Starter motor 22B

General description 22B.02

Starter motor

22B-01 To remove and to fit 22B.02
22B-02 To maintain the brush gear and the commutator 22B.02
22B-03 To test on the engine 22B.02

General description

The starter motor is a pre-engaged type and its internal drive is through an epicyclic gearbox.

A roller clutch prevent armature rotation at high speed if the starter is held in the engaged position.

These starters have needle roller bearings to allow higher loads to be applied.

Starter motor

To remove and to fit 22B-01

To remove

1 Disconnect the battery.

2 Disconnect the starter motor cables.

3 Release the fasteners and remove the starter motor.

To fit

1 Fit the starter motor and tighten the fasteners.

2 Connect the starter motor cables.

3 Connect the battery.

To maintain the brush gear and the commutator 22B-02

The starter motor must be removed from the engine.

The brush assembly can be removed from the armature assembly after the rear plate has been removed.

Inspect the brushes to ensure that they are free in their guides and that the wire connections are free to move. To check this, remove the spring retainer and the spring from each brush and pull carefully on the flexible connection. If the brush does not move freely, remove it from its holder and clean the sides with a material which is damp with gasolene.

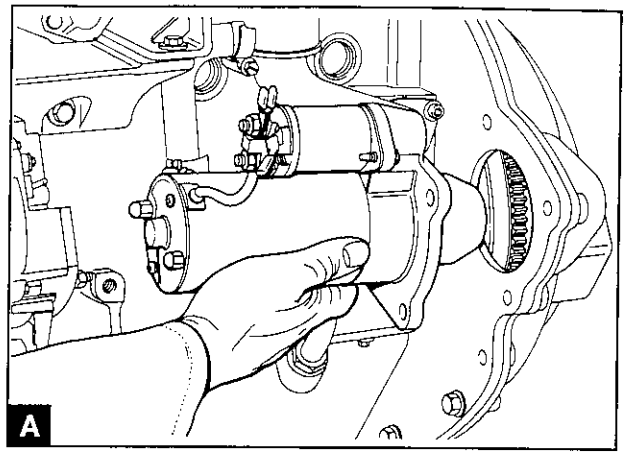
Ensure that the brushes are fitted in their original positions to keep the original wear seat. The brushes must have good seats which conform to the shape of the commutator. If the length of the brushes has been reduced to 3,5 mm (0.14 in) or less, the brushes must be renewed.

The new brushes must be the exact same grade as the original brushes. To rensure that correct brushes are fitted, use only parts from the approved manufacturer. To remove the earth brushes, release the clips and withdraw the brushes. To remove the field brushes, remove the insulation plate and remove the bus bar and brush assembly. Before the brushes are inserted in their holders, it is advised that the holders are cleaned with compressed air or with a material which is damp with gasolene.

The commutator must be completely clean of dirt or oil must be removed with a piece of clean dry material (with no loose fibres). If the commutator is dirty (or has a colour other than its natural colour) it may be possible to clean it with a fine carborundum paper or similar material. If this is not possible, send the starter to a specialist for repair.

To brush assembly and the armature assembly can be fitted into the body together but they will be pulled into position by the effect of the magnets. Ensure that the thrust washer remains in position on the front of the armature shaft.

If a repair is necessary to the switch gear, etc. the stater must be sent to a specialist for repair.



To test on the engine 22B-03

Ensure that the battery is in a fully charged condition.

Turn on lights and operate the starter switch. If no lights are fitted to the machine, connect a voltmeter across the battery terminals and operate the starter switch.

If the starter does not operate but the lights keep their power (or there is no voltage drop across the battery) check the switch and all the connections and wires. Slow action of the starter can be caused by faulty connections.

Starting aid 22C

General description 22C.02

Glow plugs

22C-01 To remove and to fit 22C.02
To check power supply and continuity 22C.02
To check operation of glow plugs 22C.02

General description

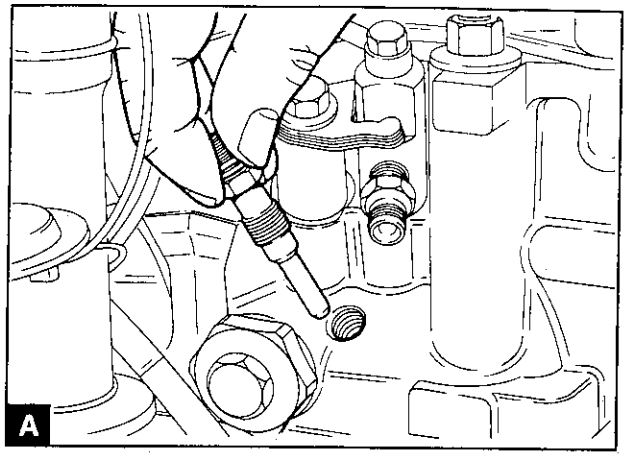
The starting aid for these engines consists of a set of glow plugs, one for each cylinder.

The glow plugs are fitted in the cylinder head near to the atomisers. The tip of the plug reaches into the combustion cavity of the piston when the piston is at TDC.

The plugs are operated electrically, usually through the start switch. When the plugs are energised, their tips become very hot and improve the combustion process during cold start conditions.

Glow plugs

To remove and to fit 22C-01



1 Disconnect the electrical connections at the glow plugs.

2 Release and remove the glow plugs (A).

3 Ensure that the threads and the contact faces of the plugs and the cylinder head are clean. Apply an anti-seize compound, which is suitable for high temperatures, to the threads and the tapered seats of the plugs. Fit the plugs and tighten them to 20 Nm (15 lbf ft) 2,0 kgf m.

4 Connect the electrical connection to the plugs.

To check power supply and continuity

1 Connect a 12 V test lamp between the positive terminal of the battery and earth to check that the lamp will show a light.

2 Connect the test lamp between the terminal of the glow plug which is furthest away from the power supply and earth. Operate the control switch and the test lamp should show a light if the power supply is correct.

3 Disconnect the cables at the glow plug terminals.

4 Connect the test lamp to the positive terminal of the battery and to the terminal of each glow plug. The lamp will show a light if the continuity is correct. If there is no light when a glow plug is checked, renew the plug.

5 When all the glow plugs have been checked, connect the cables to the plug terminals.

To check operation of glow plugs

1 Disconnect the power supply cable and the connection cables from the terminals of the glow plugs.

2 Connect a 50-0-50 ammeter between the power supply cable and the terminal of a glow plug. Connect a 0—20 voltmeter between the plug terminal and earth.

3 Engage the control switch and check the readings of the ammeter and the voltmeter.

With a 12 volt supply, there should be an initial current of approximately 27 amperes which should be reduced to approximately 14 amperes after approximately 10 seconds. The voltmeter reading after this time should be approximately 11 to 12 volts.

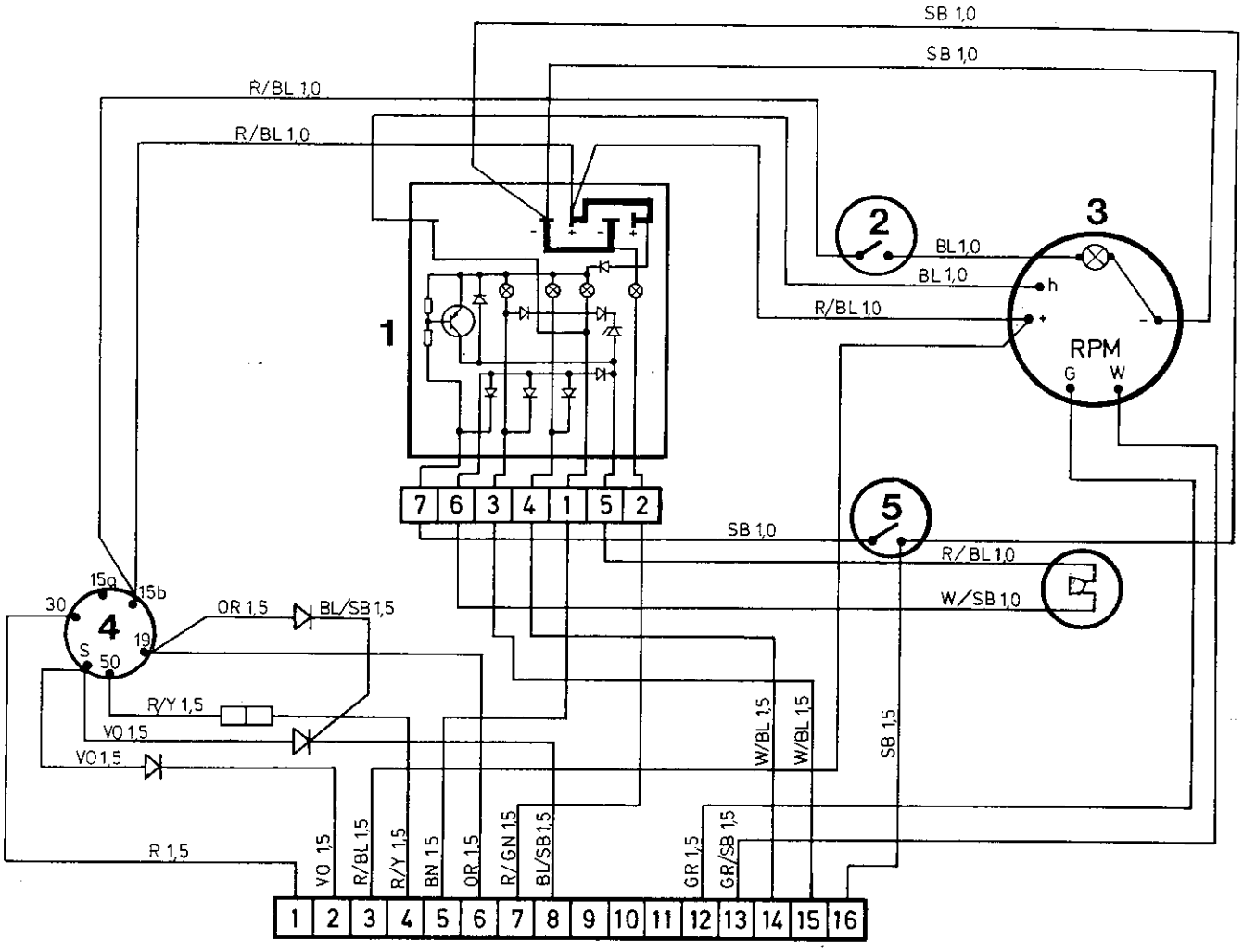
If the ammeter reading is low or there is no reading, renew the glow plug. If there is no voltmeter reading, check the switch and the power cable.

4 When all the glow plugs have been checked, remove the ammeter and the voltmeter and connect the supply cable.

Wiring diagrams 22D

Wiring diagrams for marine engines 22D.02

Electrical Wiring Diagram



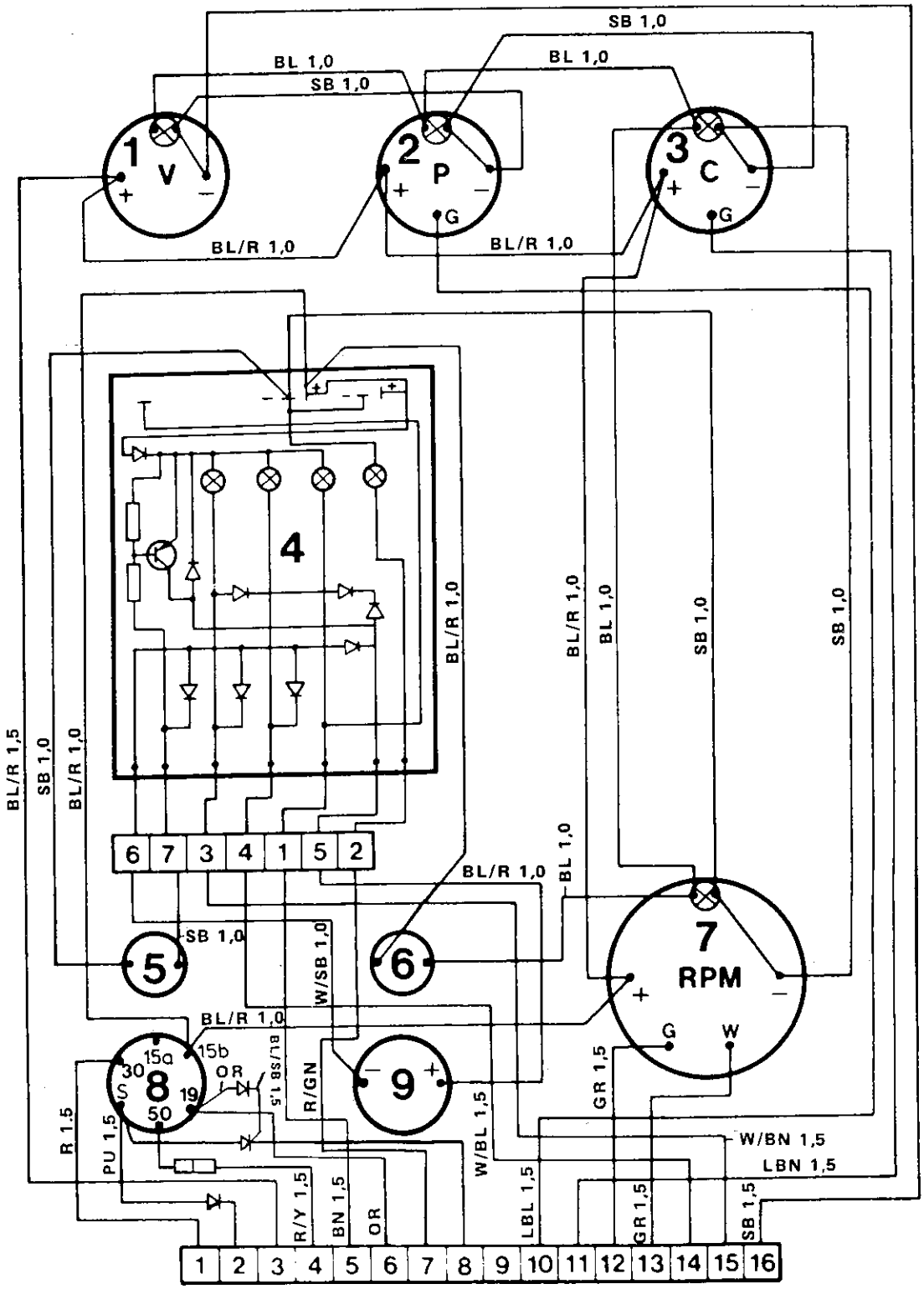
Instrument Panel

1. Printed circuit card
2. Switch for instrument lighting
3. Rev. counter
4. Start button
5. Push button

Wire color

GR	=	Grey
SB	=	Black
BN	=	Brown
LBN	=	Light brown
R	=	Red
PU	=	Purple
GN	=	Green
W	=	White
BL	=	Blue
LBL	=	Light blue
OR	=	Orange

Electrical Wiring Diagram

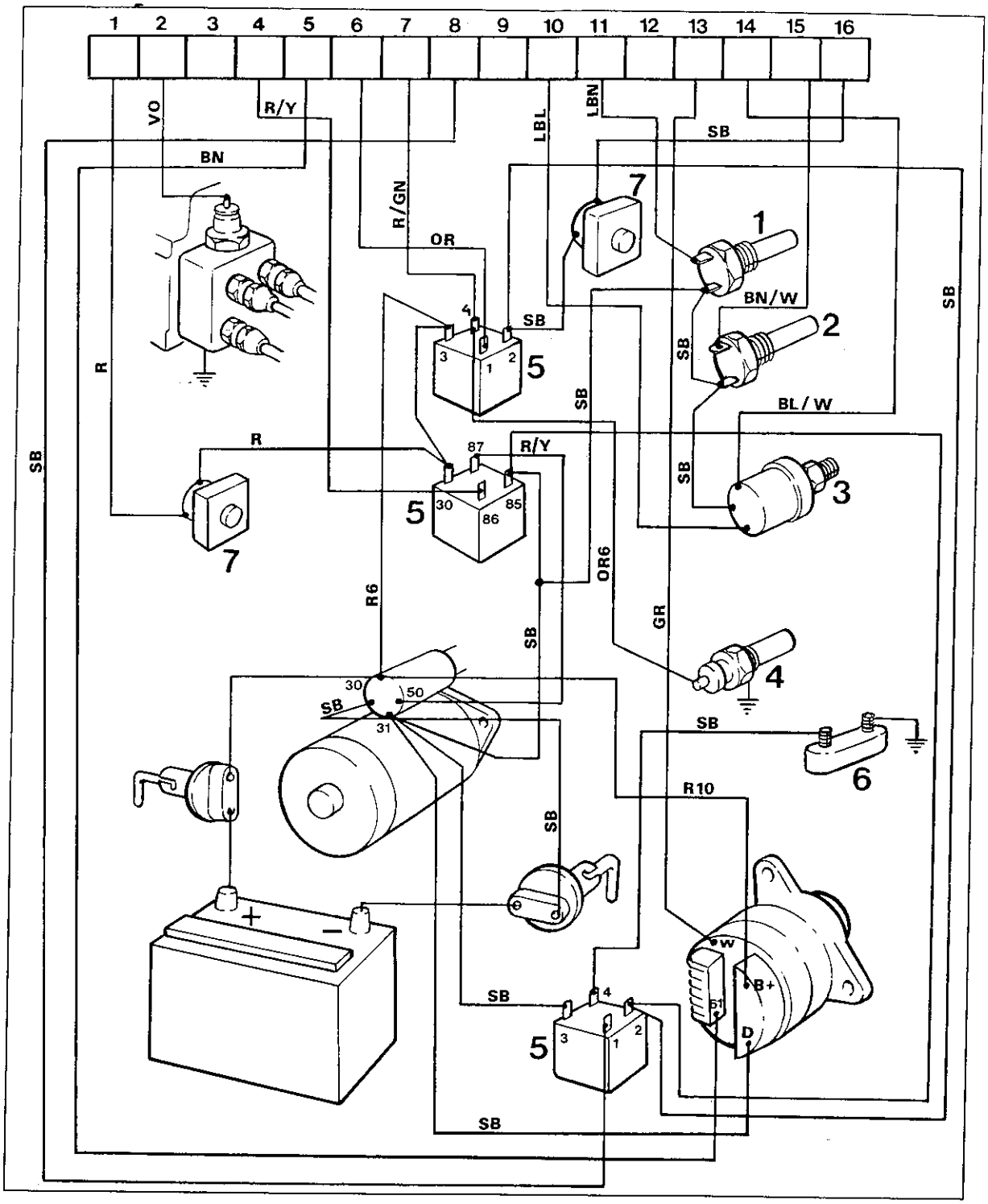


Instrument panel

1. Voltmeter
2. Oil pressure gauge
3. Coolant temperature gauge
4. Printed circuit card
5. Push button
6. Switch for instrument lighting
7. Rev. counter
8. Key switch
9. Alarm

Wire colour

GR	= Grey	GN	= Green
SB	= Black	W	= White
BN	= Brown	BL	= Blue
LBN	= Light brown	LBL	= Light blue
R	= Red	OR	= Orange
PU	= Purple		



Engine

1. Coolant temperature sender
2. Coolant temperature check
3. Oil pressure sender
4. Preheating
5. Relay
6. Ground fuse
7. Fuses

Not specified cable areas = 1.5 mm²

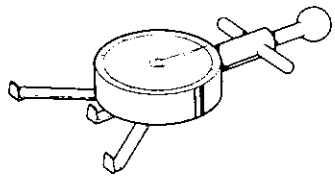
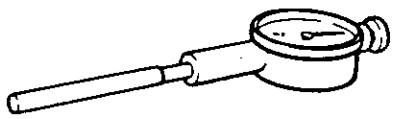
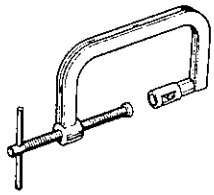
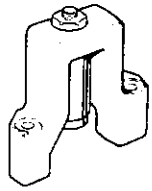
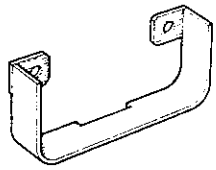
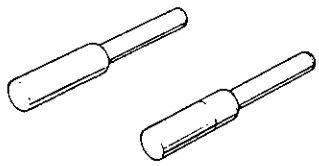
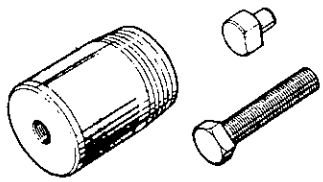
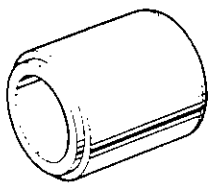
Wiring colour

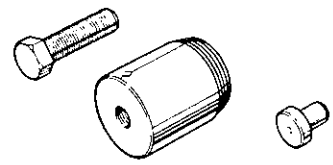
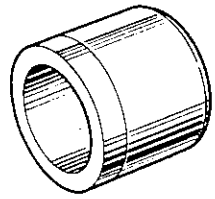
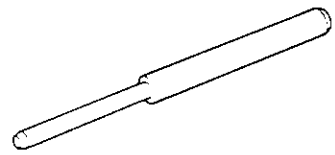
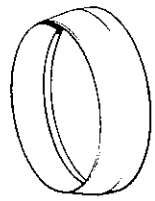
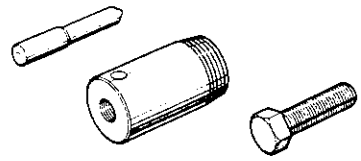
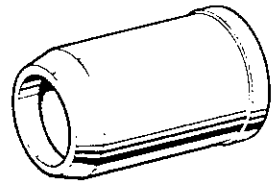
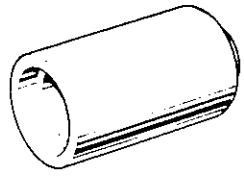
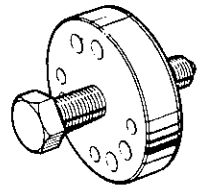
GR = Grey
SB = Black
BN = Brown
LBN = Light brown
R = Red
PU = Purple
GN = Green
W = White
BL = Blue
LBL = Light blue
OR = Orange

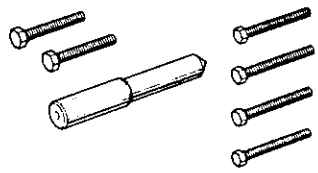
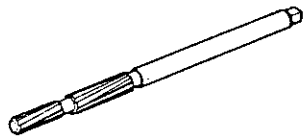
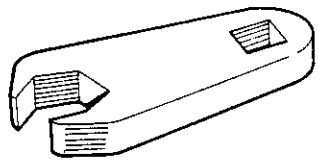
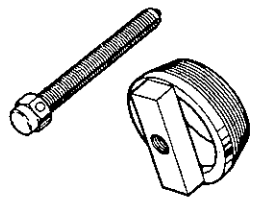
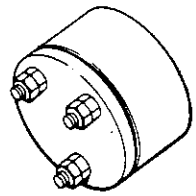
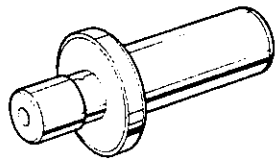
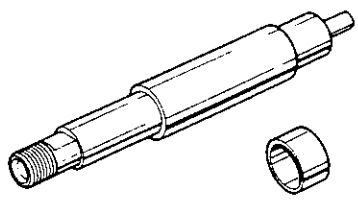
List of special tools 23

List of special tools 23A.02

List of special tools

Number	Description	Illustration
885036-4	Tension gauge for timing belt.	
884955-6	Indicator gauge, cpl.	
885023-2	Valve spring compressor.	
885024-0	Camshaft clamps (set of three).	
885025-7	Camshaft retainer.	
885037-2	Timing pins for camshaft and crankshaft.	
885026-5	Remover for front oil seal of camshaft.	
885018-2	Replacer for front oil seal of camshaft.	

Number	Description	Illustration
885019-0	Remover for real oil seal of camshaft.	
885020-8	Replacer for real oil seal of camshaft.	
885021-6	Remover/replacer for valve guides.	
885030-7	Protection sleeve for rear oil seal of crankshaft.	
885031-5	Remover for front oil seal of crankshaft.	
885032-3	Protection sleeve for front oil seal of crankshaft.	
885033-1	Replacer for front oil seal of crankshaft.	
885027-3	Remove for toothed pulleys of fuel injection pump and crankshaft (main tool).	

Number	Description	Illustration
885029-9	Adaptors for use with 885027-3.	
885022-4	Reamer for new valve guides.	
885028-1	Remover/replacer wrench for stop solenoid of fuel injection pump.	
885034-9	Remover for rear oil seal of crankshaft.	
885035-6	Replacer for rear oil seal of crankshaft.	
885038-0	Alignment adaptor for mounting of raw water pump.	
885041-4	Cylinder pressure test adaptor.	

Turbocharger

To remove and to fit

To remove

1 Thoroughly clean the turbocharger.

2 Remove the air filter or the air filter hose at the turbocharger compressor inlet.

Remove the induction cap, if necessary.

3 Disconnect the exhaust pipe.

4 Release the hose clips and push the hose of the compressor outlet up the elbow of the induction manifold.

Release the spring clips and remove the heat shield.

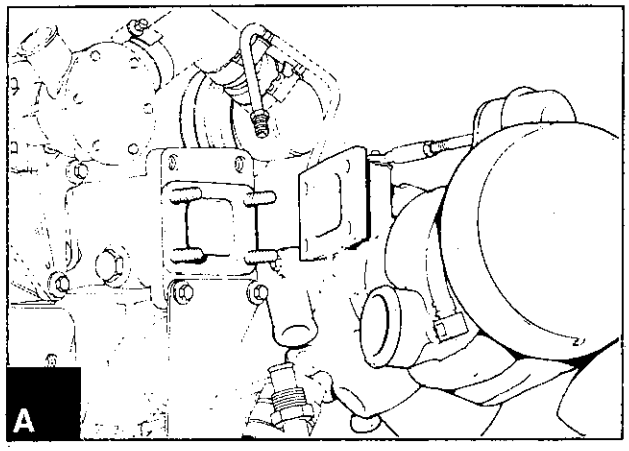
5 Disconnect the oil supply pipe and the oil drain pipe at the turbocharger. Disconnect the boost pressure pipe at the turbocharger.

6 Release the nuts at the turbocharger flange and remove the turbocharger (A) and the gasket. If necessary, remove the exhaust elbow and its joint from the turbocharger. Fit covers to the openings in the turbcharger to ensure that dirt, etc. vill not enter.

7 Fit covers to the ends of the pipes and the openings in the manifolds or in the header tank / heat exchanger / manifold assembly.

8 Check the air hoses and the oil drain hose for cracks of other damage and renew them, if necessary.

9 If necessary, remove and clean the oil drain pipe.



To fit

1 Remove the covers from the components.

2 Check that the turbocharger inlets and outlets are clean and free from restriction and that the turbocharger shaft roates freely.
Also check that the manifold and exhaust pipe openings are clean and free from restriction.

3 Fit a new gasket to the exhaust manifold to turbocharger flange. Ensure that the threads of the studs are clean and apply a suitable compound to the studs to prevent seizure. Fit the turbocharger, fit the nuts and tighten them to 22 Nm (16 ibf ft) 2,2 kgf m.
Ensure that the heatshield bracket is fitted correctly before the flange nuts are fitted and tightened. Fit the heatshield.

4 If necessary, fit the exhaust elbow to the turbocharger. Ensure that the faces of the elbow and of the turbocharger anre clean and fit a new joint. Tighten the nuts to 22 Nm (16 ibf ft) 2,2 kgf m.

5 Connect the oil drain pipe and the boost control pipe to the turbocharger.

6 Insert 100/140 ml (4/5 fluid ounces) of clean engine lubricating oil through the inlet port in the centre casing of the turbocharger.
Turn the rotating assembly by hand to send the oil around the bearings.

7 Slide the hose on the induction manifold elbow onto the compressor outlet and tighten the hose clips.

8 Check that the passages in the air filter and hose or in the induction cap and pipe are clean. Fit the air filter or the induction cap and tighten the hose clips.

9 Put the oil supply pipe in position but leave it disconnected.
Operate the starter motor with the stop button pressed or with the stop control lever in the "stop" position until oil flows from the supply pipe. Ensure that the stop control lever returns to the "run" position.
Connect the oil supply pipe.
Fit the heatshield and its spring clips.

10 Start the engine and check for lubricating oil and air leaks (especially from the boost sensor pipe that is fitted between the compressor casing and the waste-gate actuator). The engine should be operated at low speed for three to four minutes to allow for oil circulation before the speed is increased.

Waste-gate unit

If the by-pass valve of the waste-gate does not open at the correct pressure, this will affect the performance of the engine.

A low pressure setting can cause black exhaust smoke at rated speed and loss of power at 2500 rev/min.

A high pressure setting can cause high cylinder pressures which can cause failure of the cylinder head gasket and damage to the bearings and pistons.

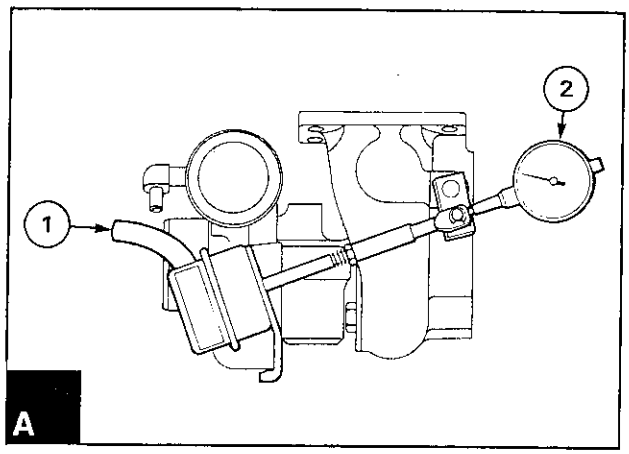
The pressure setting can be checked as follows:

1 Disconnect the boost sensor pipe (A1) and connect an air supply which can be accurately controlled and is fitted with an accurate gauge. Fasten a dial test indicator to the turbocharger with the end of the plunger in contact with the end of the actuator rod to measure axial movement of the rod (A2).

2 Check that the pressure needed to move the rod 0,38 mm (0.015 in) is within the limits of 89/97 kPa (12.9/14.1 Lbf/in²) 0,91/0.99 kgf/cm². Ensure that the dial indicator returns to zero when the air pressure is released. Repeat the test several times to ensure that an accurate reading is obtained. It may be necessary to lightly hit the rubine housing with a soft hammer during the test operation.

3 If the operation of the waste-gate is not correct, the turbocharger must be renewed. No adjustment is allowed.

4 Remove the test equipment and connect the boost sensor pipe.



Workshop Manual

Marine Engines
MD22A, MD22L-A, MD22L-B, MD22P-B, TMD22A, TMD22-A, TMD22-B, TMD22P-C, TAMD22P-B

Specifications, Technical Data

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Safety information

Introduction

This Workshop Manual contains technical data, 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 engine, 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, for example certain adjustments, 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 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 ventilated out of the working 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. Your eyes are very sensitive. Injury can lead to loss of sight!

⚠ Avoid skin contact with oil! Long-term or repeated contact with oil can remove the natural oils from your skin. The result can be 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 breathing them in for example). Ensure that ventilation is good. Handle used and excess chemicals according to 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 battery connections when starting the engine (spark risk) and do not lean over batteries.

⚠ Always ensure that the Plus (positive) and Minus (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 wiring diagrams.

⚠ 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 technical specifications, 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 that show certain parts on the engines, 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. 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. Persons using this book are assumed to have a grounding in marine drive systems and be able to carry out 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.

Specifications

Technical Data: General

No. of cylinders	4
Cylinder configuration	In-line engine
Cycle	Four stroke
Intake system	Naturally aspirated engine or turbocharged
Combustion system	Direct injection
Cylinder bore	84.5 mm
Cylinder stroke	88.9 mm
Compression ratio	
MD22	18.1:1
MD22L	17.0:1
MD22P, TMD22	18.0:1
TAMD22	17.5:1
Compression at starter motor speed	2100-3500 kPa
Overall cylinder displacement	1.994 liters
Firing order	1-3-4-2
Valve clearances, cold engine:*	
– Intake	0.25-0.35 mm
– Exhaust	0.35-0.45 mm

* Only adjust if the clearance is outside the limits:

– Intake	0.20-0.40 mm
– Exhaust	0.30-0.50 mm

When the cylinder head screws are tightened, the valve clearance reduces by 0.05 mm. If the valve clearance is checked when the cylinder head is not tightened against the cylinder block, the clearances must be as follows:

– Intake	0.30/0.40 mm
– Exhaust	0.40/0.50 mm

If the valve clearance is checked when the cylinder head is not tightened, use the clearances below when calculating shims:

– Intake	0.35 mm
– Exhaust	0.45 mm

Lubricating oil pressure (minimum value at maximum engine speed (RPM) and normal engine coolant temperature (ECT))	250 kPa
Direction of rotation	Clockwise, viewed from in front

Cylinder block

Pistons

Type	"Swirl lip" combustion chamber, controlled expansion, insert for top ring groove, center displaced piston pin
Diameter at piston bolt hole	28.004-28.010 mm
Distance between height classes	
Production class 1 to 6	0.05 mm
Service classes 3 and 6	0.15 mm
Piston height over cylinder block surface	0.46-0.65 mm
Height of groove for the upper ring	
MD22L, MD22, TMD22	2.10-2.12 mm
TMD22P, TAMD22	3.5 mm
Height of groove for the 2nd ring	
MD22L, MD22, TMD22	1.81-1.83 mm
TMD22P, TAMD22	2.06-2.08 mm
Height of groove for the 3rd ring	3.03-3.05 mm
Oversized piston	0.50 mm at the diameter

Piston rings

Upper compression ring	
MD22L, MD22, TMD22	Thin shaped (barrel face),molybdenum insert, internal face on top surface.
TMD22P, TAMD22	Keystone ring
2nd compression ring	Conical surface, alloy cast iron
Oil scraper ring	Spring-loaded, chromed surface
Height,	
upper ring	1.978-1.990 mm
2nd ring	1.73-1.74 mm
3rd ring	2.98-2.99 mm
Play in groove	
upper ring	0.11-0.14 mm
2nd ring	0.07-0.10 mm
3rd ring	0.04-0.07 mm
Ring gap	
upper ring MD22L, MD22, TMD22	0.28-0.56 mm
upper ring TMD22P, TAMD22	0.30-0.50 mm
2nd ring MD22L, MD22, TMD22	0.28-0.56 mm
2nd ring TMD22P, TAMD22	0.60-0.80 mm
3rd ring	0.23-0.56 mm

Piston bolts

Type	Moving
Outer diameter	27.995-28.000 mm
Play in piston bolt position, piston	0.004-0.015 mm

Cylinder block

Height between the cylinder head surface and contact surface for the bearing cap	236.85-236.98 mm
Cylinder bore	84.442-84.469 mm
Maximum permitted wear, cylinder bore	0.15 mm
Oversize, cylinder bore	84.942-84.969 mm
Diameter, bearing recess for main bearings	60.703-60.719 mm

Cylinder head

Valve seat angle	45°
Diameter of hole for camshaft	48.018-48.057 mm
Diameter of hole for valve guides	11.98-12.00 mm
Diameter of hole for valve lifter	31.750-31.775 mm
Pressure during leak test	200 kPa
Maximum permitted cylinder head out-of-true	0.10 mm
Cylinder head height	
MD22L, MD22, TMD22	120.0-120.1 mm
TMD22P, TAMD22	119.4-119.5 mm
Permitted machining of cylinder head surface	
MD22L, MD22, TMD22	0.20 mm (cylinder head minimum height 119.85 mm)
TMD22P, TAMD22	0.20 mm (cylinder head minimum height 119.25 mm)

Crank movement

Crankshaft

Diameter, main bearing journals	56.99-57.01 mm
Maximum permitted play and ovality for main bearing journals:	0.03 mm
Width,	
front bearing journal	27.9-28.6 mm
center bearing journal	32.35-32.43 mm
other bearing journals	30.5-31.1 mm
Diameter, big end journals	53.99-54.01 mm
Maximum permitted play and ovality for big end journals:	0.03 mm
Width, big end journals	27.45-27.65 mm
Crankshaft, axial clearance	0.03-0.26 mm
Diameter, rear flange	88.84-88.95 mm
Maximum permitted diameter, rear flange (service)	88.59 mm
Front stuffing box diameter	34.965-34.995 mm
Minimum permitted diameter, front stuffing box (service)	34.72 mm
Diameter, camshaft pulley	31.98-32.00 mm
Diameter, socket for guide bearing	28.58-28.60 mm
Depth, socket for guide bearing	20.8 mm
Lower dimensions, main bearings and big end journals	-0.30 mm

Main bearing shells

Type	Steel coated, aluminum tin
Bearing width,	
center bearing	24.27-24.52 mm
other bearings	22.35-22.60 mm
Bearing thickness	1.828-1.835 mm
Inner diameter	57.033-57.063 mm
Bearing clearance	0.023-0.073 mm
Permissible lower dimensions of bearings	-0.30 mm

Big end bearing shells

Type	Steel coated, copper-lead
Thickness	1.815-1.825 mm
Inner diameter	54.033-54.066 mm
Bearing clearance	0.023-0.076 mm
Permissible lower dimensions of bearing shells	-0.30 mm

Crankshaft thrust washers

Type	Steel coated, aluminum solder
Position	Both sides of the center bearing
Thickness	2.31-2.36 mm

Connecting rods

Type	H-section
Diameter, bearing position of the big end shells	57.683-57.696 mm
Diameter, bearing position of the connecting rod bushing	30.93-30.96 mm
Distance between bearing centers	144.98-145.03 mm

Connecting rod bushing

Type	Steel coated, lead bronze
Inner diameter (reamed)	28.005-28.018 mm
Clearance between connecting rod bushing and piston bolt	0.05-0.023 mm

Alignment of connecting rod (A)

The holes for the big end bearing shells and the connecting rod bushing must be at right angles and parallel with each other within a ± 0.25 mm tolerance, measured with a mandrel at a distance of 127 mm on each side of the connecting rod. With the connecting rod bushing installed, the tolerance is reduced to ± 0.06 mm.

Flywheel

Maximum radial runout	0.30 mm total read off on the dial indicator
Max. axial runout for every 25th mm radial clearance between the crankshaft and the gauge tip on the indicator.	0.03 mm total read off on the dial indicator

Flywheel cover

Concentric and parallel limits	0.15 mm total read off on the dial indicator

Valve mechanism

Valve guides

Inner diameter (reamed in position)	7.450-7.463 mm
Outer diameter	12.04-12.06 mm
Valve guide interference in cylinder head	0.04-0.08 mm

Intake valves

Valve stem diameter	7.41-7.42 mm
Clearance valve stem – valve guide	0.03-0.05 mm
Maximum permitted clearance valve stem – valve guide	0.13 mm
Valve crown diameter	37.10-37.25 mm
Valve contact angle	44° 30´ (91° total angle)
Total length	93.72 - 93.97 mm
Sealing equipment	Rubber seal installed on the valve guide.
Valve crown depth position under cylinder head face	
MD22L, MD22, TMD22	0.90-1.24 mm
TMD22P, TAMD22	0.25-0.59 mm

Exhaust valves

Valve stem diameter	7.39-7.41 mm
Clearance valve stem – valve guide	0.04-0.07 mm
Maximum permitted clearance valve stem – valve guide	0.13 mm
Valve crown diameter	33.55-33.70 mm
Valve contact angle	44° 30´ (91° total angle)
Total length	93.72- 93.97 mm
Sealing equipment	Rubber seal installed on the valve guide.
Valve crown depth position under cylinder head face	
MD22L, MD22, TMD22	1.30-1.64 mm
TMD22P, TAMD22	0.65-0.91 mm

Valve springs

Installed length	34.7 mm
Spring loading when installed	198 N
Number of active spring coils	4.5
Number of damper coils	0
Direction of winding	Left
Color coding	Orange

Valve lifters and shims

Material	Steel
Outer diameter of valve lifter	31.725-31.745 mm
Valve lifter clearance in cylinder head	0.005-0.050 mm
Thickness of the head of the valve lifter	6.85-6.93 mm
Total length	25.7-26.3 mm
Thickness of shims	Series of shims from 2.286 mm to 3.400 mm

Camshaft

Diameter of front and rear bearing journal	47.693-47.975 mm
Diameter of center bearing journal	47.958-47.975 mm
Clearance of the bearing journals in the holes:	
– Front and rear	0.043-0.094 mm
– Center	0.043-0.099 mm
Diameter of pulley hub	36.58-36.61 mm
Cam lift, at 0 mm valve clearance (intake/exhaust)	
MD22L	9.1/9.4 mm
MD22P, TMD22, TAMD22	9.6/9.6 mm
Axial clearance	0.11-0.27 mm
Maximum permitted axial clearance in operation	0.50 mm
Depth of socket for thrust washer	6.06-6.12 mm

Camshaft thrust washer

Type	180° washer installed in camshaft cover
Thickness	5.90-5.95 mm
Installation parameter for thrust washer in socket in camshaft cover	± 0.05 mm

Pulley for crankshaft

Number of teeth	24
Hole diameter	32.010-32.035 mm
Pulley clearance on crankshaft	0.010-0.055 mm

Pulley and hub for crankshaft

Number of teeth	48
Hole diameter in hub	36.62-36.65 mm
Hub clearance on crankshaft	0.01-0.07 mm

Pulley for fuel injection pump

Number of teeth	48
Hole	Conical
Setting tooth and marking letter	
MD22, MD22L	"A"
TMD22, TAMD22	"B"

Idler pulley for timing belt

Outer diameter	79.8-80.2 mm
Internal radial clearance	0.005-0.025 mm

Tension pulley for timing belt

Outer diameter	59.8-60.2 mm
Internal radial clearance	0.005-0.025 mm
Timing belt tension (according to gauge)	
New belt	425-465 N
If the tension of the existing (used) belt has fallen to 270 N or lower, adjust to	340-370 N

Lubrication system

Lubricating oil pump

Type	Differential rotor, installed around the front end of the crankshaft
Number of teeth	Inner rotor 10, outer rotor 11
Clearance,	
outer rotor-housing	0.30-0.36 mm
inner rotor-outer rotor	0.025-0.082 mm
Axial clearance,	
inner rotor	0.030-0.075 mm
outer rotor	0.05-0.10 mm

Relief valve, oil pressure

Valve opening pressure	414 kPa
Hole diameter, control sleeve	14.21-14.25 mm
Outer diameter, plunger	14.160-14.186 mm
Clearance plunger-sleeve	0.024-0.090 mm
Spring length (integrated)	30.4 mm
Spring loading (integrated)	51.1 N

Fuel system

Injection pump

Make	Bosch
Type	EPVE
Rotational direction, (viewed from drive end)	Clockwise
Exit point for cylinder 1	"A"
Pump element lift, motor TDC	
MD22	1.37 ±0.02 mm
MD22L	1.42 ±0.02 mm
TMD22	1.26 ±0.02 mm
TMD22P	1.22 ±0.02 mm
TAMD22	1.10 ±0.02 mm

Injector

Opening pressure,	
MD22L (Code RG)	22.8+10 MPa
MD22 (Code JD)	22.8+10 MPa
TMD22 (Code JC)	22.8 ±5 MPa
TMD22P, TAMD22 (Code RY)	23.5 ±5 MPa

Feed pump

Type	A.C. Delco, type YD
Drive method	Eccentric from camshaft
Static pressure (no power supply)	41-69 kPa

Fuel filter

Make	Bosch
Type	Spin-on

Turbocharging system

Turbocharger (TC)

Make	Garret
Lubrication system	Force-feed lubrication from the engine

Cooling system

Circulation pump

Type	Centrifugal pump, belt driven

Sea water pump

Make	Jabsco
Type	Rubber impeller
Drive	Belt drive

Thermostat

Type	Wax filled thermostat, by-pass version
Starts opening at	77°-85°C
Fully open at	92°-98°C
Valve lift height, fully open	9.1 mm

Electrical system

Generator

Make	Valeo
Type	A13N 147M
Marking data	12V/60A (early version 12V/50A)
Direction of rotation	Clockwise, viewed from drive end

Starter motor

Make	Lucas
Type	M80R
Voltage	12V
Number of teeth on the drive	10
Maximum resistance of engine starter cable at 20°C	0.0017 ohm
Brush length:	
New	9.0 mm
Minimum permissible, used	3.5 mm

Glow plugs

Make	Bosch
Current after 20 seconds	12A
Probe length	23 mm

Tightening torque

	Thread	Torque (Nm)*
Cylinder head assembly		
Bolts, cylinder head	M 12	(see next page)
Bolts, camshaft cover	M 8	22
Piston and connecting rod assembly		
Nuts, big ends	11/32 UNF	47
Crankshaft assembly		
Screws, main bearing	M 12	112
Screws, crankshaft pulleys	M 14	180
Domed screws, crankshaft pulley	M 6	10
Screws, housing for rear stuffing box	M 10	43
Timing cover and drive		
Screws, timing cover	M 5	3
	M 6	6
	M 8	10
Screws, hub for camshaft pulley	M 12	85
Screws, camshaft pulley to hub	M 8	22
Domed screw, tension pulley	M 10	43
Screws, idler pulley	M 10	43
Intake system		
Screws, intake and exhaust manifold	M 8	22
Lubrication system		
Plug, lubricating oil sump	1/4 BSP	43
Screws, lubricating oil pump	M 6	9
	M 8	22
Screws, rear face of oil pump	M 4	4
Screws, filter head to oil pump	M8	22
Screws, lubricating oil sump	M 6	12
Fuel injection system		
Nuts, high pressure fuel lines	M 12	18
Screws, injector holder	M 10	43
Fuel feed pump screws	M 8	22
Screws, mounting bracket for fuel injection pump	M 10	43
Nut, pulley for injector pump	M 14	60
Nuts for flange for fuel injection pump	M 8	22
Cooling system		
Screws, water pump	M 8	22
	M10	48
Screws, seawater pump	M 6	9
Domed screws, drive adapter for seawater pump	M 6	9
	M 10	43
Flywheel and flywheel housing		
Screws, flywheel to crankshaft	7/16 UNF	65
Screws, flywheel housing	M8	22
	M 10	43
	M 12	81
Electrical system		
Nuts, generator (GEN) pulley	M 17	60
Glow plugs	M 12	20

* The above tightening torques apply to components lightly lubricated with clean engine oil prior to installation.

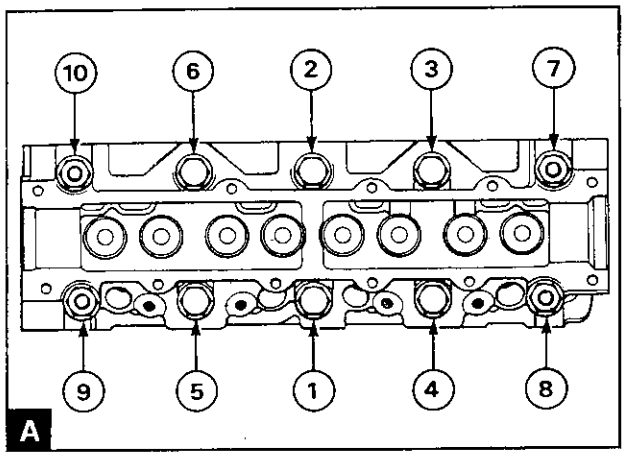
Cylinder head screws

Tighten the screws in 3 stages according to diagram A.

1st tightening: 50 Nm

2nd tightening: 100 Nm

3 rd tighten by 90° in one operation



Tightening diagram