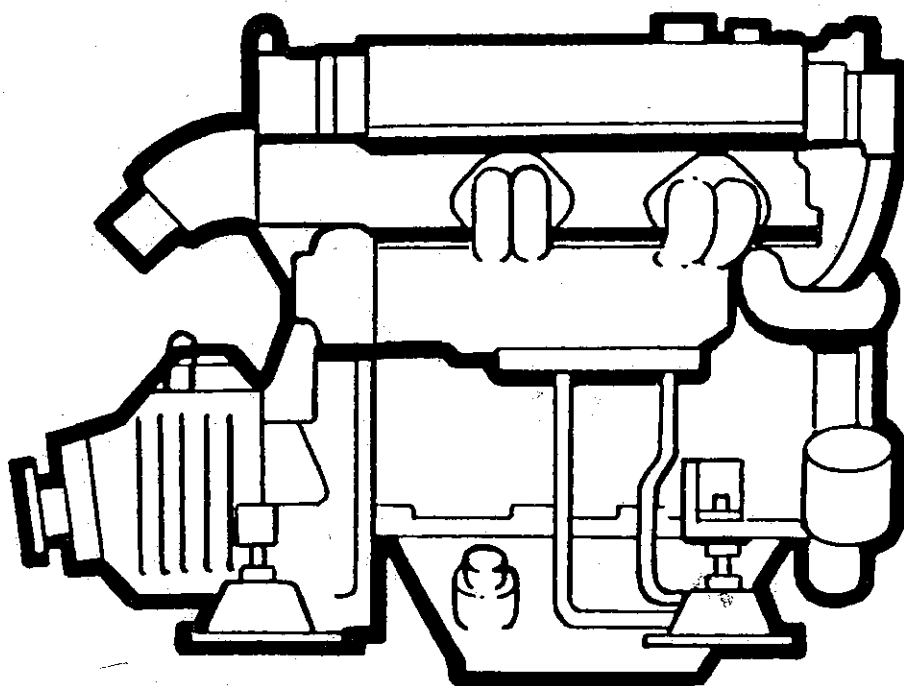


Workshop Manual

MD22L, MD22, TMD22



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General information

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Introduction

This workshop manual has been designed to provide assistance in the service and overhaul of Volvo Penta MD22.

When reference is made to the "left" or "right" side of the engine, this is as seen from the flywheel end of the engine.

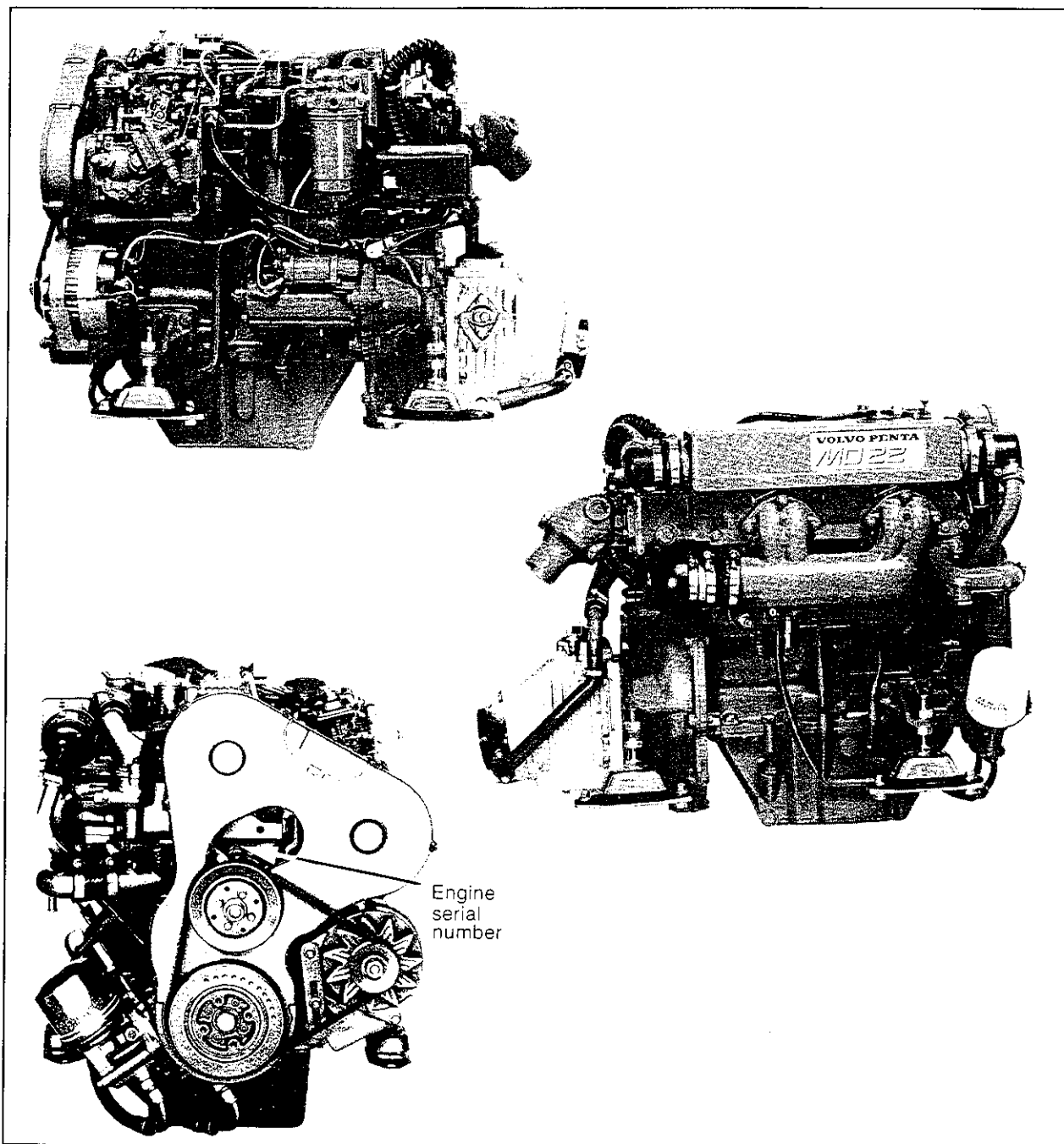
Special tools have been made available and a list of these is given in section 23. Reference to relevant special tools is also made at the beginning of each operation.

All the joints on these engines can be fitted dry unless instructions are given for the application of sealant. Where fasteners are fitted into threaded holes which are open to the inside of the engine, manifolds, etc., a suitable sealant must be applied to the threads. If necessary, sealant is already applied to new fasteners but, if these are used more than once, the threads should be cleaned and new sealant applied.

Read and remember the "Safety precautions". They are given for your protection and must be used at all times.



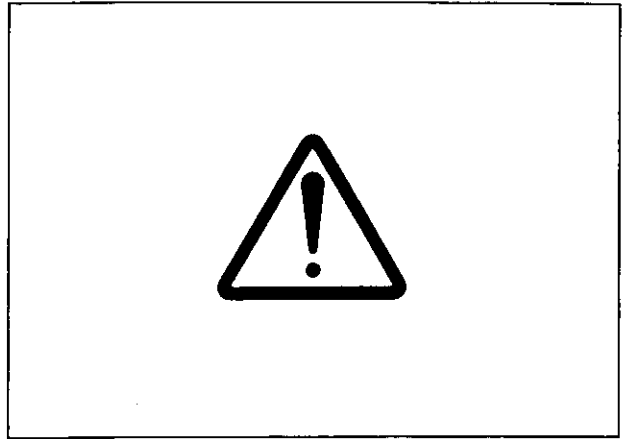
A hazard symbol in the text indicates that there is a danger of personal injury if certain operations are not done correctly.



Safety precautions

These safety precautions are important. You must refer also to the local regulations in the country of use. Some items only apply to specific applications.

- Do not change the specification of the engine.
- Do not smoke when you put fuel in the tank.
- Clean away fuel which has been spilt. Material which has been contaminated by fuel must be moved to a safe place.
- Do not put fuel in the tank while the engine runs (unless it is absolutely necessary).
- Do not clean, add lubricating oil, or adjust the engine while it runs (unless you have had the correct training; even then extreme caution must be used to prevent injury).
- Do not make adjustments that you do not understand.
- Ensure that the engine does not run in a location where it can cause a concentration of toxic emissions.
- Other persons must be kept at a safe distance while the engine, or equipment, is in operation.
- Do not permit loose clothing or long hair near moving parts.
- Keep away from moving parts during engine operation.
Attention: Some moving parts cannot be seen clearly while the engine runs.
- Do not operate the engine if a safety guard has been removed.
- Do not remove the filler cap of the cooling system while the engine is hot and while the coolant is under pressure, because dangerous hot coolant can be discharged.
- Do not use salt water or any other coolant which can cause corrosion in the closed coolant circuit.
- Do not allow sparks or fire near the batteries (especially when the batteries are on charge) because the gases from the electrolyte are highly flammable. The battery fluid is dangerous to the skin and especially to the eyes.
- Disconnect the battery terminals before a repair is made to the electrical system.
- Only one person must control the engine.
- Ensure that the engine is operated only from the control panel or from the operator's position.
- If your skin comes into contact with high-pressure fuel, obtain medical assistance immediately.
- Diesel fuel and lubricating oil (especially used lubricating oil) can damage the skin of certain persons. Protect your hands with gloves or a special solution to protect the skin.
- Do not wear clothing which is contaminated by lubricating oil. Do not put material which is contaminated with oil into the pockets.
- Discard used lubricating oil in a safe place to prevent contamination.
- Use extreme care if emergency repairs must be made at sea or in adverse conditions.
- Read and use the instructions relevant to asbestos joints.



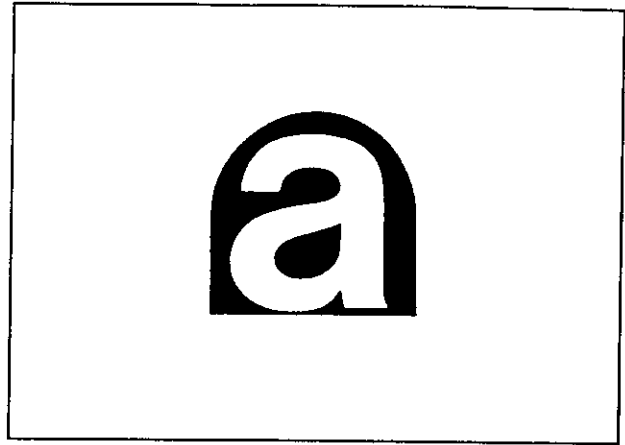
Asbestos joints

Some joints and gaskets contain compressed asbestos fibres in a rubber compound or in a metal outer cover. The "white" asbestos (Chrysotile) which is used is a safer type of asbestos and the risk of damage to health is extremely small.

The risk of asbestos from joints occurs at their edges or if a joint is damaged when a component is removed or if a joint is removed by abrasion.

To ensure that the risk is kept to a minimum, the procedures given below must be applied when an engine which has asbestos joints is dismantled or assembled.

- Work in an area with good ventilation
- Do not smoke
- Use a hand scraper to remove the joints — do not use a rotary wire brush
- Ensure that the joint to be removed is wet with oil or water to contain loose particles.
- Spray all asbestos debris with water and put it in a closed container which can be sealed for safe disposal.



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Basic engine data

11A

Basic engine data 11A.02

Basic engine data

Number of cylinders	4
Cylinder arrangement	In-line
Cycle	Four stroke
Induction system	Naturally aspirated or turbocharged
Combustion system	Direct injection
Nominal bore	84,5 mm (3.33 in)
Stroke	88,9 mm (3.50 in)
Compression ratio	18.1:1
Compression pressure at starter motor speed	2,1—3,5 MPa (21—35 kp/cm ²)
Cubic capacity	1,994 litres (122 in ³)
Firing order	1, 3, 4, 2
Tappet clearances (cold):*	
— Inlet	0,25/0,35 mm (0.010/0.014 in)
— Exhaust	0,35/0,45 mm (0.014/0.018 in)
* Adjust only if clearances are outside limits of:	
— Inlet	0,20/0,40 mm (0.008/0.016 in)
— Exhaust	0,30/0,50 mm (0.012/0.020 in)
When the cylinder head fasteners are tightened, the tappet clearances are reduced by 0,05 mm (0.002 in). Therefore, if the tappet clearances are checked with the cylinder head not fastened to the cylinder block, the correct clearances will be as shown below:	
— Inlet	0,30/0,40 mm (0.012/0.016 in)
— Exhaust	0,40/0,50 mm (0.016/0.020 in)
If the tappets are adjusted with the head not fastened, use the clearances given below when the shim calculations are made:	
— Inlet	0,35 mm (0.014 in)
— Exhaust	0,45 mm (0.018 in)
Lubricating oil pressure (minimum at maximum engine speed and normal engine temperature)	250 kN/m ² (36 lbf/in ²) 2,5 kgf/cm ²
Direction of rotation	Clockwise from the front

Recommended torque tensions

11B

Cylinder head assembly	11B.02
Piston and connecting rod assemblies	11B.02
Crankshaft assembly	11B.02
Timing case and drive assembly	11B.02
Aspiration system	11B.02
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Cooling system	11B.02
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Electrical equipment	11B.03

Recommended torque tensions

The torque tensions below apply to components lubricated lightly with clean engine oil before they are fitted.

Description	Thread size	Torque		
		Nm	lbf ft	kgf m
Cylinder head assembly				
Setscrews, cylinder head	M12	See section 12		
Setscrews, camshaft cover	M8	22	16	2,2
Piston and connecting rod assemblies				
Nuts, connecting rod big ends	11/32 UNF	47	35	4,8
Crankshaft assembly				
Setscrews, main bearings	M12	112	83	11,4
Setscrews, crankshaft pulleys	M14	180	133	18,4
Cap screws, crankshaft pulley	M6	10	7	1,0
Setscrews, rear oil seal housing	M10	43	32	4,4
Timing case and drive assembly				
Setscrews, timing case	M5	3	2	0,3
	M6	6	4	0,6
	M8	10	7	1,0
Setscrews, hub of camshaft pulley	M12	85	63	8,7
Setscrews, camshaft pulley to hub	M8	22	16	2,2
Cap screw, tensioner pulley	M10	43	32	4,4
Setscrew, idler pulley	M10	43	32	4,4
Aspiration system				
Setscrews, inlet and exhaust manifolds	M8	22	16	2,2
Lubrication system				
Plug, lubricating oil sump	1/4 BSP	43	32	4,4
Setscrews, lubricating oil pump	M6	9	7	0,9
	M8	22	16	2,2
Screws, backplate to oil pump	M4	4	3	0,4
Setscrews, filter head to oil pump	M8	22	16	2,2
Setscrews, lubricating oil sump	M6	12	9	1,2
Fuel system				
Nuts, high-pressure fuel pipes	M12	18	13	1,8
Setscrews, atomiser clamps	M10	43	32	4,4
Setscrews, fuel lift pump	M8	22	16	2,2
Setscrews, mounting bracket for fuel injection pump	M10	43	32	4,4
Nut, pulley to fuel injection pump	M14	60	44	6,1
Nuts for flange of fuel injection pump	M8	22	16	2,2
Cooling system				
Setscrews, water pump	M8	22	16	2,2
	M10	48	35	4,9
Setscrews, raw water pump	M6	9	7	0,9
Cap screws, drive adaptor for raw water pump	M6	9	7	0,9
	M10	43	32	4,4

Description	Thread size	Torque		
		Nm	lbf ft	kgf m
Flywheel and housing				
Setscrews, flywheel to crankshaft	7/16 UNF	65	48	6.6
Setscrews, flywheel housing	M8	22	16	2,2
	M10	43	32	4,4
	M12	81	60	8,3
Electrical equipment				
Nut, alternator pulley	M17	60	44	6,1
Glow plug	M12	20	15	2,0

Data and dimensions

11C

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Fuel system	11C.09
Cooling system	11C.10
Flywheel and housing	11C.10
Electrical equipment	11C.11

Introduction

This information is given as a guide for personnel engaged on engine overhauls. The dimensions which are shown are those which are mainly used in factory.

Cylinder head assembly

Cylinder head

Angle of valve seats	45°
Diameter of bores for camshaft	48,018/48,057 mm (1.890/1.892 in)
Diameter of parent bores for valve guides	11,98/12,00 mm (0.4716/0.4724 in)
Diameter of bores for tappets	31,750/31,775 mm (1.250/1.251 in)
Leak test pressure	200 kPa (29 lbf/in ²) 2,04 kgf/cm ²
Maximum permissible distortion of cylinder head	0,10 mm (0.004 in)
Head thickness	120,0/120,1 mm (4.724/4.728 in)
Permissible amount to machine from cylinder head face	0,20 mm (0.008 in) — depth of head must not be less than 119,85 mm (4.718 in)

Valve guides

Inside diameter (reamed in position)	7,450/7,463 mm (0.2933/0.2938 in)
Outside diameter	12,04/12,06 mm (0.474/0.475 in)
Interference fit of valve guide in cylinder head	0,04/0,08 mm (0.0016/0.0031 in)
Protrusion above location face for valve spring	10 mm (0.39 in)

Inlet valves

Diameter of valve stem	7,41/7,42 mm (0.2917/0.2922 in)
Clearance in valve guide	0,03/0,05 mm (0.001/0.002 in)
Maximum permissible clearance in valve guide	0,13 mm (0.005 in)
Diameter of valve head	37,10/37,25 mm (1.461/1.467 in)
Angle of valve face	44° 30' (91° included angle)
Depth of valve head below face of cylinder head	0,90/1,24 mm (0.035/0.049 in)
Overall length	93,72/93,97 mm (3.690/3.700 in)
Seal arrangement	Rubber seal fitted to valve guide

Exhaust valves

Diameter of valve stem	7,39/7,41 mm (0.2909/0.2917 in)
Clearance in valve guide	0,04/0,07 mm (0.0016/0.0028 in)
Maximum permissible clearance in valve guide	0,13 mm (0.005 in)
Diameter of valve head	33,55/33,70 mm (1.321/1.327 in)
Valve face angle	44° 30' (91° included angle)
Depth of valve head below face of cylinder head	1,30/1,64 mm (0.051/0.065 in)
Overall length	93,72/93,97 mm (3.690/3.700 in)
Seal arrangement	Rubber seal fitted to valve guide

Valve springs

Fitted length	34,7 mm (1.37 in)
Load at fitted length	198 N (44.5 lbf) 20,2 kgf
Number of active coils	4,5
Number of damper coils	0
Direction of coils	Left hand
Identification colour	Orange

Tappets and shims

Material	Steel
Outside diameter of tappet	31,725/31,745 mm (1.2490/1.2498 in)
Clearance of tappet in cylinder head	0,005/0,050 mm (0.0002/0.0020 in)
Thickness of tappet head	6,85/6,93 mm (0.270/0.273 in)
Overall length	25,7/26,3 mm (1.01/1.04 in)
Shim thickness	Range of 45 shims from 2,286 mm (0.090 in) to 3,400 mm (0.134 in) in grads of 0,025 mm (0.001 in)

Camshaft

Diameter of front and rear journals	47,693/47,975 mm (1.8883/1.8888 in)
Diameter of centre journal	47,958/47,975 mm (1.8881/1.8888 in)
Clearance of journals in bores:	
— Front and rear	0,043/0,094 mm (0.0017/0.0037 in)
— Centre	0,043/0,099 mm (0.0017/0.0039 in)
Diameter for pulley hub	36,58/36,61 mm (1.440/1.441 in)
Cam lift:	
— Inlet and exhaust	9,544/9,724 mm (0.3757/0.3828 in)
End-float	0,11/0,27 mm (0.004/0.011 in)
Maximum permissible end-float in service	0,50 mm (0.020 in)
Width of recess for thrust washer	6,06/6,12 mm (0.239/0.241 in)

Camshaft thrust washer

Type	180° washer fitted in camshaft cover
Thickness	5,90/5,95 mm (0.232/0.235 in)
Transition fit of thrust washer in camshaft cover recess	±0,05 mm (±0.002 in)

Piston and connecting rod assemblies

Pistons

Type	"Swirl lip" combustion bowl, controlled expansion, insert for top ring groove, off centre gudgeon pin
Diameter of bore for gudgeon pin	28,004/28,010 mm (1.1025/1.1028 in)
Difference between height grades:	
— Production grades 1 to 6	0,05 mm (0.002 in)
— Service grades 3 and 6	0,15 mm (0.006 in)
Height of piston above top face of cylinder block	0,46/0,65 mm (0.018/0.026 in)
Width of groove for top ring	2,10/2,12 mm (0.0827/0.0835 in)
Width of groove for second ring	1,81/1,83 mm (0.071/0.072 in)
Width of groove for third ring	3,03/3,05 (0.119/0.120 in)
Oversize piston	0,50 mm (0.020 in) on diameter

Piston rings

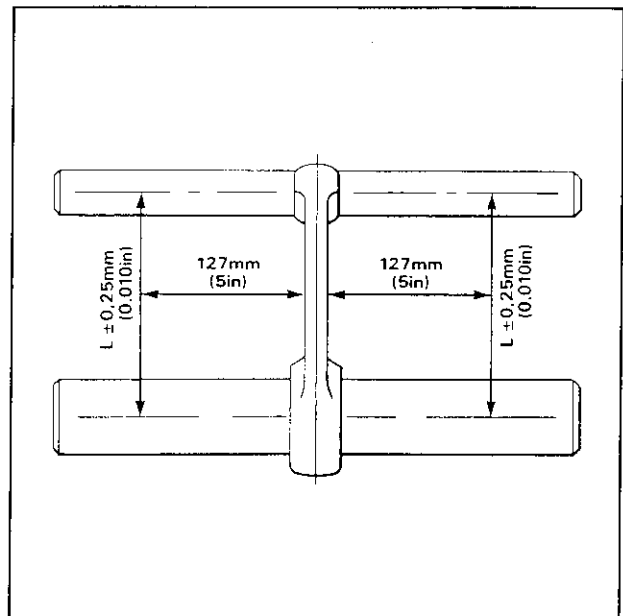
Top compression ring	Barrel face, molybdenum insert, internal chamfer in top face
Second compression ring	Taper face, cast iron
Oil scraper ring	Coil spring loaded, chromium faced
Width of top ring	1,978/1,990 mm (0.0778/0.0783 in)
Width of second ring	1,73/1,74 mm (0.068/0.069 in)
Width of third ring	2,98/2,99 mm (1.117/1.118 in)
Clearance of top ring in groove	0,11/0,14 mm (0.004/0.006 in)
Clearance of second ring in groove	0,07/0,10 mm (0.003/0.004 in)
Clearance of third ring in groove	0,04/0,07 mm (0.002/0.003 in)
Gap of top ring	0,28/0,56 mm (0.011/0.022 in)
Gap of second ring	0,28/0,56 mm (0.011/0.022 in)
Gap of third ring	0,23/0,56 mm (0.009/0.022 in)

Connecting rods

Type	"H" section
Diameter of parent bore for big end	57,683/57,696 mm (2.2710/2.2715 in)
Diameter of parent bore for small end	30,93/30,96 mm (1.218/1.219 in)
Length between centres	144,98/145,03 mm (5.708/5.710 in)

Connecting rod alignment (A)

The large and small end bores must be square and parallel with each other within the limits of $\pm 0,25$ mm (0.010 in) measured 127 mm (5.0 in) each side of the connecting rod axis on a test mandrel. With the small end bush fitted, the limits are reduced to $\pm 0,06$ mm (0.0025 in).



Gudgeon pins

Type	Fully floating
Outside diameter	27,995/28,000 mm (1.1022/1.1024 in)
Clearance fit in piston boss	0,004/0,015 mm (0.0002/0.0006 in)

Small end bushes

Type	Steel back, lead bronze bearing material
Inside diameter (reamed)	28,005/28,018 mm (1.1026/1.1031 in)
Clearance between small end bush and gudgeon pin	0,005/0,023 mm (0.0002/0.009 in)

Connecting rod bearings

Type	Steel back, copper lead bearing material
Thickness	1,815/1,825 mm (0.0715/0.0719 in)
Inside diameter	54,033/54,066 mm (2.1273/2.1286 in)
Bearing clearance	0,023/0,076 mm (0.001/0.003 in)
Available undersize bearings	−0,30 mm (−0.012 in)

Crankshaft assembly**Crankshaft**

Diameter of main journals	56,99/57,01 mm (2.2437/2.2445 in)
Maximum permissible wear and ovality of main journals	0,03 mm (0.001 in)
Width of front journal	27,9/28,6 mm (1.10/1.13 in)
Width of centre journal	32,35/32,43 mm (1.724/1.727 in)
Width of all other journals	30,5/31,1 mm (1.20/1.22 in)
Diameter of crank pins	53,99/54,01 mm (2.1256/2.1264 in)
Maximum permissible wear and ovality of crank pins	0,03 mm (0.001 in)
Width of crank pins	27,45/27,65 mm (1.081/1.089 in)
Crankshaft end-float	0,03/0,26 mm (0.001/0.010 in)
Diameter of rear flange	88,84/88,95 mm (3.498/3.502 in)
Minimum permissible diameter of rear flange (service)	88,59 mm (3.488 in)
Diameter of front oil seal	34,965/34,995 mm (1.3766/1.3778 in)
Minimum permissible diameter for front oil seal (service)	34,72 mm (1.367 in)
Diameter of toothed pulley	31,98/32,00 mm (1.259/1.260 in)
Diameter of recess for spigot bearing	28,58/28,60 mm (1.125/1.126 in)
Depth of recess for spigot bearing	20,8 mm (0.82 in)
Undersize journals and crank pins	—0,30 mm (—0.012 in)

Main bearings

Type	Steel back, aluminium tin bearing material
Bearing width, centre bearing	24,27/24,52 mm (0.956/0.965 in)
Bearing width, all other bearings	22,35/22,60 mm (0.880/0.890 in)
Bearing thickness	1,828/1,835 mm (0.0720/0.0722 in)
Inside diameter	57,033/57,063 mm (2.2454/2.2466 in)
Bearing clearance	0,023/0,073 mm (0.001/0.003 in)
Available undersize bearings	—0,30 mm (—0.012 in)

Crankshaft thrust washers

Type	Steel back, aluminium tin bearing material
Position	Each side of centre main bearing
Thickness	2,31/2,36 mm (0.091/0.093 in)

Timing case and drive assembly**Toothed pulley for crankshaft**

Number of teeth	24
Diameter of bore	32,010/32,035 mm (1.2602/1.2612 in)
Clearance fit of pulley on crankshaft	0,010/0,055 mm (0.0004/0.0022 in)

Toothed pulley and hub for crankshaft

Number of teeth	48
Diameter of bore in hub	36,62/36,65 mm (1.442/1.443 in)
Clearance fit of hub on camshaft	0,01/0,07 mm (0.0004/0.0028 in)

Toothed pulley for fuel injection pump

Number of teeth	48
Bore	Tapered
Timing tooth and keyway letter	"A" (MD22, MD22L)
Timing tooth and keyway letter	"B" (TMD22)

Idler pulley for timing belt

Outside diameter	79,8/80,2 mm (3.14/3.16 in)
Radial internal clearance	0,005/0,025 mm (0.0002/0.0010 in)

Tensioner pulley for timing belt

Outside diameter	59,8/60,2 mm (2.35/2.37 in)
Radial internal clearance	0,005/0,025 mm (0.0002/0.0010 in)
Timing belt tension (gauge):	
— New belt	95/105 lbf
— Used belt	80 lbf

Cylinder block assembly**Cylinder block**

Height between top face and location face for bearing cap ..	236,85/236,98 mm (9.325/9.330 in)
Cylinder bore diameter	84,442/84,469 mm (3.3245/3.3256 in)
Maximum permissible wear in bore	0,15 mm (0.006 in)
Oversize cylinder bore diameter	84,942/84,969 mm (3.3442/3.3452 in)
Diameter of parent bore for main bearing	60,703/60,719 mm (2.3899/2.3905 in)

**Lubrication system****Lubricating oil pump**

Type	Differential rotor, fitted around nose of crankshaft
Number of lobes	Inner rotor 10, outer rotor 11
Outer rotor to body clearance	0,30/0,36 mm (0.012/0.014 in)
Inner rotor to outer rotor clearance	0,025/0,082 mm (0.001/0.003 in)
Inner rotor end clearance	0,030/0,075 mm (0.001/0.003 in)
Outer rotor end clearance	0,05/0,10 mm (0.002/0.004 in)

Oil pressure relief valve

Valve open pressure	414 kPa (60 lbf/in ²) 4,2 kgf/cm ²
Bore diameter of sleeve	14,21/14,25 mm (0.5594/0.5610 in)
Outside diameter of plunger	14,160/14,186 mm (0.5575/0.5585 in)
Clearance of plunger in sleeve	0,024/0,090 mm (0.0009/0.0035 in)
Length of spring (fitted)	30,4 mm (1.2 in)
Load on spring (fitted)	51,1 N (11.5 lbf) 5,2 kgf

Fuel system**Fuel injection pump**

Make	Bosch
Type	EPVE
Direction of rotation (from drive end)	Clockwise
Outlet for number 1 cylinder	"A"
Plunger lift at engine TDC (MD22)	1,37 mm (0.054 in)
Plunger lift at engine TDC (MD22L)	1,42 mm (0.056 in)
Plunger lift at engine TDC (TMD22)	1,17 mm (0.046 in)

Atomisers

Code	Holder	Nozzle	Set and reset pressure		
			atm	lbf/in ²	MPa
JC	LRB67030	JB6801061	225	3310	22,8
JD	LRB67030	JB6801062	225	3310	22,8
RG	KBEL68P40	DLLA150P159	225	3310	22,8

Fuel lift pump

Type	A.C.Delco, type YD
Method of drive	Eccentric on camshaft
Static pressure (no delivery)	41/69 kPa (6/10 lbf/in ²) 0,4/0,7 kgf/cm ²

Fuel filter

Make	Bosch
Type	Screw type canister

Cooling system

Water pump

Type Centrifugal, belt driven

Raw water pump

Make Jabsco
 Type Rubber impeller
 Drive From rear end of camshaft

Thermostat

Type Wax pellet, by-pass blanking
 "Start to open" temperature 77°/85°C (171°/185°F)
 "Fully open" temperature 92°/98°C (198°/208°F)
 Valve lift, fully open 9,1 mm (0.358 in) minimum

Flywheel and housing

Flywheel

Maximum permissible run-out 0,30 mm (0.012 in) total indicator reading
 Maximum alignment error 0,03 mm (0.001 in) total indicator reading for every
 25 mm (1.0 in) of flywheel radius from crankshaft
 axis to indicator plunger

Flywheel housing

Limits for concentricity and alignment 0,15 mm (0.006 in) total indicator reading

Electrical equipment**Alternator**

Manufacturer	Valeo
Type	A13N 147M
Rating	12V/50A
Rotation	Clockwise, from drive end

Starter motor

Manufacturer	Lucas
Type	M80R
Voltage	12V
Number of teeth on pinion	10
Maximum resistance of starter cable at 20°C (68°F)	0.0017 ohms
Brush length:	
— New	9,0 mm (0.35 in)
— Minimum permissible, worn	3,5 mm (0.14 in)

Glow plugs

Manufacturer	Bosch
Current after 20 seconds	12A
Length of probe	23 mm (0.90 in)

Cylinder head assembly

12

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12A-12	To inspect and to correct	12A.12
12A-13	To correct a valve seat with a valve seat cutter	12A.13
12A-14	To fit valve seat inserts	12A.13

General description

In a diesel engine there is little carbon deposit and for this reason the number of hours run is no indication of when to overhaul a cylinder head assembly. The factors which indicate when an overhaul is necessary are how easily the engine starts and its general performance.

The cylinder head is made of aluminium and the head and the camshaft cover are bored together to provide bearing locations for the camshaft. The cams of the camshaft are directly above the valves and operate them through tappets which are fitted on top of the valves. Shims are fitted between the tappets and the tops of the valves to allow for adjustment of tappet clearances.

The cylinder head assembly has two valves fitted for each cylinder. Each valve is fitted with a single valve spring.

The valves move in cast iron guides which are a press fit in the cylinder head and can be renewed.

Both valve stems are fitted with oil seals which fit over the top of the valve guides.

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

Camshaft cover

To remove and to fit

12A-01

To remove

1 Remove the setscrew which fastens the front flange of the camshaft cover to the timing case (A1).

Remove the setscrew which is fitted through the drive housing of the raw water pump into the rear flange of the cover (A3). If the cover is too tight for removal, loosen the mounting bracket for the raw water pump.

2 Remove the setscrew from the timing hole in the top front of the camshaft cover (A4). Turn the crankshaft until the timing hole in the front journal of the camshaft aligns with the hole in the cover. This will ensure easier removal of the fuel lift pump and the camshaft cover.

3 Remove the engine lift brackets. If nothing is driven from the rear of the camshaft, remove the rear cover and fit the camshaft retainer 885025-7 (B1). This will ensure that the camshaft will not tilt when the camshaft cover is removed.

4 Remove the fuel lift pump, operation 19A-03.

5 Loosen evenly the setscrews of the camshaft cover in the reverse sequence to that given in figure D. Remove the setscrews and the cover (B). Ensure that the thrust washer (B2) remains in position in the cover.

To fit

1 Check the cover and the thrust washer for the camshaft for wear and for other damage. If the cover is worn or damaged, a new cylinder head assembly will be needed as the bores for the camshaft journals are machined with the cover and the head fastened together.

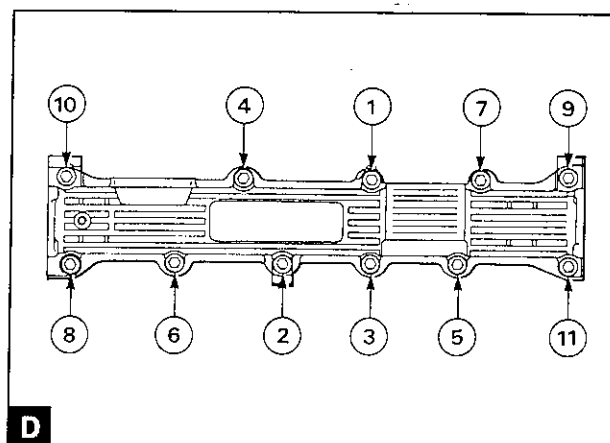
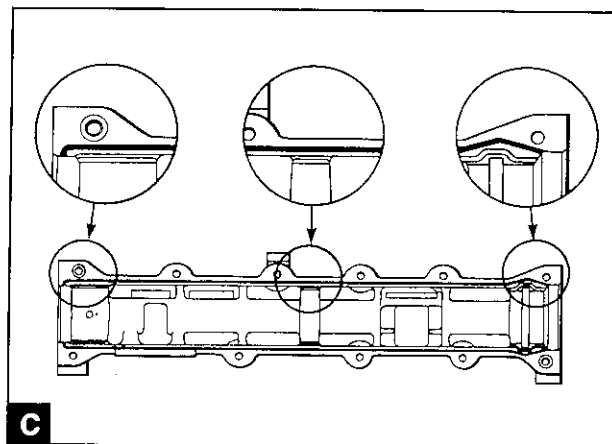
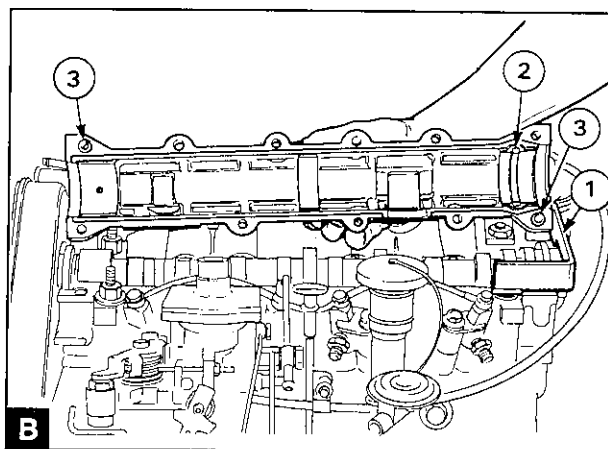
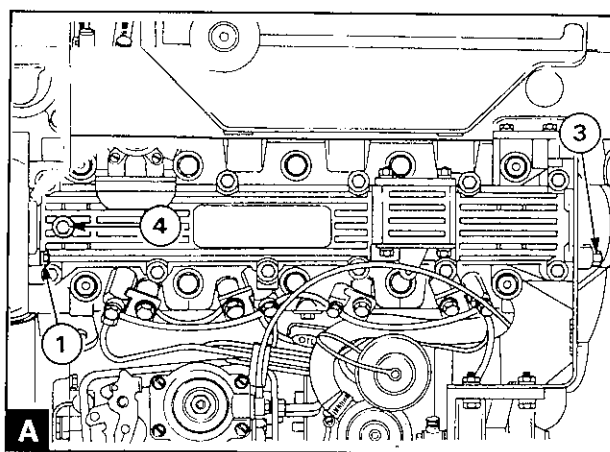
2 Check that the location thimbles (B3) and the thrust washer (B2) are correctly fitted. Ensure that the front and the rear seals of the camshaft are still in their correct positions against the shoulders in the cylinder head and that they are not tilted.

3 Ensure that the grooves in the camshaft cover and the contact faces of the cylinder head and the cover are clean. Apply a 2 mm (0.08 in) diameter bead of Silicone to the outer grooves of the cover but leave the inner grooves empty, as shown in figure (C). As soon as the sealant has been applied, fit the cover. Fit the cover setscrews with the longer setscrews at each end of the cover. Gradually tighten the setscrews to keep the cover parallel to the cylinder head as it is pulled down. Finally tighten the cover setscrews to 22 Nm (16 lbf ft) 2,2 kgf m in the sequence shown in figure (D).

4 Fit and tighten the setscrew which fastens the drive housing of the raw water pump to the camshaft cover. If the mounting bracket for the raw water pump has been loosened, align the bracket before it is fastened, see operation 20A-08.

5 Fit and tighten the setscrews which fastens the timing case to the camshaft cover. If necessary, fit the timing case cover.

6 Ensure that the timing hole in the front journal of the camshaft aligns with the timing hole in the camshaft cover. Fit the fuel lift pump, operation 19A-03. Fit the setscrew in the timing hole in the camshaft cover. Fit the engine lift brackets.



12 CYLINDER HEAD ASSEMBLY

Tappet clearances

To check

12A-02

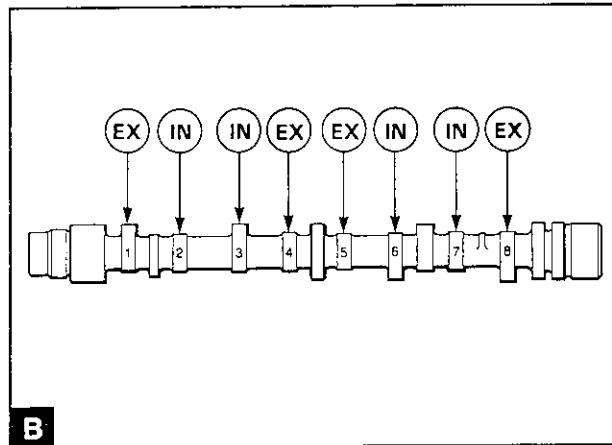
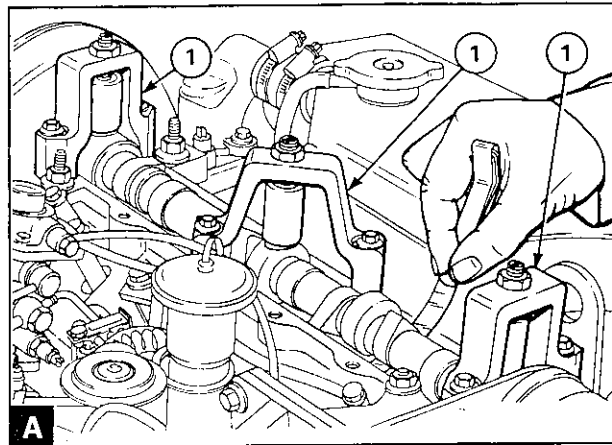
Special tools:

Camshaft retainer, 885025-7
Camshaft clamps, 885024-0

The tappet clearances are measured between the camshaft and the top of the tappets (A). With the engine cold, the correct clearances are 0,25/0,35 mm (0.010/0.014 in) for the inlet valves and 0,35/0,45 mm (0.014/0.018 in) for the exhaust valves. See B for the position of the inlet and exhaust cams.

Number 1 cam is at the pulley end of the camshaft.

- 1 Disconnect the battery.
- 2 Remove the camshaft cover, operation 12A-01. Remove the raw water pump, operation 20A-06 and fit the camshaft retainer before the cover is removed.
- 3 Fit the camshaft clamps 885024-0 (A1) to retain the camshaft and fit the relevant cover setscrews to the clamps. It will be necessary to move the rear seal on the camshaft to ensure that there is clearance between the rear clamps and the seal. Ensure that the spring loaded pads are correctly fitted on the camshaft journals and tighten evenly the clamp setscrews.
- 4 Turn the crankshaft until the lobes of numbers 1 and 3 cams are both near to their top position. Use feeler gauges with bent blades to measure the tappet clearances of numbers 1 and 3 valves. Make a note of the clearances.
- 5 Repeat 4 for valves 2 and 5, 6 and 8, and 4 and 7.
- 6 Adjustment is only necessary if the clearances are outside the limits of 0,20/0,40 mm (0.008/0.016 in) for inlet valves or 0,30/0,50 mm (0.012/0.020 in) for exhaust valves. If adjustment is necessary, see operation 12A-03.
- 7 When the clearances are correct, remove the camshaft journal clamps and fit the camshaft cover, operation 12A-01.
- 8 Connect the battery.



To adjust

12A-03

Special tools:

Camshaft clamps, 885024-0
Camshaft retainer, 885025-7
Timing pins for camshaft and crankshaft, 885037-2.
Anti-rotation tool, 885055-4

If it is found during a check of the tappet clearances, operation 12A-02, that adjustment is necessary, proceed as follows:

- 1 Turn the crankshaft until the timing hole in the front journal of the camshaft is in the 12 o'clock position. Fit the timing pin 885037-2 through the backplate or through the flywheel housing into the timing hole in the flywheel. Remove the starter motor, operation 22B-01 and fit the anti-rotation tool 885055-4 to the flywheel.
- 2 Remove the timing case cover, operation 15A-01.
- 3 Loosen the setscrews of the camshaft pulley and the setscrew of the pulley hub.
- 4 Fit two screws (M6 x 50) to hold the pulley of the fuel injection pump.
- 5 Remove the timing belt, the camshaft pulley and the pulley hub, see section 15.
- 6 Remove the raw water pump, operation 20A-06 and the pump mounting bracket, operation 20A-08.

7 Remove the camshaft clamps and remove the camshaft (12A.07/A). Remove the seals from the camshaft.

8 Adjust at each tappet in sequence: Remove the tappet (A1) and remove the shim (A2) which is fitted in the top of the valve spring cap (A3). From the notes obtained in operation 12A-02, find the amount of adjustment needed for this tappet. Measure the thickness of the shim. If the clearance needs to be increased, put in a shim which is thinner by the necessary amount. If the clearance needs to be decreased, put in a thicker shim. For calculation purposes, use the average clearances of 0,30 mm (0.012 in) for inlet valves and 0,40 mm (0.016 in) for exhaust valves. Lubricate the tappet and fit it into its bore. Repeat the operation for each tappet which needs adjustment.

9 When all the necessary shims have been changed, put the camshaft in position and temporarily fit the hub for the camshaft pulley. Remove the timing pin and the anti-rotation tool from the flywheel. Turn the crankshaft a quarter of a turn in a clockwise direction. Fit the camshaft clamps 885024-0 and that that the tappet clearances are correct, operation 12A-02.

10 When the clearances are correct, remove the hub for the camshaft pulley and the camshaft clamps. Turn the crankshaft a quarter of a turn in a counter-clockwise direction. Fit the timing pin and the anti-rotation tool to the flywheel. Lubricate the tappets and the journals and cams of the camshaft.

11 Fit the camshaft cover, operation 12A-01.

12 Fit new front and rear seals to the camshaft, operations 12A-04 and 12A-05.

13 Fit the camshaft pulley and the timing belt, see section 15. Remove the location pins from the pulley of the fuel injection pump and adjust the belt tension, operation 15A-03.

14 Remove the flywheel timing pin and the anti-rotation tool. Check the timing of the fuel injection pump, operation 17A-03.

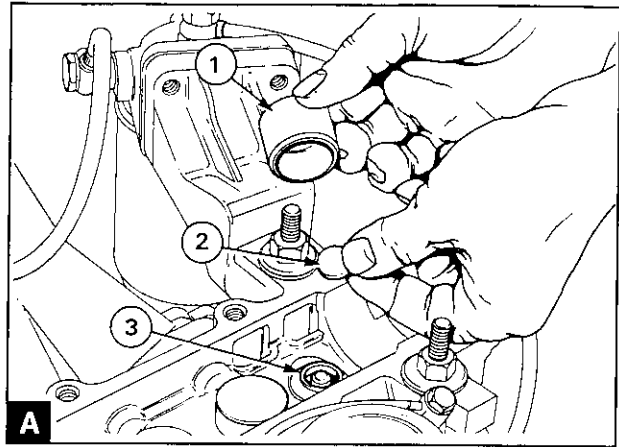
15 Fit the timing case cover, operation 15A-01.

16 Fit the setscrew in the timing hole of the camshaft cover. Fit the rear plate of the camshaft cover.

Fit the bracket for the raw water pump, operation 21A-08 and the raw water pump, operation 20A-06.

17 Turn the crankshaft through two revolutions to ensure that there is no restriction to movement.

18 Fit the starter motor, operation 22B-01 and connect the battery.



Front oil seal of camshaft

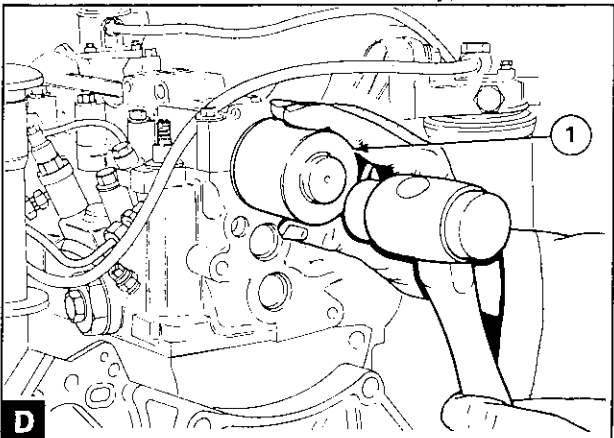
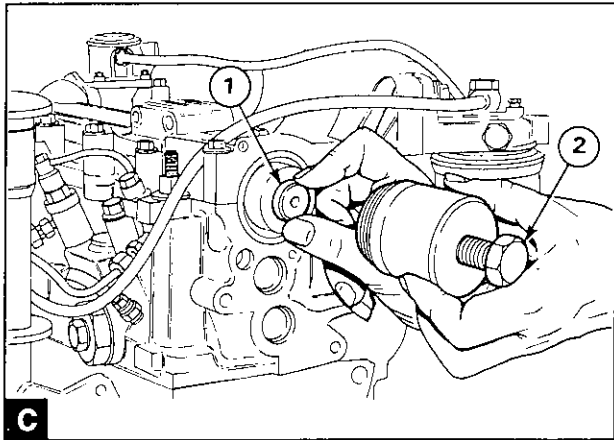
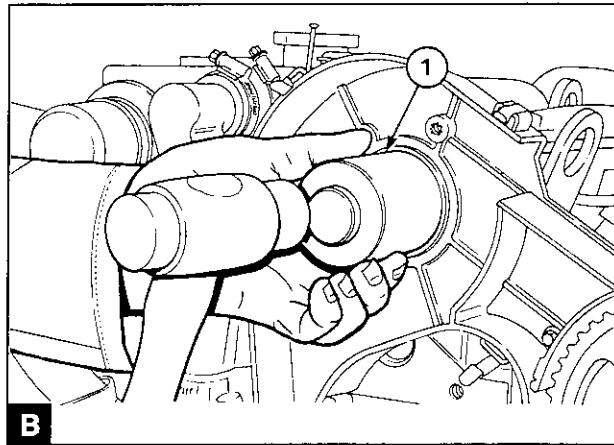
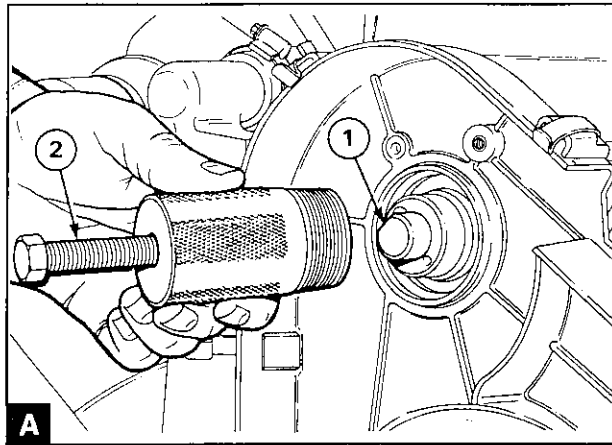
To remove and to fit

12A-04

Special tools:

Remover for front seal of camshaft, 885026-5
 Replacer for front seal of camshaft, 885018-2
 Timing pins for camshaft and crankshaft, 885037-2
 Anti-rotation tool, 885055-4

- 1 Disconnect the battery.
- 2 Remove the setscrew from the timing hole in the top front of the camshaft cover (12A.03/A4). Turn the crankshaft until the timing hole in the front journal of the camshaft aligns with the hole in the cover.
- 3 Fit the timing pins 885037-2 to the camshaft and to the flywheel. Remove the starter motor, operation 22B-01 and fit the anti-rotation tool 885028-1 to the flywheel.
- 4 Remove the timing case cover, operation 15A-01.
- 5 Remove the camshaft pulley, operation 15A-06.
- 6 Fit the plug of tool 885026-5 (A1) into the front end of the camshaft. Release the centre screw (A2) enough to ensure that it will not reach the plug and enter the main tool into the seal. Turn the tool clockwise to ensure that it is tight in the seal and tighten the centre screw onto the plug to remove the seal.
- 7 Ensure that the seal housing and the camshaft are clean and that they are not damaged. Lubricate the new seal with clean engine lubricating oil and enter it into position with the seal lip to the inside. Use the seal replacer 885026-5 (B1) with a soft face hammer to fit the seal into its final position.
- 8 Fit the camshaft pulley and the timing belt, see section 15. Remove the location pins from the pulley of the fuel injection pump and adjust the tension of the timing belt, operation 15A-03.
- 9 Remove the anti-rotation tool.
- 10 Check the timing of the fuel injection pump, operation 17A-03.
- 11 Remove the timing pins and turn the camshaft through two revolutions to ensure that there is no restriction to movement.
- 12 Fit the screw in the timing hole in the camshaft cover. Fit the starter motor, operation 22B-01 and connect the battery.



Rear oil seal of camshaft

To remove and to fit

12A-05

Special tools:

Remover for rear seal of camshaft, 885019-0
 Replacer for rear seal of camshaft, 885020-8
 Alignment adaptor for drive housing of raw water pump, 885038-0

- 1 Remove the raw water pump and its drive housing and remove the drive adaptor from the end of the camshaft, see section 20.
- 2 Fit the plug of tool 885019-0 (C1) into the rear of the camshaft.
- 3 Release the centre screw (C2) enough to ensure that it will not reach the plug and enter the main tool into the seal. Turn the tool clockwise to ensure that it is tight in the seal and tighten the centre screw onto the plug to remove the seal.
- 4 Ensure that the seal housing and the camshaft are clean and that they are not damaged. Lubricate the new seal with clean engine lubricating oil and enter it into position with the seal lip to the inside. Use the seal replacer 885020-8 (D1) with a soft face hammer to fit the seal into its final position.

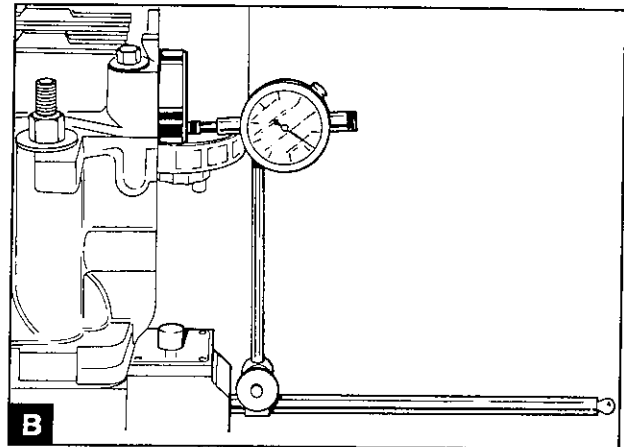
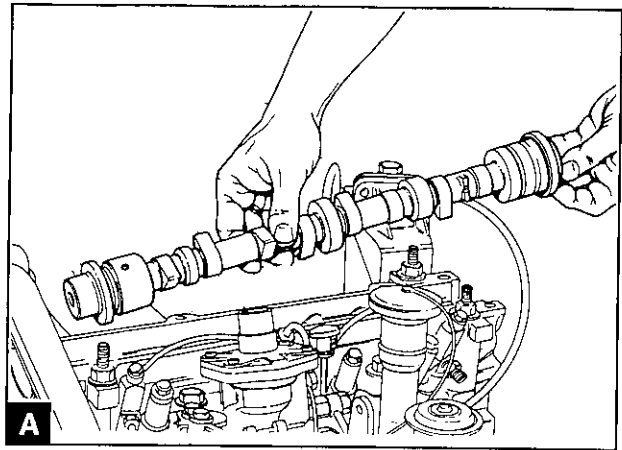
5 Fit the drive housing of the raw water pump with the bore correctly aligned, operation 20A-08. Fit the drive adaptor for the raw water pump and tighten the cap screws to 9 Nm (7 lbf ft) 0,9 kgf m. Fit the raw water pump, operation 20A-06.

Camshaft

To remove and to fit

12A-06

- 1 Disconnect the battery.
 - 2 Remove the setscrew from the timing hole in the top front of the camshaft cover (12A.03/A4). Turn the crankshaft until the timing hole in the front journal of the camshaft aligns with the hole in the cover.
 - 3 Fit the timing pins 885037-2 to the camshaft and to the flywheel. Remove the starter motor, operation 22B-01 and fit the anti-rotation tool 885055-4 to the flywheel.
 - 4 Remove the timing case cover, operation 15A-01.
 - 5 Remove the camshaft pulley, operation 15A-06.
 - 6 Remove the camshaft cover, operation 12A-01.
- Remove the raw water pump and its drive housing and bracket and, if necessary, the drive adaptor from the end of the camshaft, see section 20.
- 7 Remove the camshaft (A) and remove the camshaft seals.
 - 8 Check the camshaft for wear and for damage and renew it, if necessary.
 - 9 Fit the drive adaptor for the raw water pump.
 - 10 Ensure that the camshaft is clean and lubricated with clean engine oil. Put the camshaft in position and, if necessary, check the tappet clearances, see operation 12A-02.
 - 11 Fit the camshaft cover, operation 12A-01.
 - 12 Check the end-float of the camshaft with a dial test indicator (B). The limits are given in section 11C.
 - 13 Fit the camshaft seals, operations 12A-04 and 12A-05.
 - 14 Fit the rear cover of the camshaft.
- Fit the drive bracket and the housing for the raw water pump and fit the pump, section 20.
- 15 Fit the camshaft pulley and the timing belt and adjust the belt tension, section 15.
 - 16 Check the timing of the fuel injection pump, operation 17A-03.
 - 17 Fit the timing case cover, operation 15A-01. Fit the setscrew in the timing hole in the top front of the camshaft cover.
 - 18 **Ensure that all the timing pins and the anti-rotation tool are removed.** Turn the crankshaft through two revolutions to ensure that there is no restriction to movement.
 - 19 Fit the starter motor operation 22B-01 and connect the battery.



Cylinder head assembly

To remove and to fit

12A-07

To remove

- 1 Disconnect the battery.
 - 2 Drain the cooling system.
 - 3 Disconnect the coolant hose from the thermostat housing. If necessary, disconnect the by-pass hose at the bottom of the thermostat housing.
 - 4 Disconnect all electrical connections at the cylinder head and the thermostat housing.
 - 5 Disconnect the air inlet pipe and the exhaust pipe.
 - 6 If the cylinder head is to be dismantled.
- Remove the inlet manifold, and the heat exchanger/manifold/header tank assembly, operation 20A-12.
- 7 Disconnect the fuel lift pump.
 - 8 Disconnect the fuel filter and remove it from its bracket.
 - 9 Remove the high-pressure pipes from the atomisers and from the fuel injection pump — do not bend the pipes. When a pipe nut is loosened at the pump, hold the outlet connection of the pump with a spanner to prevent movement of the connection. Fit covers to the open connections of the atomisers and of the pump.
 - 10 Remove the atomisers, operation 19A-02, and the glow plugs, operation 22C-01, to prevent possible damage to their tips.
 - 11 Remove the setscrew from the timing hole in the top front of the camshaft cover 12A.03/A4. Turn the crankshaft until the timing hole in the front journal of the camshaft aligns with the hole in the cover.

12 Remove the starter motor, operation 22B-01 and fit the anti-rotation tool 885055-4 to the flywheel.

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

14 Remove the setscrew which is fitted through the camshaft cover into the timing case (A1).

Remove the setscrew which fastens the timing case to the cylinder head (A3).

15 Release evenly the setscrews of the cylinder head in the reverse sequence to that shown in figure 12A.09/A. Remove the setscrews and remove the head (B) — ensure that the camshaft does not hit the timing case. Put the head on a flat surface which will not damage the bottom face.

16 Check the top face of each cylinder head setscrew for centre punch marks. If there are four centre punch marks on the setscrew head it has been tightened four times in service and it cannot be used again. Also check the setscrews for distortion with a straight edge held along the setscrew. If there is a visual reduction in the diameter of the stem or of the thread that has not been in engagement with the cylinder head, the setscrew must be discarded.

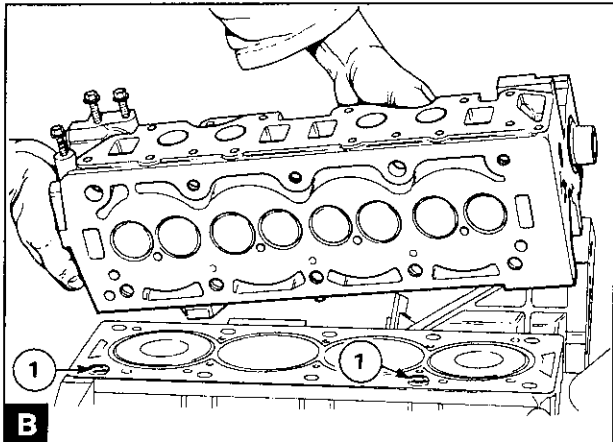
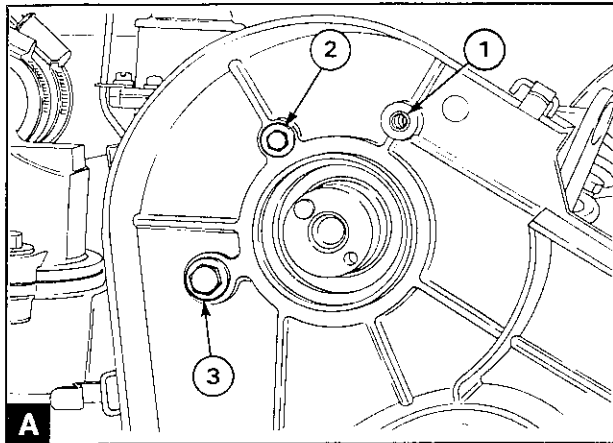
17 Remove the cylinder head gasket.

To fit

Special tools:

Angle gauge, to tighten cylinder head setscrews

- 1 Clean the bottom face of the cylinder head and the top face of the cylinder block. Ensure that there is no debris in the cylinder bores.



2 Ensure that numbers 1 and 4 pistons are at TDC and that the timing pin is fitted through the backplate or through the flywheel housing into the timing hole in the flywheel.

3 Ensure that the two location thimbles (12A.08/B1) are in position in the top face of the cylinder block and fit the cylinder head gasket without jointing compound. The gasket will only fit in one position over the thimbles.

4 Ensure that the timing pin is fitted through the camshaft cover into the timing hole in the camshaft. Put the cylinder head in position over the thimbles. Engage the cylinder head setscrews with the longer setscrews fitted at the ends of the head. Tighten evenly all the setscrews in the sequence shown in figure (A) to a torque of 50 Nm (37 lbf ft) 5,1 kgf m. Tighten all the setscrews again, in the same sequence, to a torque of 100 Nm (74 lbf ft) 10,2 kgf m. Finally tighten the setscrews, in the same sequence, another quarter of a turn (90°). Fit the tool between the socket and the handle. Put the stop (B1) against a suitable protrusion on the cylinder head to prevent movement of the degree dial in a clockwise direction. Turn the pointer to align with the 90° mark on the degree dial. Tighten the setscrew until the pointer aligns with the zero position.

If no tool is available, make a suitable mark on the flange of each setscrew (C1). Make other marks on the cylinder head (C2) at 90° clockwise to the marks on the setscrews. Tighten each setscrew in the correct sequence until the marks on the flange are next to, and in line with, the marks on the cylinder head (C3). The setscrews do not need to be tightened again with the engine hot or after a period in service.

If the original setscrews have been fitted again, mark the top of each setscrew with a centre punch to indicate that it has been tightened in service. A maximum of four centre punch marks is permissible.

5 Fit the heat exchanger/manifold/header tank assembly, operation 20A-10 and fit the inlet manifold.

6 Connect the air filter and the exhaust pipe.

7 Fit the setscrews which fasten the timing case to the cylinder head (12A.08/A1) and to the camshaft cover 12A.03/A1.

8 Fit the camshaft pulley, fit the timing belt and check the belt tension, see section 15.

9 Check the timing of the fuel injection pump, operation 17A-03 and remove the timing pins. Remove the anti-rotation tool and turn the crankshaft through two revolutions to ensure that there is no restriction to movement.

10 Fit the starter motor, operation 22B-01.

11 Fit the glow plugs, operation 22C-01.

12 Fit the atomisers, operation 19A-02.

13 Fit the high-pressure fuel pipes and tighten the pipe nuts to 18 Nm (13 lbf ft) 1,8 kgf m. Ensure that a separate spanner is used to prevent movement of the outlets of the fuel injection pump.

14 Fit the fuel filter and the low-pressure fuel pipes between the fuel injection pump and the fuel filter.

15 If necessary, fit the fuel lift pump, operation 19A-03. Connect the pipes to the fuel lift pump.

16 Fit the timing case cover, operation 15A-01.

17 Connect the coolant by-pass and the coolant outlet pipe.

Connect the raw water pipes to the heat exchanger and to the raw water pump.

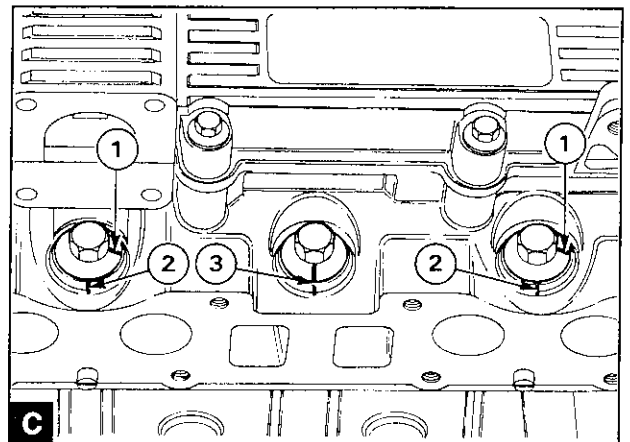
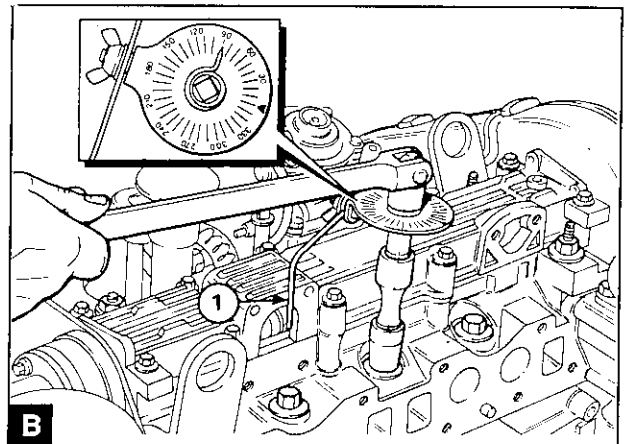
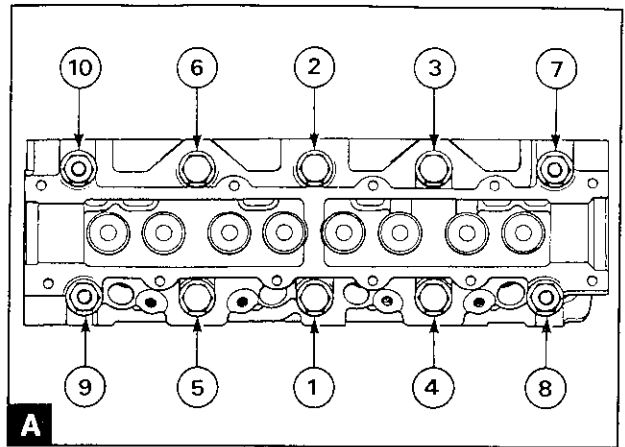
18 Connect the electrical connections to the cylinder head and to the thermostat housing.

19 Fill the cooling system. See operation 20A-02.

20 Connect the battery.

21 Eliminate air from the fuel system, operation 19A-08.

22 Start the engine and check for leaks.



Valves and valve springs

To remove and to fit **12A-08**

Special tools:

Valve spring compressor, 885023-2

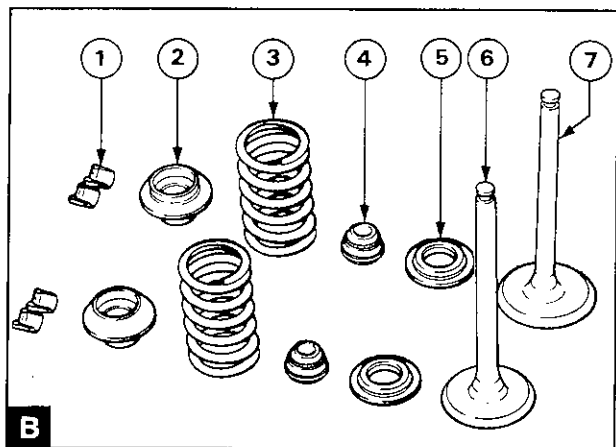
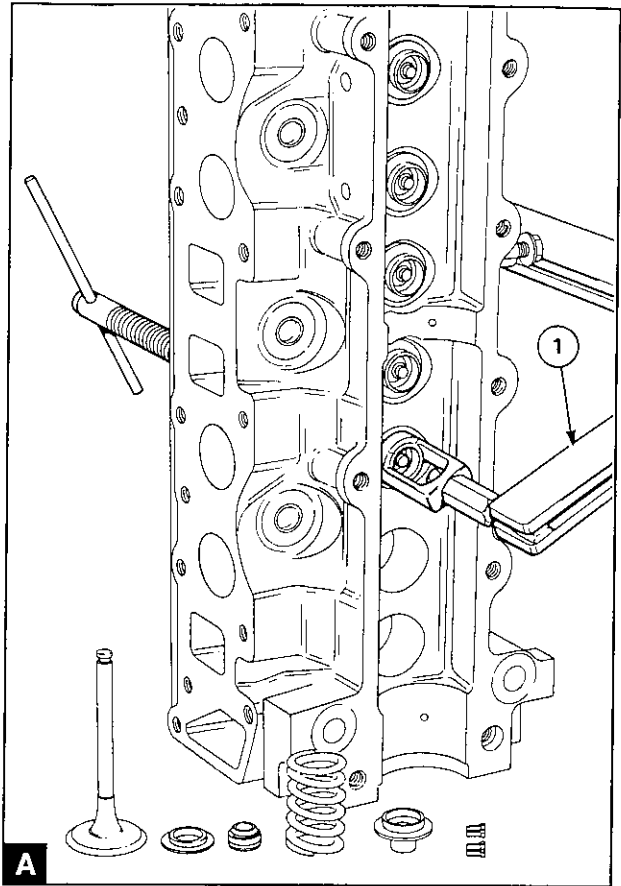
To remove

- 1 Remove the cylinder head, operation 12A-07.
- 2 Remove the raw water pump, operation 20A-06.
- 3 Remove the camshaft cover, operation 12A-01.
- 4 Remove the tappets and the shims and keep the tappet and shim from each valve together in a marked container to ensure that they can be fitted in their original positions.
- 5 Clean the bottom face of the cylinder head and check the depth of the heads of the valves below the face of the cylinder head, see operation 12A-09.
- 6 Make a suitable mark on the heads of the valves to ensure that the valves can be fitted in their original positions, if they are to be used again.
- 7 Use the valve spring compressor to compress the valve spring (A1). Ensure that the valve spring is compressed squarely or damage can occur to the valve stem. Remove the split collets (B1).
- 8 Release the valve spring compressor and remove the valve spring cap (B2), the valve spring (B3), the valve stem seal (B4) and the valve seat washer (B5). Remove the exhaust valve (B6) or the inlet valve (B7).
- 9 Repeat items 7 and 8 for the other valves.

To fit

The components of the valve assembly are shown in B.

- 1 Ensure that all the components are clean.
- 2 Lubricate the valve stems with clean engine oil and fit the valves (B6/B7) in their relevant guides. Ensure that the valve head depth is correct, see operation 12A-09.
- 3 Fit the spring seat washers (B5). Fit new valve stem seals (B4) on the valve guides. Fit the valve springs (B3) and the valve spring caps (B2).
- 4 Use the valve spring compressor to compress the valve spring and fit the collets (B1). Ensure that the valve spring is compressed squarely or damage can occur to the valve stem.
- 5 Lubricate the shims and the tappets. Fit each shim in the top of the spring cap of the relevant valve and fit the tappet on the top of the shim.
- 6 Put the camshaft in position and check the tappet clearances as shown in operation 12A-02. Adjust the clearances as necessary.
- 7 Fit the camshaft and the camshaft cover, operation 12A-02.
- 8 Fit the raw water pump, operation 20A-06.
- 9 Fit the cylinder head, operation 12A-07.



To inspect and to correct **12A-09**

- 1 Check the depth of the valves below the face of the cylinder head before the valve springs are removed. Ensure that the heads of the valves and the bottom face of the cylinder head are clean. Put the valve depth tool on the face of the cylinder head and set the dial gauge to zero. Carefully put the valve depth tool in position over the head of each valve (A) and make a note of the measurement. The limits for the valve head depth are given in section 11C. If a valve is deeper than the maximum limit, check the valve depth with a new valve in position and, if the valve depth is still below the limit, a new valve seat insert can be fitted, operation 12A-14.

2 Check the valves for cracks. Check the stems of the valves for wear and for correct fit in their valve guides.

3 Check that the seat faces of the valves are not badly burnt or damaged. Seat faces of valves which are damaged can be ground on a special machine. Valves which have only little damage can be lapped to their valve seats. When new valves are fitted, the valve depths must be checked, see 1.

4 Check that the load on the valve springs is correct at their fitted length, see section 11C.

Fit new valve springs at every complete engine overhaul.

Valve guides

To inspect 12A-10

Check the valve guides for wear. The maximum clearance between the valve stem and the bore of the guide is 0,13 mm (0.005 in). If the clearance with a new valve fitted is more than the limit, then a new valve guide must be fitted.

To remove and to fit 12A-11

Special tools:

Remover/replacer for valve guides, 885021-6

Reamer for new valve guides, 885022-4

To remove

1 Ensure that the face of the cylinder head and the base of a suitable press are clean.

2 Heat the whole cylinder head slowly and evenly to approximately 100° (212°F) and put the head on the press, with the head face downward. Ensure that the head face is not damaged during this operation.

Attention: Use suitable gloves as a protection against hot metal.

3 Put the narrow shaft of tool 885021-6 in the guide and press out the guide. Repeat as necessary, if other guides need to be renewed.

To fit

1 Clean the parent bore for the valve guide and ensure that it is not damaged.

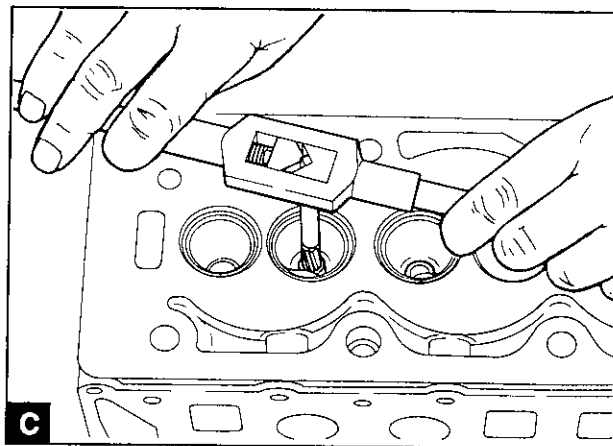
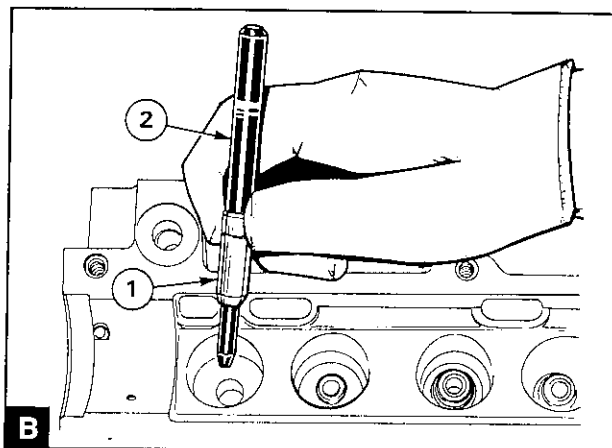
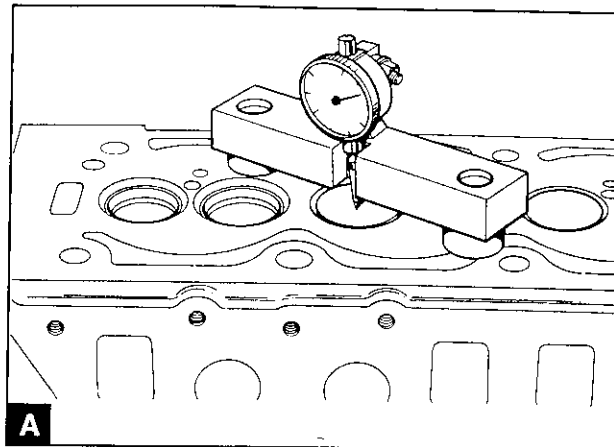
2 Heat the whole cylinder head slowly and evenly to approximately 100°C (212°F). Put the head on the press, with the head face downward and with a flat plate underneath the valve port. Ensure that the head face is not damaged during this operation.

Attention: Use suitable gloves as a protection against hot metal.

3 Put the guide (B1) on to the narrow shaft of the tool 885021-6 (B2) with the chamfer towards the narrow end of the tool (B). Enter the chamfer end of the guide into the top of the parent bore and press in the guide until the end of the tool is in contact with the flat plate. Check that the guide protrusion above the location face for the valve spring is 10 mm (0.39 in).

4 Allow the head to cool.

5 Ream the bore of the new guide(s) with reamer 885022-4 (C).



Cylinder head

To inspect and to correct **12A-12**

- 1 Remove the cylinder head assembly, operation 12A-07.
- 2 Remove the thermostat housing.
- 3 Remove the raw water pump, operation 20A-06.
- 4 Remove the camshaft cover, operation 12A-01 and the camshaft.

Remove the tappets and the shims and keep the tappet and shim from each valve together in a marked container to ensure that they can be fitted in their original positions.

- 5 Inspect the cylinder head for signs of gas or coolant leakage.
- 6 Remove the valve springs and the valves, operation 12A-08.
- 7 Clean the face of the cylinder head. Clean the passages for coolant and for lubricating oil. The water jacket can be cleaned with a special solvent which must be used in accordance with the manufacturer's instructions.

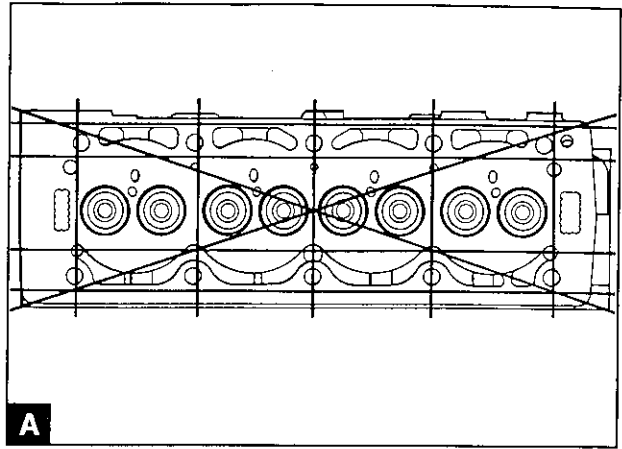
8 Test the cylinder head for leaks at the pressure given in section 11C.

9 When the cylinder head is thoroughly clean, check it for cracks. Examine carefully the areas around the valve seats and around the holes for the atomiser nozzles.

10 Use a straight edge and feeler gauge to check the cylinder head for distortion across and along its bottom face (A). If the distortion is more than 0,10 mm (0.004 in), the bottom face can be machined. Remove only the minimum material and ensure that the thickness of the cylinder head will not be less than 119,85 mm (4.718 in) after the cylinder head has been machined.

Attention: After the cylinder head has been machined, the valve seats must be corrected to give the correct valve head depth. It is advisable to work to the minimum limit to allow for later wear.

- 11 Check the valve seats for wear and for damage.
- 12 Before any work is done on the valve seats, ensure that there is no wear on the valve guides, see section 11C. If the valve guide wear is more than the limit, then the valve guide must be renewed, operation 12A-11.
- 13 Where there is little damage, the valve and valve seat can be lapped. When the valve seats are lapped keep the seat as narrow as possible and ensure that all the compound used to lap the valve and seat is removed.
- 14 More badly damaged valve seats can be corrected by use of the cutter tool, operation 12A-13, or new inserts can be fitted, operation 12A-14.
- 15 Fit the valve springs and the valves, operation 12A-08.
- 16 Fit the camshaft cover, operation 12A-01 and the camshaft. Fit the tappets and the shims in their relevant positions. Put the camshaft in position and check the tappet clearances, operation 12A-02 and adjust if necessary, operation 12A-03.
- 17 Fit the raw water pump, operation 20A-06.
- 18 Fit the thermostat housing.
- 19 Remove the cylinder head assembly, operation 12A-07.

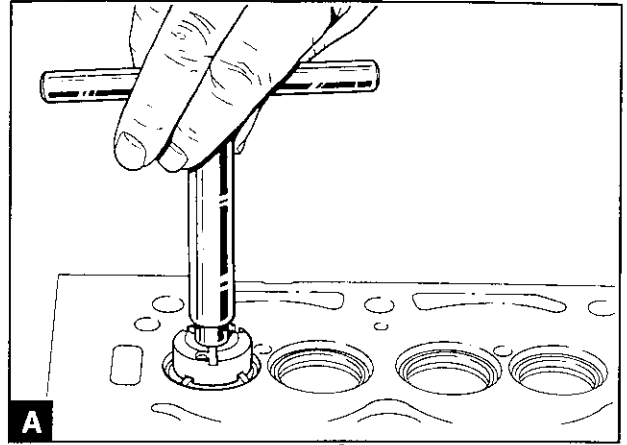


To correct a valve seat with a valve seat cutter

12A-13

- 1 If the valve guide is worn, renew it, operation 12A-11.
- 2 Fit the pilot in the valve guide and tighten the pilot.
- 3 Fit the cutter on the pilot with the 46° side towards the valve seat and fit the handle (A). Ensure that the cutter is not allowed to fall on the seat as this can damage the blades.
- 4 Carefully turn the cutter in a clockwise direction. Remove only the minimum material to ensure a good seat. Keep the seat as narrow as possible.
- 5 When the seat is correct, remove the cutter and the pilot. Remove any debris from the area of the valve seat and the port.
- 6 Fit the valve and lightly lap the valve and the seat.
- 7 Check that the valve depth is within limits, see operation 11C.

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



To fit a valve seat insert

12A-14

- 1 Fit a new valve guide, operation 12A-11.
- 2 Machine a small segment from the inside of one side of the insert to a depth of 8,25 mm (0.325 in) from the face of the cylinder head. Break the insert at its thinnest point and remove it from the recess. Ensure that the recess is not damaged during this operation.
- 3 The valve seat insert must be fitted with the cylinder head hot and the insert cold. Heat the whole cylinder head slowly and evenly to approximately 100°C (212°F) and cool the insert, if possible, in liquid nitrogen to -35°C (-31°F). If liquid nitrogen is not available, reduce the temperature of the insert as far as possible in a deep freeze unit. Fit the insert in position with the outside chamfer to the inside of the head. Ensure that the bottom of the insert is in contact with the bottom of the recess.

Attention: Use suitable gloves as a protection against the hot cylinder head and the cold insert.

- 4 Cut the valve seat, operation 12A-09 and lightly lap the valve and the valve seat. Ensure that the depth of the valve head below the face of the cylinder head is within the production limits, see section 11C. Work as near as possible to the minimum figure to allow for future wear on the valve seat.