlet connection for the with a new gasket and tighten the mounting screws.

7

Connect the upper hose and fill the coolant system with the correct coolant, see the relevant manual.

Thermostat, checking

1

Suspend the thermostat in a suitable container filled with water.

2

Warm the water slowly. Use a thermometer to measure at what water temperature the thermostat starts to open and at what temperature it is fully open. For the correct temperatures see Workshop Manual “Technical data”.

3

If the thermostat does not operate correctly, it must be replaced. Do not try to change the setting.

.

Circulation pump, replacement (20A-05)

1

Disconnect the battery.

2

Drain the coolant circuit, operation 20A-01.

3

Disconnect the suction pipe at the circulation pump and, if necessary, the by-pass connection.

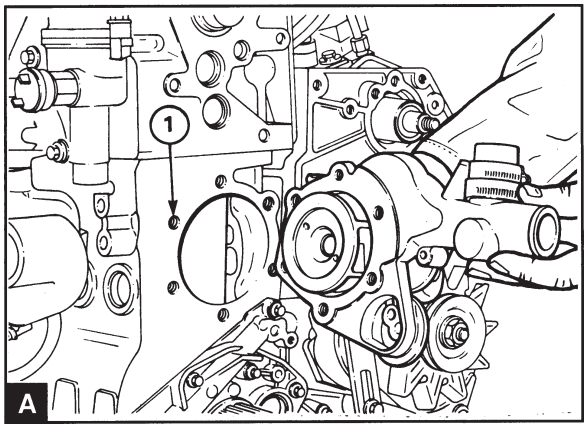
4

Position the piston in cylinder 1 at TDC in the compression stroke, operation 17A-01 and install the adjustment drifts.

5

Remove the cap of the timing cover, operation 15A-01 and the timing belt, operation 15A-4.

6



Remove the timing cover, operation 15A-08. Remove the pump mounting screws and remove the pump (A).

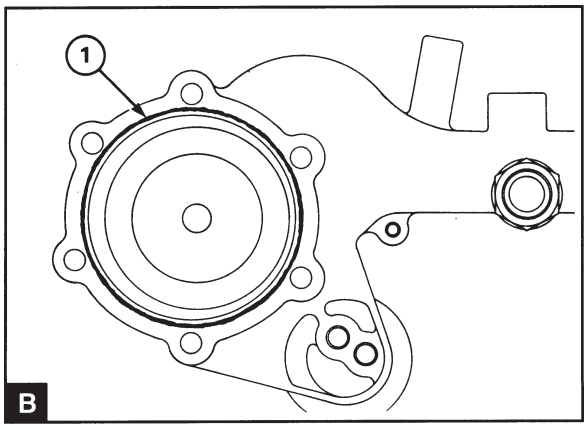
7

Check the pump for wear and damage. If there is any fault, the pump must be replaced as one unit.

8

Check that the mating surfaces of the circulation pump and cylinder block are clean.

9



Apply a 1.0-1.5 mm continuous line of sealant on the pump mating surfaces, on the impeller side of the mounting holes (B1). If the old mounting screws are to be used, clean the threads of the screw which is to be installed at the “10 o’clock” position (A1) and apply sealant to the thread. Place the pump in position and tighten the mounting screws immediately after applying the sealant. Tighten the screws evenly in stages using the correct torque, see section 11B.

10

Install the timing belt, operation 15A-04 and adjust the belt tension, operation 15A-03. Check the setting of the injection pump, operation 17A-03.

11

Check that the adjustment drifts have been removed and install the screw in the adjustment hole on the top of the camshaft cover.

12

Connect the hose to the intake side of the pump and, if necessary, connect the by-pass connection. Fill the cooling system with the correct coolant, see the relevant manual.

Fill the coolant circuit, operation 20A-02.

13

Connect the battery. Run the engine and check for leakage.

Sea water pump, replacement (20A-06)

Applies to MD22A, MD22L-A, TMD22A

NOTE! If the installation plate and adapter plate for the sea water pump are removed, they must be aligned (using alignment tool 885038) before the pump is installed, see operation 20A-08.

1

Drain the sea water circuit, operation 20A-03.

2

Detach the hose clamp at the pump.

3

Remove the four mounting screws which hold the pump against the adapter plate and remove the pump.

4

Clean the mating surfaces on the pump housing and adapter plate.

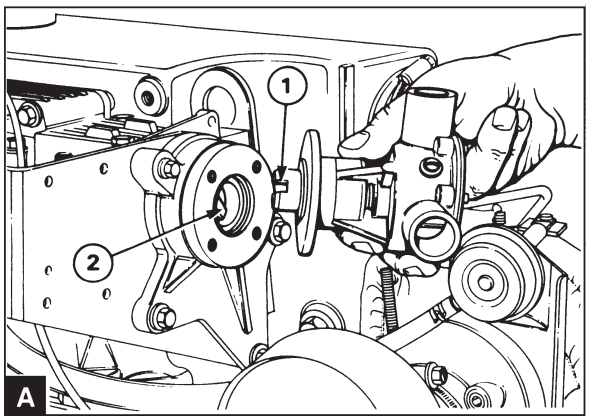
5

Clean the pump drive components and check them for wear. Replace worn components if necessary. If the flange has been removed from the camshaft, tighten the flange screws to **9 Nm**.

6

Apply grease with a high melting point (eg Shell Alvania R2) on the drive components and fill the inside of the drive housing.

7



Align the cut out in the pump shaft (A1) with the flange driving pin (A2). Install the pump on the engine with a new gasket between the pump and the adapter plate. Install the mounting screws and tighten to **9 Nm**.

8

Connect the hose connectors to the pump.

9

Open the seacock if necessary.

Sea water pump, replacement (20A-06)

Applies to MD22L-B, MD22P-B, TMD22-B, TMD22P-C, TAMD22P-B

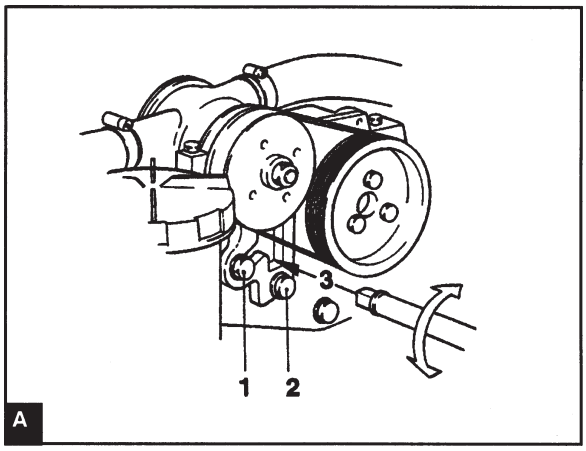
1

Drain the sea water circuit, operation 20A-03.

2

Detach the hose clamp at the pump.

3



Detach the two mounting screws (A1) and (A2) and remove the belt. Remove the pump.

4

Clean the mating surfaces on the pump housing.

5

Clean the pump drive components and check them for wear.

Replace worn components if necessary. If the pulley has been removed from the pump, tighten the nuts to **41 Nm**.

6

Apply grease with a high melting point (eg Shell Alvania R2) on the drive components and fill the inside of the drive housing.

7

Install the pump on the engine with two screws (A1) and (A2) and install the belt. At the correct tension it should be possible to press in the belt approximately 5 mm between the pulleys. A torque wrench is required for making adjustments. Place the square plug of the torque wrench in the hole (A3). Set the torque wrench to **60 Nm** and tighten the screws (A1) and (A2).

8

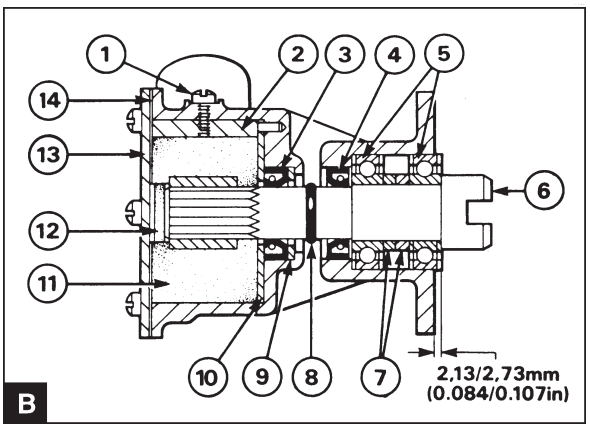
Connect the hose connectors to the pump.

9

Open the seacock if necessary.

Sea water pump, reconditioning (20A-07)

Applies to MD22A, MD22L-A, TMD22A



1

Remove the pump, operation 20A-06.

2

Remove the end cover (B13) and the gasket (B14).

3

Remove the rubber plug (B12) from the end of the impeller (B11).

4

Carefully remove the impeller from the shaft (B6) using a suitable lever or long nose pliers.

5

Press out the shaft and the bearing unit from the drive side of the housing using a suitable drift. If the bearing (B5) and spacer (B7) do not come out with the shaft, these can be pressed out later when the seal (B3) has been removed. Do not lose the O-ring (B8) when the shaft is removed.

6

Slacken off the cam plate screw (B1) two or three turns and tap gently on the screw head to detach the cam plate (B2) from the housing. Remove the screw and the cam plate.

7

Remove the wear ring (B10), the seal (B3) and the spacer (B9) from the impeller housing.

8

Remove the seal (B4) from the bearing housing.

9

Check the components for wear or other damage and replace as necessary. Replace the seals and gaskets.

10

Check that all the components are clean.

11

Press one of the bearings (B5) on to the shaft (B6), install the spacer (B7) and press on the other bearing. Use a suitable drift which presses on the inner ring of the bearing.
The bearings are permanently lubricated.

12

Press stuffing box (B4) into position in the bearing housing with the lip against the side of the bearing. Lubricate the sealing lip a little.

13

Support the pump by the end of the cover and press the shaft and bearing unit into the bearing housing. If the shaft and bearing unit is pressed in correctly, the outer bearing should protrude 2.13-2.73 mm from the mating surface (see illustration B).

14

Slide the O-ring (B8) up on the shaft until it is located in the middle of the space between the bearing housing and the impeller housing.

15

Install the seal spacer (B9) in the impeller housing. Lubricate the seal lip a little and press the seal (B3) into position in the impeller housing with the lip facing the impeller.

16

Install the wear ring (B10) in the impeller housing with the locating pin in the ring cut out. If the ring is worn on one side, turn the ring so that the side without wear faces the impeller.

17

Apply a suitable sealant on the top and side of the cam plate (B2). Also apply sealant on the thread of the cam plate screw (B1). Install the cam plate and tighten the screw.

18

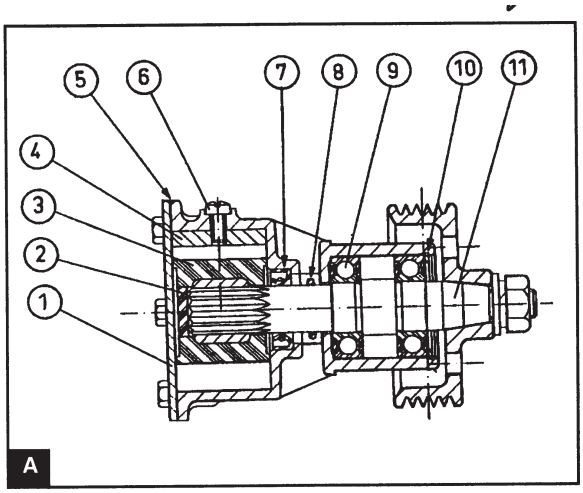
Grease the blades of the impeller (B11) and install it on the shaft using a clockwise movement. If the blades are slightly worn, the impeller may be installed with its original front side facing to the rear. Install the rubber plug (B12) in the end of the impeller.

19

Use a new gasket (B14). Install the gasket, end cover (B13) and screws. Tighten the screws evenly in stages.

Sea water pump, reconditioning (20A-07)

Applies to MD22L-B, MD22P-B, TMD22-B, TMD22P-C, TAMD22P-B



1

Remove the pump, operation 20A-06.

2

Remove the end cover (A1) and the gasket (A5).

3

Remove the rubber plug (A2) from the end of the impeller (A3).

4

Carefully remove the impeller from the shaft (A11) using a suitable lever or long nose pliers.

5

Remove the snap ring (A10) and press out the shaft and the bearing unit from the drive side of the housing using a suitable adapter.

6

Slacken off the cam plate screw (A6) two or three turns and tap gently on the screw head to detach the cam plate (A4) from the housing. Remove the screw and the cam plate.

7

Remove the stuffing box (A7) from the housing.

8

Check the components for wear or other damage and replace as necessary.

9

Check that all the components are clean.

10

Press the bearing (A9) on the shaft (A11). The bearings are permanently lubricated.

11

Press the stuffing box (A7) into position in the bearing housing. Lubricate the sealing lip a little.

12

Support the pump by the end of the cover and press the shaft and bearing unit into the bearing housing. Install the snap ring (A10).

13

Slide the O-ring (A8) up on the shaft until it is located in the middle of the space between the bearing housing and the impeller housing.

14

Apply a suitable sealant on the top and side of the cam plate (A4). Also apply sealant on the thread of the cam plate screw (A6). Install the cam plate and tighten the screw.

15

Grease the blades of the impeller (A3) and install it on the shaft using a clockwise movement. If the blades are slightly worn, the impeller may be installed with its original front side facing to the rear. Install the rubber plug (A2) in the end of the impeller.

16

Use a new gasket (A5). Install the gasket, end cover (A1) and screws. Tighten the screws evenly in stages.

Installation and adapter plate for sea water pump, replacement (20A-08)

Special tools: 885038

Applies to MD22A, MD22L-A, TMD22A

1

Remove the sea water pump, operation 20A-06 and remove the adapter plate.

2

Disconnect the fuel pipe from the fuel filter and, if necessary, remove the filter.

3

Remove the four mounting screws and remove the installation and adapter plate.

4

Check the components for cracks or other damage.

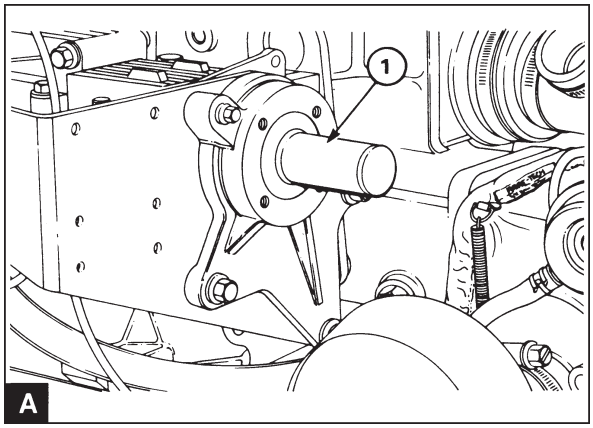
5

Remove the screws, then remove the flange from the camshaft.

6

Position the installation and adapter plate in place and install the mounting screws without tightening them.

7



Position alignment tool 885038 (A1) with the narrow diameter in the camshaft and the wider diameter in the adapter plate. Tighten the mounting screws evenly in stages and remove the alignment tool.

8

Install the sea water pump flange and tighten the screws to **9 mm**.

9

Install the seawater pump, operation 20A-06.

Oil cooler, replacement (20A-09)

Applies to MD22A, MD22L-A, TMD22A

The pipes in the oil cooler do not usually need cleaning because the coolant which passes through them comes from the closed freshwater circuit.

1

Drain the coolant circuit, operation 20A-01.

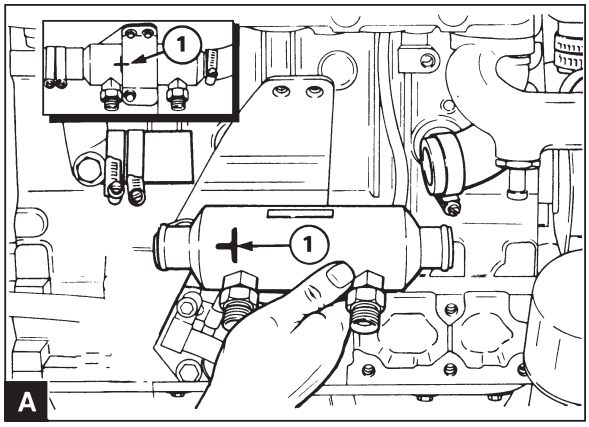
2

Disconnect hose connectors to oil cooler.

3

Disconnect hose connectors to oil cooler.

4



Make a mark with a felt-tip pen on the oil cooler housing and on the clamp (A1) in order to be able to reinstall the oil cooler in the same position.

5

If the oil cooler must be removed: Remove the three mounting screws from the clamp. Then remove the clamp and the oil cooler (A) from the suspension bracket.

6

Check the components for signs of damage and replace if necessary.

7

If the oil cooler and suspension bracket have been removed: Hold the unit in position and install the two front mounting screws. Install the rear mounting screw through the bracket to the main oil pump and the spacer sleeve into the cylinder block. Ensure that the oil cooler housing is in the correct position. Tighten the front mounting screws to **22 Nm** and the rear screw to **43 Nm**.

If only the oil cooler has been removed: Place the oil cooler in the correct position, install the clamp and tighten the three mounting screws to **22 Nm**.

8

Connect the coolant hoses and the engine oil pipe.

9

Fill the coolant circuit, operation 20A-02.

10

Run the engine and check for leakage.

Oil cooler, replacement (20A-09)

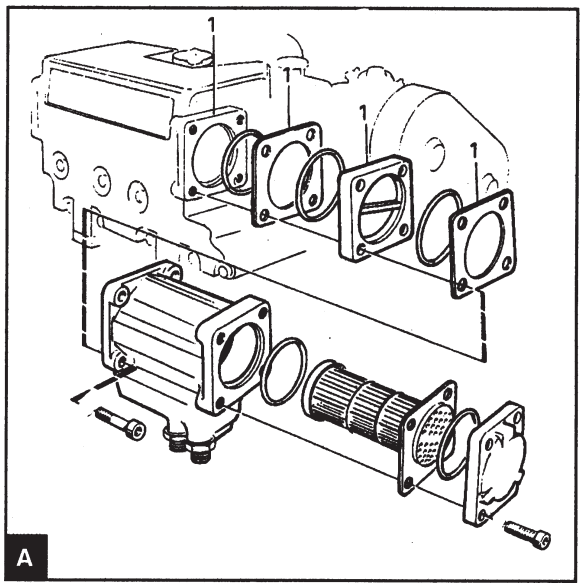
Applies to MD22P-B, TMD22-B, TMD22P-C, TAMD22P-B

The oil cooler may need cleaning because the coolant which passes through it comes from the sea water circuit.

1

Remove the oil pipes / hose from the cooler.

2



Make a mark on the flanges (A1) and the coolant tank, so that the flanges can be reinstalled in the same position.

3

Remove the four mounting screws and remove the oil cooler.

4

Check the components for signs of damage and replace if necessary.

5

Reinstall the components in reverse order and connect the oil lines.

6

Run the engine and check that there is no leakage of coolant or oil.

Heat exchanger / manifold / coolant tank, replacement (20A-10)

Applies to MD22A, MD22L-A, TMD22A

1

Drain the coolant circuit, operation 20A-01 and the sea water circuit, operation 20A-03.

2

Detach the support clamp which holds the output pipe from the heat exchanger to the bottom of the intake manifold.

3

Disconnect the sea water intake and outlet pipes on the heat exchanger.

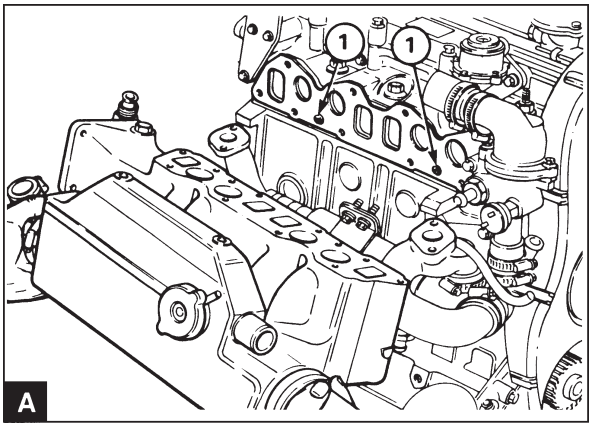
4

Disconnect the flange screws from the coolant pipes at the bottom of the heat exchanger / manifold unit.

5

Remove the support bracket which is installed between the rear end of the bracket and the adapter housing for the reverse gear.

6



Unscrew the screws which secure the unit to the cylinder head evenly in stages in reverse order to the order shown in the illustration (B). Remove the unit (A).

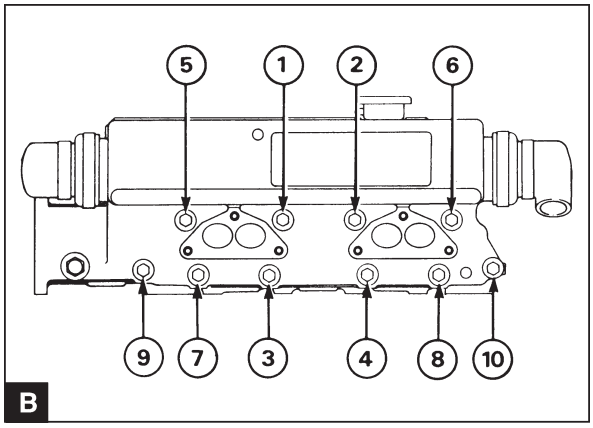
7

Remove the gaskets and clean the mating surfaces on the unit, the cylinder head and the coolant pipes. Check the components for signs of damage and replace if necessary. If the heat exchanger insert needs replacing, see operation 20A-11.

8

Place a new manifold gasket in position over the guide pins in the cylinder head (A1). You do not need to use any sealing compound. Check that the gasket is correctly installed.

9



Place the unit in position on the cylinder head and install the mounting screws. Tighten the screws evenly in stages to **22 Nm** in the order illustrated (B).

10

Install the support bracket between the rear end of the unit and the flywheel cover.

11

Install the coolant pipes in the bottom of the unit with new gaskets.

12

Connect the sea water intake and outlet pipes to the heat exchanger. The output pipe must be pushed in so that the end of the pipe is in the center of rubber end of the heat exchanger.

13

Install the intake manifold together with new gaskets and tighten the mounting screws to **22 Nm**.

14

Install the support clamp which holds the outlet pipe from the heat exchanger.

15

Fill the coolant circuit, operation 20A-02 and open the seacock.

16

Start the engine and check for leaks.

Heat exchanger / manifold / coolant tank, replacement (20A-10)

Applies to MD22L-B, MD22P-B, TMD22-B, TMD22P-C, TAMD22P-B

1

Drain the coolant circuit, operation 20A-01 and the sea water circuit, operation 20A-03.

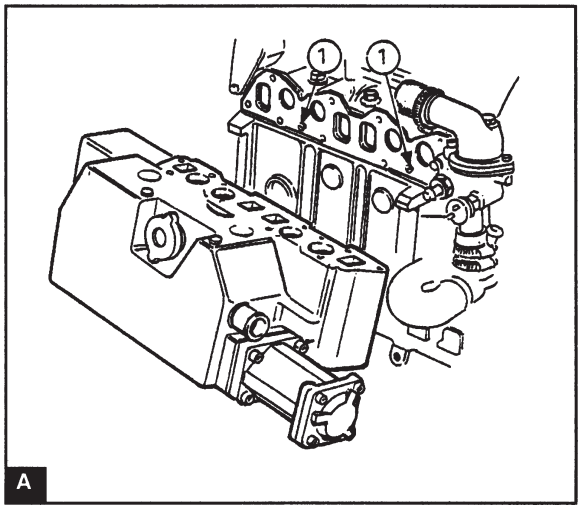
2

Remove the pipe to the oil cooler and all the connecting hoses.

3

Remove the support bracket which is installed between the rear end of the bracket and the adapter housing for the reverse gear.

4



Unscrew the screws which secure the unit to the cylinder head evenly in stages in reverse order to the order shown in the illustration (B). Remove the unit (A).

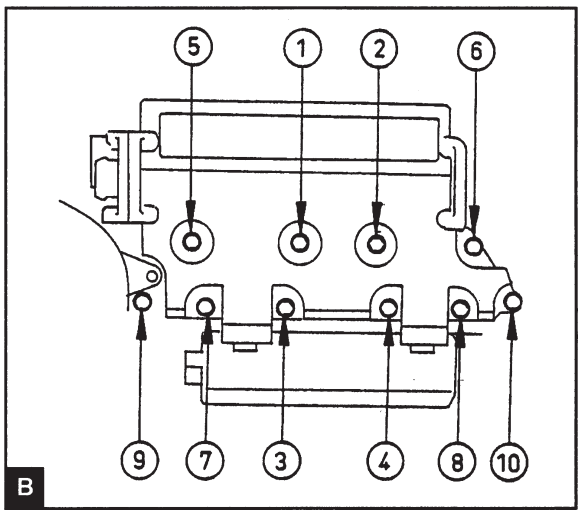
5

Remove the gaskets and clean the mating surfaces on the unit and the cylinder head. Check the components for signs of damage and replace if necessary. If the insert needs replacing, see operation 20A-11.

6

Place a new manifold gasket in position over the guide pins in the cylinder head (A1). You do not need to use any sealing compound. Check that the gasket is correctly installed.

7



Place the unit in position on the cylinder head and install the mounting screws. Tighten the screws evenly in stages to **22 Nm** in the order illustrated in B.

8

Install the support bracket between the rear end of the unit and the flywheel cover.

9

Install the coolant hoses and pipes to the oil cooler on the unit.

10

Fill the coolant circuit, operation 20A-02.

11

Start the engine and check for leaks.

Heat exchanger, reconditioning (20A-11)

Applies to MD22A, MD22L-A, TMD22A

The heat exchanger insert can be removed (with the heat exchanger installed on the engine) if the space behind or in front of the heat exchanger is at least 555 mm.

1

Drain the coolant circuit, operation 20A-01 and the sea water circuit, operation 20A-03.

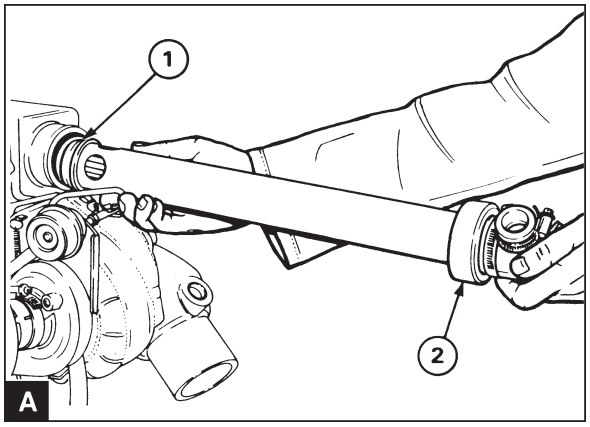
2

Detach the support clamp which holds the output pipe from the heat exchanger to the bottom of the intake manifold. Remove the outlet pipe.

3

Remove the rubber ends by detaching the hose clamps.

4



Press out the insert in whichever direction. Ensure that the sleeve (A1) also comes out of the heat exchanger.

5

Check that the holes in the pipes are clean. If there are hard deposits or contaminants in the pipe, the best way of cleaning them is to use a non-corrosive solution approved by the manufacturer. If the deposits or contaminants are soft, the pipe can be cleaned with a steel rod of 3 mm diameter. Push the rod through the pipes in the opposite direction to the water flow. Take care that the rod does not damage the pipes.

6

Check the components for signs of damage and replace if necessary.

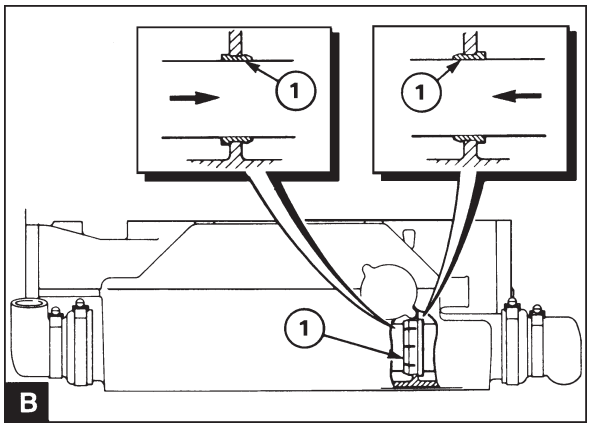
7

Slide the sleeve (A1) on the end of the insert until the insert is in contact with the reduced diameter of the sleeve.

8

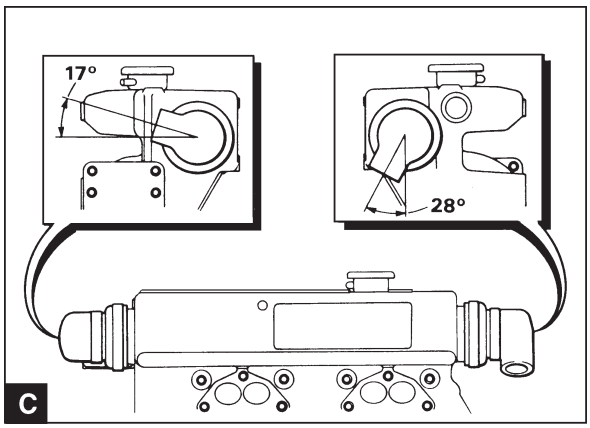
Press a rubber end (A2) over the other end of the insert until the protrusion inside the rubber end touches the end of the sleeve.

9



If a rubber sleeve is used, lubricate it with a little soap solution. Place the sleeve end of the assembly in the housing and carefully insert the sleeve in the hole in the baffle plate Carefully press the pipe ends of the housing until the journal in the housing is correctly positioned inside the end cover. Do not pull the pipe cluster backwards during installation, as this pulls the sleeve out of the baffle plate. Check through the filler opening that the sleeve is positioned correctly in the baffle plate (B).

10



Install the second rubber end. Check that the pipe connectors of the rubber ends are in the correct position and tighten the clamps. Place the rubber ends in the positions shown in C if the assembly has be removed from the engine.

11

Connect the sea water intake and outlet pipes to the heat exchanger. The output pipe must be pushed in so that the end of the pipe is in the center of rubber end of the heat exchanger. Tighten the clamp to the outlet pipe.

12

Fill the coolant circuit, operation 20A-02 and open the seacock.

13

Run the engine and check for leakage.

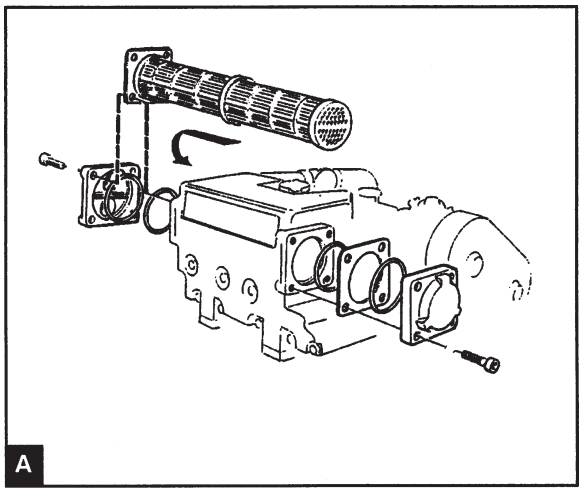
Heat exchanger, reconditioning (20A-11)

Applies to MD22L-B, MD22P-B, TMD22-B, TMD22P-C, TAMD22P-B

1

Drain the sea water circuit, operation 20A-03.

2



Remove the cover and press the insert out of the heat exchanger.

3

Check that the holes in the pipes are clean. If there are hard deposits or contaminants in the pipe, the best way of cleaning them is to use a non-corrosive solution approved by the manufacturer. If the deposits or contaminants are soft, the pipe can be cleaned with a steel rod. Push the rod through the pipes in the opposite direction to the water flow. Take care that the rod does not damage the pipes.

4

Check the components for signs of damage and replace if necessary.

5

Install the components in reverse order. There is only one way to install the insert and cover.

6

Run the engine and check for leakage.

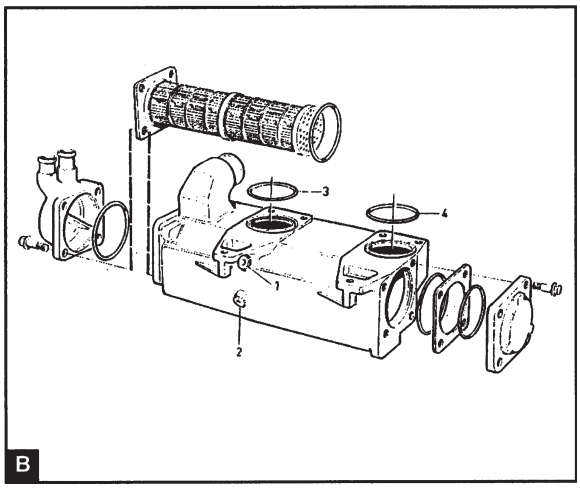
Charge air cooler (CAC), reconditioning (20A-12)

Applies to TAMD22P-B

1

Drain the sea water circuit, operation 20A-03.

2



Remove the charge air cooler assembly from the heat exchanger. Remove the cover and the plugs (B1 and B2). Press the insert out of the heat exchanger.

3

Check that the holes in the pipes are clean. If there are hard deposits or contaminants in the pipe, the best way of cleaning them is to use a non-corrosive solution approved by the manufacturer. If the deposits or contaminants are soft, the pipe can be cleaned with a steel rod. Push the rod through the pipes in the opposite direction to the water flow. Take care that the rod does not damage the pipes.

4

Check the components for signs of damage and replace if necessary.

5

Install the components in reverse order. Do not forget the plugs (B1 and B2) and the O-rings (B3 and B4). There is only one way to install the insert and covers.

6

Run the engine and check for leakage.

Flywheel, flywheel cover

General

The motor may be equipped with a back plate of aluminum or soft carbon steel or a flywheel cover of cast iron. Marine engines have an aluminum adapter housing between the back plate and the reverse gear.

The steel flywheel has a hardened ring gear which is installed by the process of shrinking-on. The ring gear has 104 teeth.

Repair Instructions

Flywheel, replacement (21A-01)

1

Remove the drive components from the rear end of the engine.

Remove the adapter housing for the reverse gear. Remove the elastic drive disc from the flywheel.

2

Remove the two counter-positioned mounting screws from the flywheel. Temporarily install two guide pins to ensure the safe removal and installation of the flywheel.

3

Remove the remaining mounting screws and remove the flywheel.

4

Check the flywheel and ring gear for signs of damage and replace if necessary.

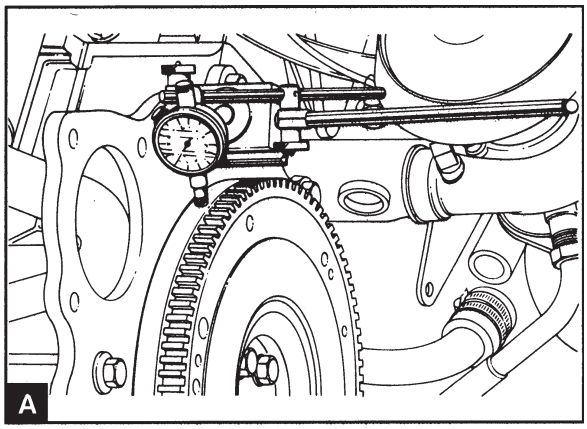
5

Check that the mating surfaces of the crankshaft and the flywheel are clean and undamaged.

6

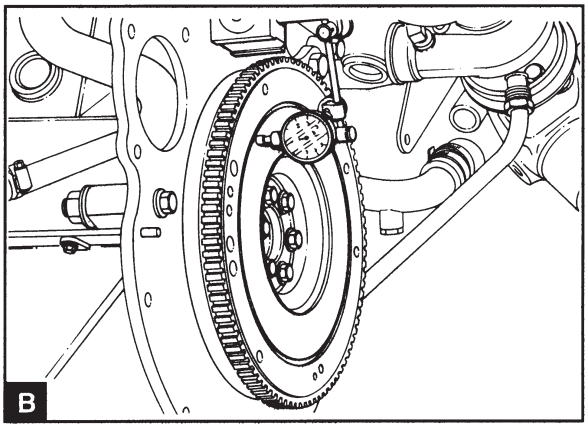
Check that the guide pin is installed in the crankshaft flange. Install the flywheel over the guide pins. Install the four mounting screws. Remove the guide pins and install the two remaining mounting screws. Tighten the screws in stages and evenly to **65 Nm**.

7



Check the radial run-out of the flywheel using a dial indicator (A). The run-out must be less than 0.30 mm as a total reading on the indicator.

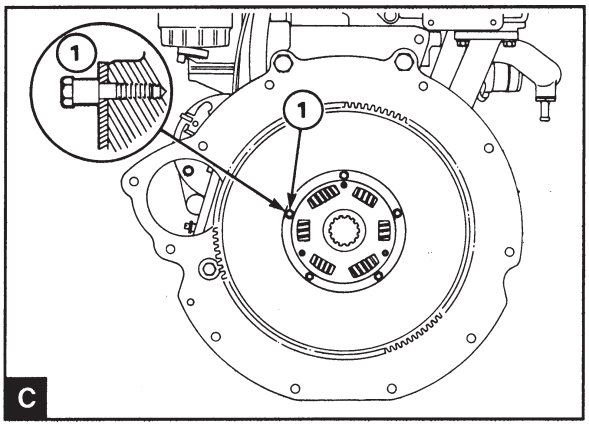
8



Check the axial run-out on the flywheel surface (B). The axial run-out must not be greater than 0.03 mm as a total reading on the dial indicator for every 25 mm radius of the flywheel (calculated from the center of the crankshaft to the tip of the dial indicator). During this measurement, the crankshaft must be pressed forward to prevent the axial run-out of the crankshaft from affecting the reading.

MS2, 120S, HBW250, HS25

9



Install the elastic disc for the reverse gear (C). Apply Locktite 243 on the threads of the mounting screws for the disc. Ensure that the small guide section of each mounting screw goes into the flywheel (C1). Tighten the mounting screws evenly in stages to **9 Nm**. Do not start the engine until the locking fluid has hardened.

10

Install the drive components at the rear of the engine.

Ring gear, replacement (21A-01)

⚠ **WARNING!** Protective goggles must be worn for this operation.

Check the position of the chamfering on the teeth before removing the ring gear.

Removing

The ring gear can be removed using a hammer and chisel to break off the collar. Make sure that the flywheel is not damaged during this operation.

Installation

The collar is installed on the flywheel by heating it. When a new collar is installed, ensure that it is not heated above 250°C. Check that the chamfering on the teeth is facing in the correct direction.

Flywheel cover, replacement (21A-3)

Special tools: 885030

1

Remove the drive components from the rear end of the engine.

2

Remove the starter motor, operation 22B-01. Engines with reverse gear: Remove the adapter housing for the reverse gear.

3

Remove the flywheel, operation 21A-01.

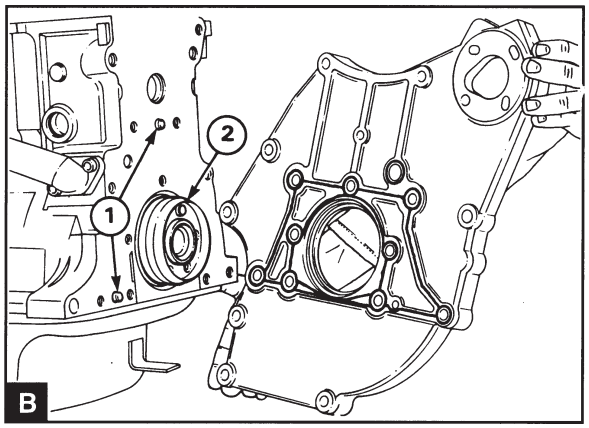
4

Remove the mounting screws for the flywheel cover. Use a hammer with a soft face to detach the flywheel cover from the guide pins.

5

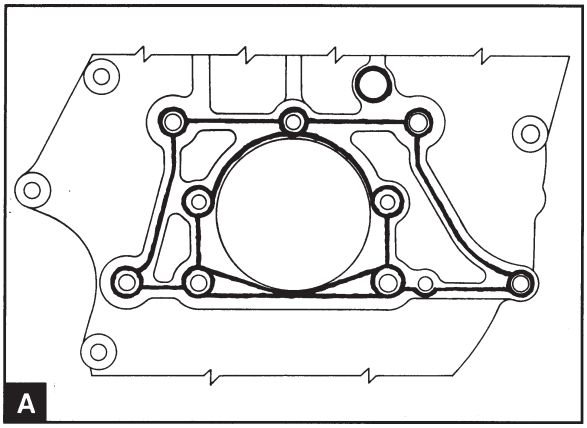
Check that rear surface of the cylinder block and the surfaces of the flywheel cover are clean and undamaged.

6



Check that the guide pins (B1) are correctly installed. Check that the outer diameter of the crankshaft flange is clean. Install the protective sleeve for the stuffing box (B2) in position on the crankshaft flange. Lightly lubricate the outer diameter of the crankshaft flange and the protective sleeve with fresh engine oil.

7



Apply a continuous 1.5 mm line of sealant on the front surface of the cover, as shown in illustration A. This operation is not necessary if a separate housing is installed for the stuffing box.

8

Install the cover on the guide pins and tighten the mounting screws.

Only reverse gear and S-drive

9

Check the concentricity of the cover using a dial indicator. The maximum permissible total reading on the indicator dial is 0.15 mm. If adjustment is necessary, this must be carried out on the cover and then the concentricity must be checked again.

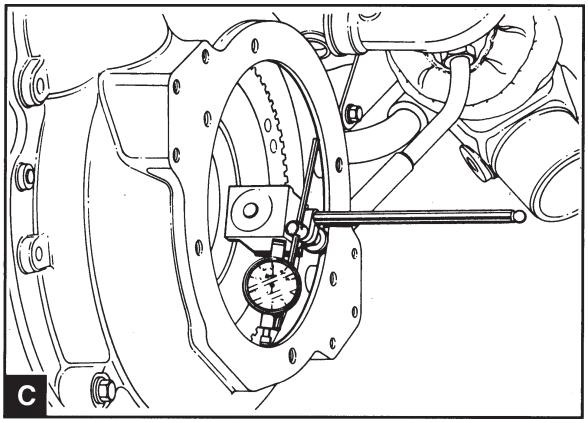
10

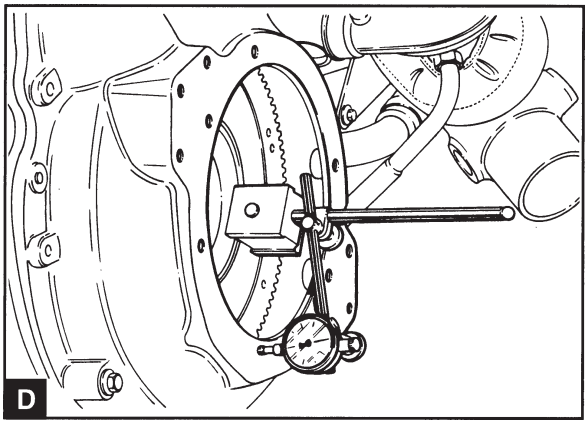
Tighten the mounting screws evenly in stages with the appropriate torque, as stated in section 11B, and in the order shown in illustration 21A.05/A.

11

Check the axial run-out of the rear section of the cover. The maximum permissible total reading on the indicator dial is 0.15 mm. Any adjustments must be carried out on the cover, not the cylinder block.

12





Install the flywheel and the drive adapter for the reverse gear, operation 21A-01. Check that the guide pins are correctly installed in the housing. Install the adapter housing for the reverse gear and tighten the mounting screws to **43 Nm**. Check the concentricity of the housing (C) and the axial run-out (D) in the same way as in points 5 and 7 above. Install the support plate for the manifold.

13

Install the starter motor, operation 22B-01. Install the drive components from the rear of the engine.

Electrical system

Component description

Generator

The Valeo A13N 147M generator is driven from the crankshaft pulley with a single drive belt. The generator has a capacity of 60 A (early version 50 A).

Starter motor

The starter motor is of the pre-connected type and the internal drive operates via a planetary train.

A roller clutch prevents the rotor rotating at high speed if the starter motor is kept in the engaged position.

These starter motors are equipped with needle bearings to allow for higher loads.

Glow plugs

The starting aid for these engines consists of a set of glow plugs, one for each cylinder.

The glow plugs are installed in the cylinder head next to the injectors. The tip of the glow plug protrudes into the combustion chamber in the piston when the piston is at TDC.

The glow plug is controlled electrically, usually with the ignition switch. When the plugs are supplied with power the tips become very hot and improve the combustion process during cold starting.

Repair Instructions

Generator, replacement (22A-01)

To prevent damage to the diodes and resistance, the following instructions must be followed.

- Do not disconnect the battery when the engine is running. This causes an increase in voltage in the generator charging system, which may cause damage to the diodes or transistors.
- Do not disconnect any electrical cables until the engine has stopped and all electrical switches are in the OFF position.
- Do not cause a short-circuit by connecting electrical cables to the wrong socket. The correct identification of electrical cable to socket must be carried out. A short-circuit or incorrect connection, which reverses polarity, may cause lasting damage to diodes and transistors.
- Do not connect a battery to the system until it has been checked for the correct polarity and voltage.
- Do not check whether a cable is carrying current by seeing if it sparks, as this may damage the transistors.

Removing

1

Disconnect the electrical connections at the generator.

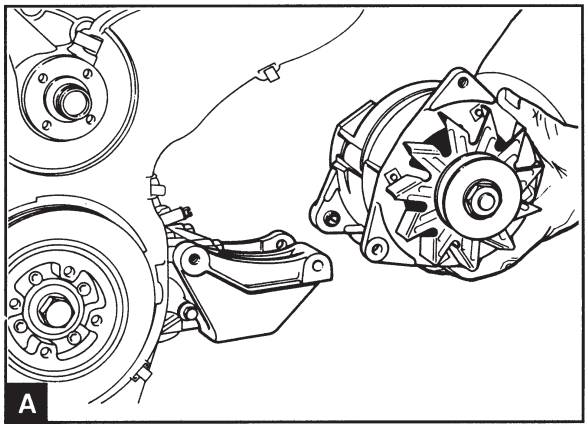
2

Detach the generator mounting from the pivot mounting and the mountings for the adjuster link.

3

Slacken off the belt tension and remove the belt.

4



Remove the adjuster link from the generator and remove the pivot shaft. Note the position of the washer to ensure that it is correctly installed. Remove the generator (A).

Installation

5

Place the generator in position and loosely install the pivot mountings and the mountings for the adjuster link. Check that the washer is installed in the correct position and that the generator pulley is aligned with the crankshaft pulley.

6

Install the drive belt and adjust the pulley. Tighten the mountings for the adjuster link and the pivot and check the belt tension again.

7

Connect the electrical connectors to the generator.

Generator, maintenance

1

Check that the drive belt is not worn and that the belt tension is correct.

2

Keep the generator clean. When cleaning the generator, use a material which is moistened with kerosene or a fluid which is specially designed for the purpose. Ensure that the fluid does not enter the generator.

3

Check that air can pass over the housing to cool it.

Generator, fault-tracing

The generator is constructed so that a current (indicated by an unlit warning lamp or a value on a voltmeter) shows that the system is operating correctly. If the system is operating correctly, no check is required of open circuits, voltage or current output on the unit unless:

- The warning lamp does not light when the generator is not running and the switch is in the ON position, or it lights when the generator is running.
- No charge current is shown on the voltmeter.
- The battery is discharged.
- The battery is warmer than normal, which suggests that the voltage control is not operating.

If one or more of the above symptoms occur, the following action must be taken.

1

Check that the battery is charged.

2

Connect a good-quality voltmeter with a range of 0-50 V across the generator and the negative terminals.

If an ammeter is not connected in the circuit: Connect a good-quality ammeter with a range of 0-100 A to the lead between the generator and the battery positive terminal.

3

Turn the switch for the warning lamp to the ON position (the main switch on the instrument panel). The warning indicator should come on.

4

Connect a load of 10-15 A, e.g. lighting.

5

Start the engine and run it at high idling speed, at which time either: the warning lamp will go out or the ammeter will show a low charge current in relation to the engine speed.

6

Increase the engine speed for a short time to almost max rpm; the charge current should be approximately 50 A.

7

Run the engine at approximately half max rpm and remove the electrical load.

The voltage should increase to 14 V for a 12 V system and then remain constant. At the same time, the current indicator should show a fall.

Any change in the above data may indicate a fault and the generator must be removed to be checked by a specialist.

The governor is a sealed unit and repairs are not possible. If the governor is faulty it must be replaced.

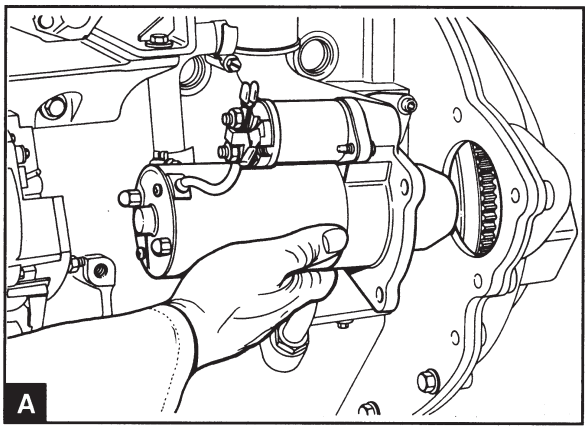
Starter motor, replacement (22B-01)

1

Disconnect the battery.

2

Disconnect the starter motor cables.



3

Slacken off the mountings and remove the starter motor.

4

Install the starter motor and tighten the mountings.

5

Connect the starter motor cables

6

Connect the battery.

Starter motor, maintenance (22B-02)

The starter motor must be removed from the engine.

The brush unit can be removed from the rotor unit the back plate has been removed.

Inspect the brushes to ensure that they move freely in their guides and that the cable connectors move freely. To check this, remove the spring holder and spring from each brush and gently pull the moveable connector. If the brush does not move freely, remove it from its holder and clean the sides with a material which is moistened with gasoline.

Ensure that the brushes are installed in their original positions to maintain the original wear pattern. The brushes must make good contact in alignment with the shape of the commutator. If the brushes have worn down to a length of 3.5 mm or less, the brushes must be replaced.

The new brushes must be exactly the same type as the originals. To ensure that the correct brushes are installed, use only replacement parts from approved manufacturers. To remove the grounding brushes, remove the clip and pull back the brushes. To remove the field brushes, remove the insulation plate and bus rail and the brush unit. Before placing the brushes in their holders, the holders should be cleaned with compressed air or material moistened with gasoline.

The commutator must be absolutely clean. Dirt or oil can be removed using a clean dry cloth (without loose fibers). If the commutator is dirty (or is discolored) it can be cleaned with fine carborundum paper or similar. If this is not possible, send the starter motor to a specialist for repair.

The brush unit and rotor unit can be installed together in the housing, but they will be drawn into position by the solenoids. Check that the thrust washer is still in position in the front end of the rotor shaft.

If the engagement unit etc needs repairing, the starter motor must be sent to a specialist for repair.

Starter motor, checking (22B-03)

Check that the battery is charged.

Switch on the lamps and engage the ignition switch. If no lamps are connected to the engine, connect a voltmeter across the battery poles and engage the ignition switch.

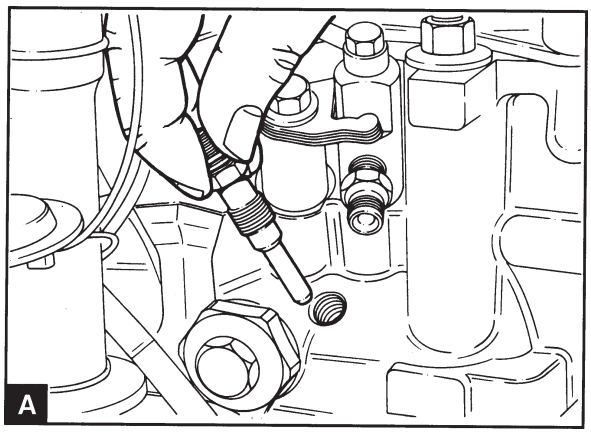
If the starter motor does not operate, but the lamps keep their power (or if there is no fall in voltage across the battery) check the switch and all the connections and cables. Slow operation of the starter motor may be caused by faulty connections

Glow plugs, replacement (22C-01)

1

Disconnect the electrical connections for the glow plugs.

2



Disconnect and remove the plugs (A).

3

Check that the threads and mating surfaces of the plugs and in the cylinder head are clean. Apply lubricating agent which is designed for high temperatures on the threads and the bevelled seats of the plugs. Install the plugs and tighten to **20 Nm**.

4

Connect the electrical connectors to the plugs.

Glow plugs, checking power supply/continuity

1

Connect a 12 V test lamp between the battery positive pole and ground to check that the lamp operates.

2

Connect the test lamp between the output of the glow plug which is furthest away from the power source and ground. When the control switch is engaged, the test lamp should light if the power supply is correct.

3

Disconnect the cables at the glow plug connections.

4

Connect the test lamp to the positive pole of the battery and the connector of each glow plug The lamp should light if the continuity is correct. If the lamp does not light when checking one of the terminals, the terminal must be replaced.

5

Connect the cables to the glow plug connectors when all the glow plugs have been checked.

Glow plugs, function check

1

Disconnect the power supply cable and the cables at the glow plug connectors.

2

Connect a 50-0-50 ammeter between the power supply cable and the connector for one glow plug. Connect a 0-20 voltmeter between the glow plug connector and ground.

3

Connect the control switch and note the reading on the ammeter and voltmeter.

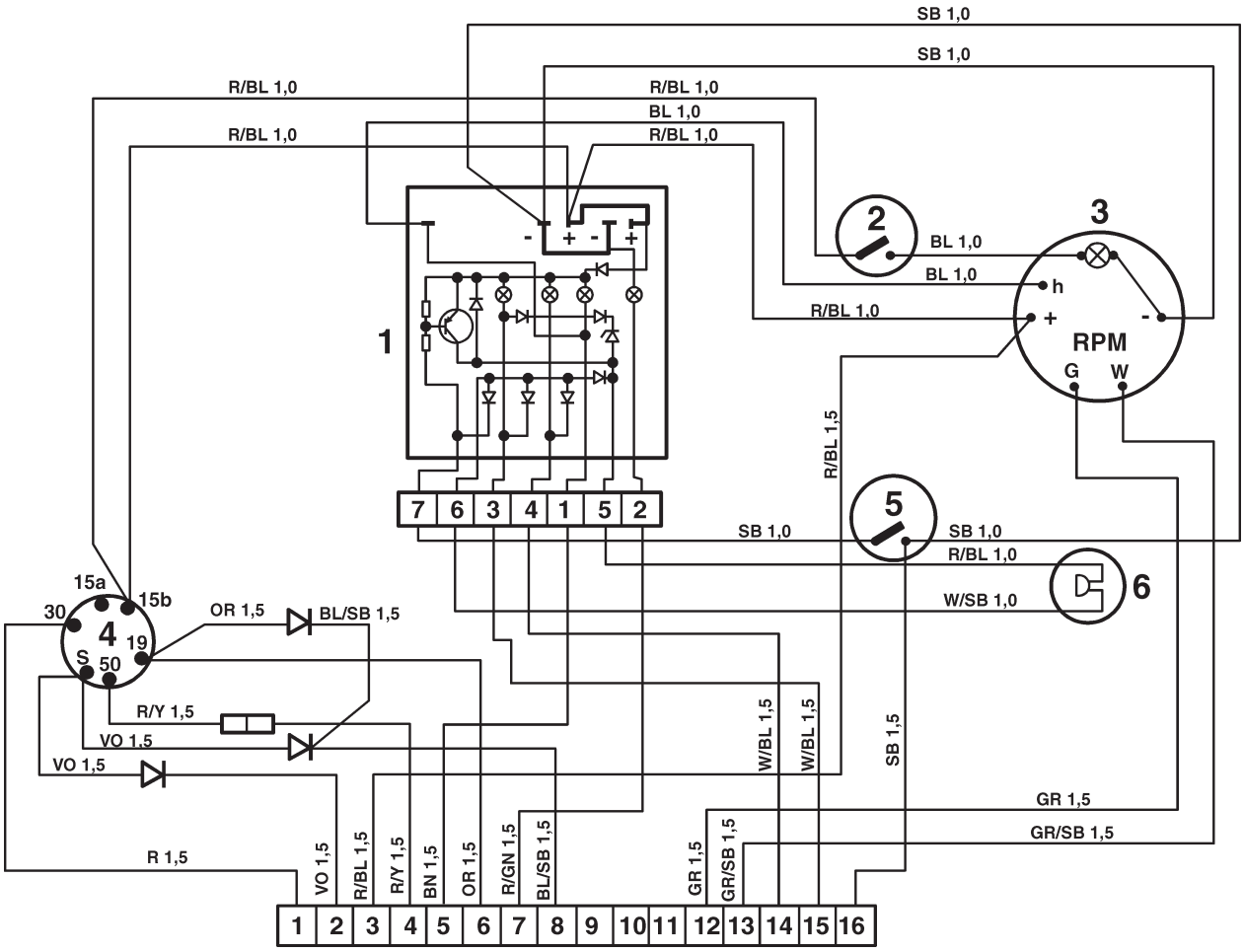
In a 12 V system there should be an initial current of 27 A which drops to 14 A after approximately 10 seconds. After that period the reading on the voltmeter should be approximately 11-12 V.

If the reading on the ammeter is low or if there is no reading at all, replace the glow plug. If there is no reading on the voltmeter, check the switch and the power cable.

4

When all the glow plugs have been checked, remove the ammeter and voltmeter and connect the supply cable.

Wiring Diagram

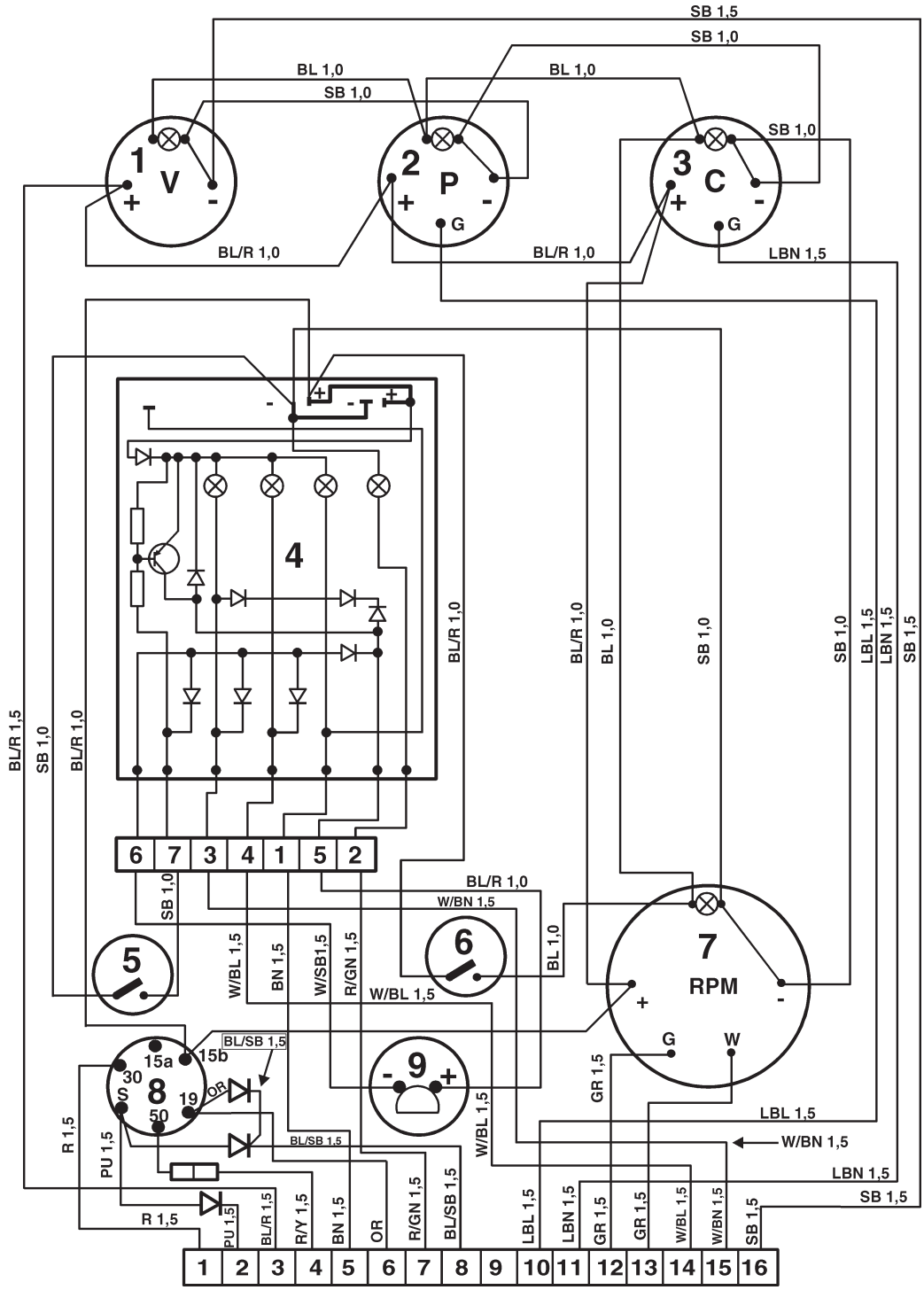


Instrument panel

1. Printed circuit board
2. Switch for instrument lighting
3. Tachometer
4. Starter button
5. Button
5. Alarm connector

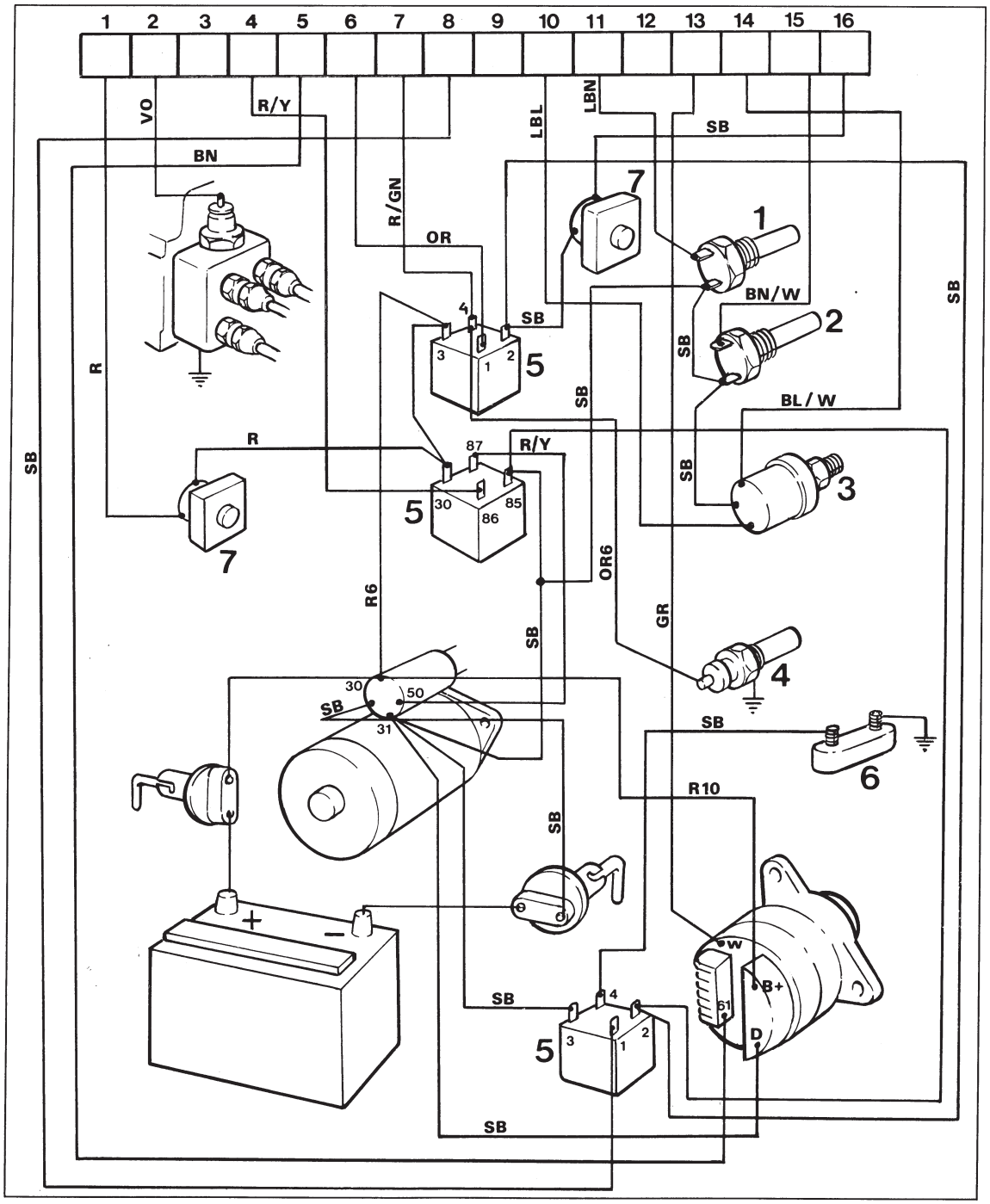
Cable color

GR =gray
SB =black
BN =brown
LBN =light brown
R =red
PU =purple
GN =green
W =white
BL =blue
LBL =light blue
OR =orange
Unless otherwise stated, cable cross sections = 1.5 mm^2



Instrument panel

1. Voltmeter
2. Oil pressure gauge
3. Engine coolant temperature gauge
4. Printed circuit board
5. Button
6. Switch for instrument lighting
7. Tachometer
8. Ignition switch
9. Alarm



Engine

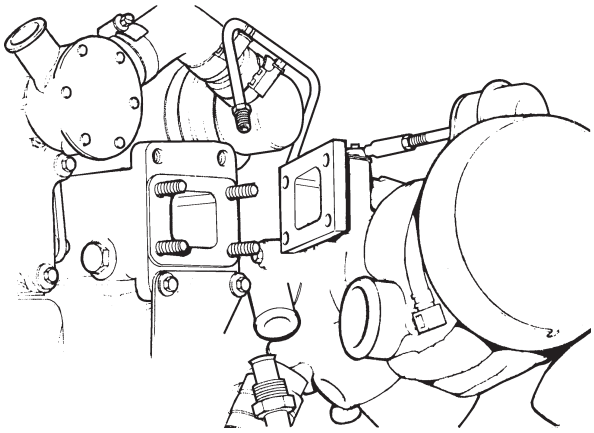
1. Engine coolant temperature sensor
2. Coolant temperature switch
3. Oil pressure sensor
4. Pre-heating
5. Relay
6. Ground fuse
7. Fuses

Cable color

GR =gray
SB =black
BN =brown
LBN =light brown
R =red
PU =purple
GN =green
W =white
BL =blue
LBL =light blue
OR =orange
Unless otherwise stated, cable cross sections = 1.5 mm^2

Turbocharger, replacement (only TMD, TAMD)

Removing and installing



1

Clean the turbocharger (TC) carefully.

2

Remove the air filter or the air filter hose from the turbocharger (TC) compressor intake.

Remove the intake cover if installed.

3

Unscrew the exhaust pipe.

4

Detach the hose clamps and slide the compressor outlet hose up on the intake manifold elbow.

Remove the spring clamps and the turbine backplate (heat shield).

5

Disconnect the supply line and the oil return line at the turbocharger (TC). Remove the boost pressure pipe at the turbocharger (TC).

6

Remove the nuts at the turbocharger flange and remove the turbocharger (TC) (A) and the gasket. Remove the exhaust elbow and its joint from the turbocharger (TC) if installed. Install a protective cover over the openings in the turbocharger (TC) to prevent dirt etc from getting in.

7

Install covers in the ends of the lines and over the openings in the manifold or in the coolant tank / heat exchanger / manifold unit.

8

Check the air hoses and the oil return hose for cracking or other damage and replace if necessary.

9

Remove and clean the oil return line if installed.

10

Remove the protective covers from the components.

11

Check the turbocharger (TC) intake and outlet are clean and free from blockages and that the turbocharger (TC) shaft rotates freely. Also check that the openings in the manifold and exhaust pipe are clean and free from blockages.

12

Install a new gasket between the exhaust manifold and the turbocharger flange. Check that the stud threads are clean and apply a suitable lubricating agent. Install the turbocharger (TC), install the nuts and tighten to **22 Nm**.

Check that the bracket for the turbine backplate (heat shield) is correctly installed before the flange nuts are installed and tightened. Install the turbine backplate (heat shield).

13

Install the exhaust elbow for the turbocharger (TC) if required. Check that the mating surfaces on the elbow and the turbocharger (TC) are clean. Install a new gasket. Tighten the nuts to **22 Nm**.

14

Connect the oil return line and the boost pressure line to the turbocharger (TC).

15

Pour 100-140 ml of clean engine oil through the intake opening in the turbocharger central housing.

Turn the rotating unit by hand to distribute the oil to the bearings.

16

Slide the hose on the intake manifold elbow onto the compressor outlet and tighten the hose clamps.

17

Check that the passages in the air filter and hose and in the intake cover and pipe are clean. Install the air filter and intake cover and tighten the hose clamps.

18

Place the supply line for the oil in position but do not connect it. Operate the starter motor with the stop button depressed or with the stop lever in the STOP position until oil runs out of the supply line. Ensure that the stop lever returns to the operating position.

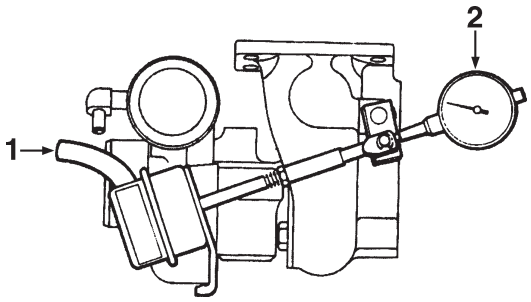
Connect the oil supply line.

Install the turbine backplate (heat shield) and its spring clamps.

19

Start the engine and check that there are no oil or air leaks (particularly at the line for the boost pressure sensor which is installed between the compressor housing and the control valve for the boost pressure. The engine must be run at low speed for 3 or 4 minutes to start the oil circulating before the engine speed is increased.

Boost pressure control valve, checking



If the by-pass valve in the boost pressure control valve does not open at the correct pressure, this will affect the performance of the engine.

A low pressure setting can cause black exhaust emissions at the marked engine speed and power loss at 2,500 rpm.

A high pressure setting may cause excess pressure in the cylinders, which may lead to damage to the cylinder head gasket and to the bearings and pistons.

The pressure setting can be checked as follows:

1

Disconnect the line for the boost pressure sensor (1) and connect an air supply which can be regulated precisely and which is equipped with a precision manometer. Position a dial indicator on the turbocharger (TC) with the measuring tip in contact with the control rod to measure the axial movement of the rod (2).

2

Check that the pressure required to move the rod 0.38 mm is within the range 89-97 kPa for the TMD22 (the values for the TAMD22 are 1 mm and 135 kPa). Check that the dial indicator returns to zero when the air pressure is released. Repeat the test several times to ensure an accurate measurement. It may be necessary to tap lightly on the turbine housing with a soft-faced hammer during this procedure.

3

If the function of the pressure control valve is faulty, the turbo must be replaced. No adjustments are permitted.

4

Remove the test equipment and connect the line to the boost pressure sensor.

Notes

Notes

Report form

Do you have any complaints or other comments about this manual? Please make a copy of this page, write your comments down and post it to us. The address is at the bottom of the page. We would prefer you to write in English or Swedish.

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