



Perkins Peregrine and New Generation 1300 Series

WORKSHOP MANUAL

Peregrine	6 cylinder diesel engines for automotive applications
NGD 1300	6 cylinder diesel engines for agricultural and industrial applications



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Contents

General information	10
Specifications	11
SERVICE OPERATIONS	
Cylinder head assembly	12
Piston and connecting rod assemblies	13
Crankshaft assembly	14
Timing case and drive assembly	15
Cylinder block assembly	16
Engine timing	17
Turbocharger	18
Lubrication system	19
Fuel system	20
Cooling system	21
Flywheel and housing	22
Electrical equipment	23
Auxiliary equipment	24
List of special tools	25



General information **10A**

Introduction 10A.02

Engine identification 10A.04

Safety

General Safety precautions 10A.05

Asbestos joints 10A.06

Engine lift equipment 10A.06

POWERPART recommended consumable products 10A.07



General information

Introduction

The New Generation Peregrine and 1300 Series is an improved family of engines for automotive, industrial and agricultural applications from Perkins Engines Limited, a world leader in the design and manufacture of high performance diesel engines.

Perkins approved assembly and quality standards, together with the latest technology, have been applied to the manufacture of your engine to give you reliable and economic power.

Most of the general information which is included in the relevant User's Handbook (chapters 1 to 9) has not been repeated in this workshop manual and the two publications should be used together.

To ensure that you use the relevant information for your specific engine type, refer to "Engine identification" on page 10A.03.

Where the information applies only to certain engine types, this is indicated in the text.

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 chapter 25. Reference to the relevant special tools is also made at the beginning of each operation.

Data and dimensions are included at the end of each chapter.

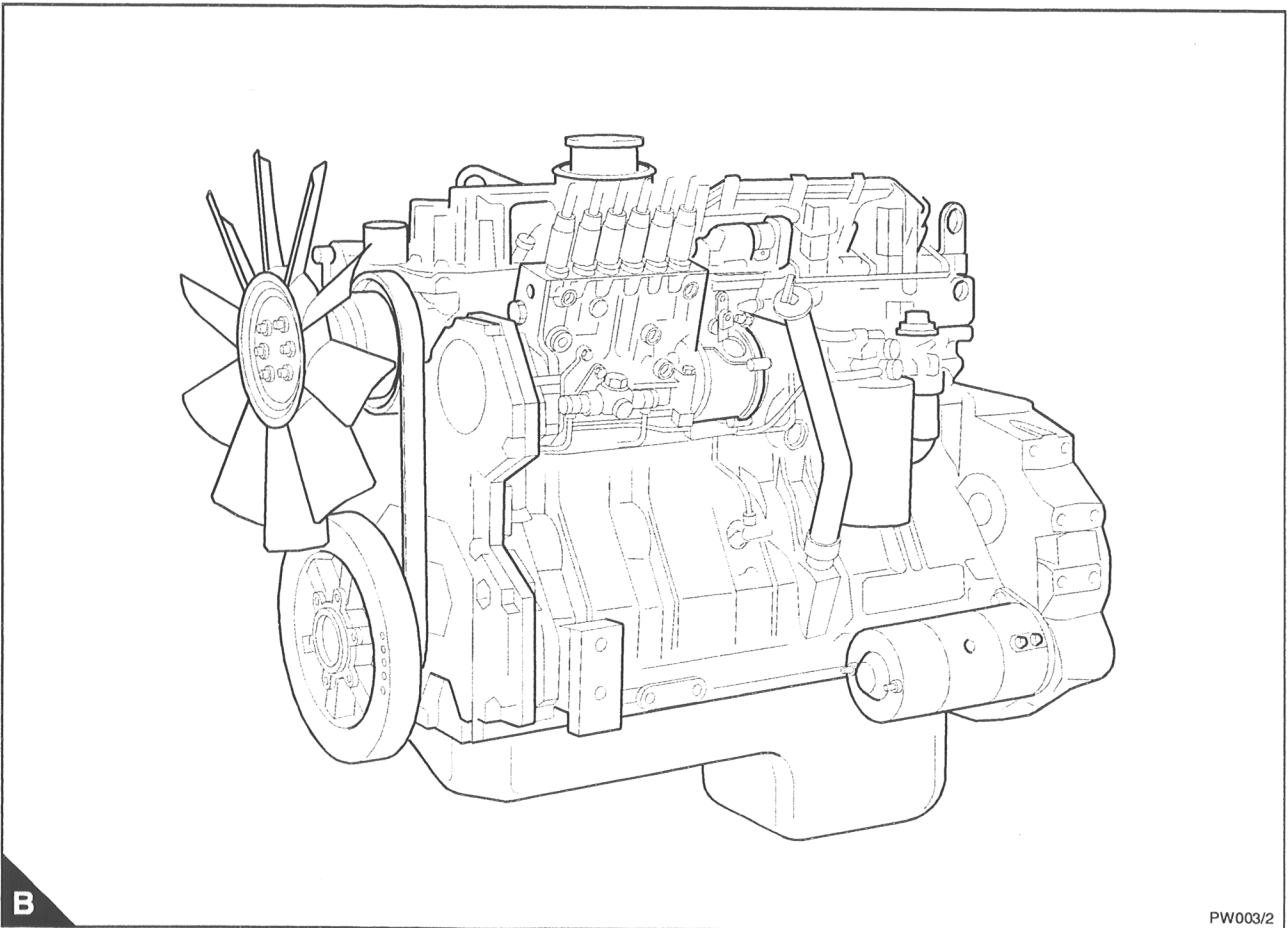
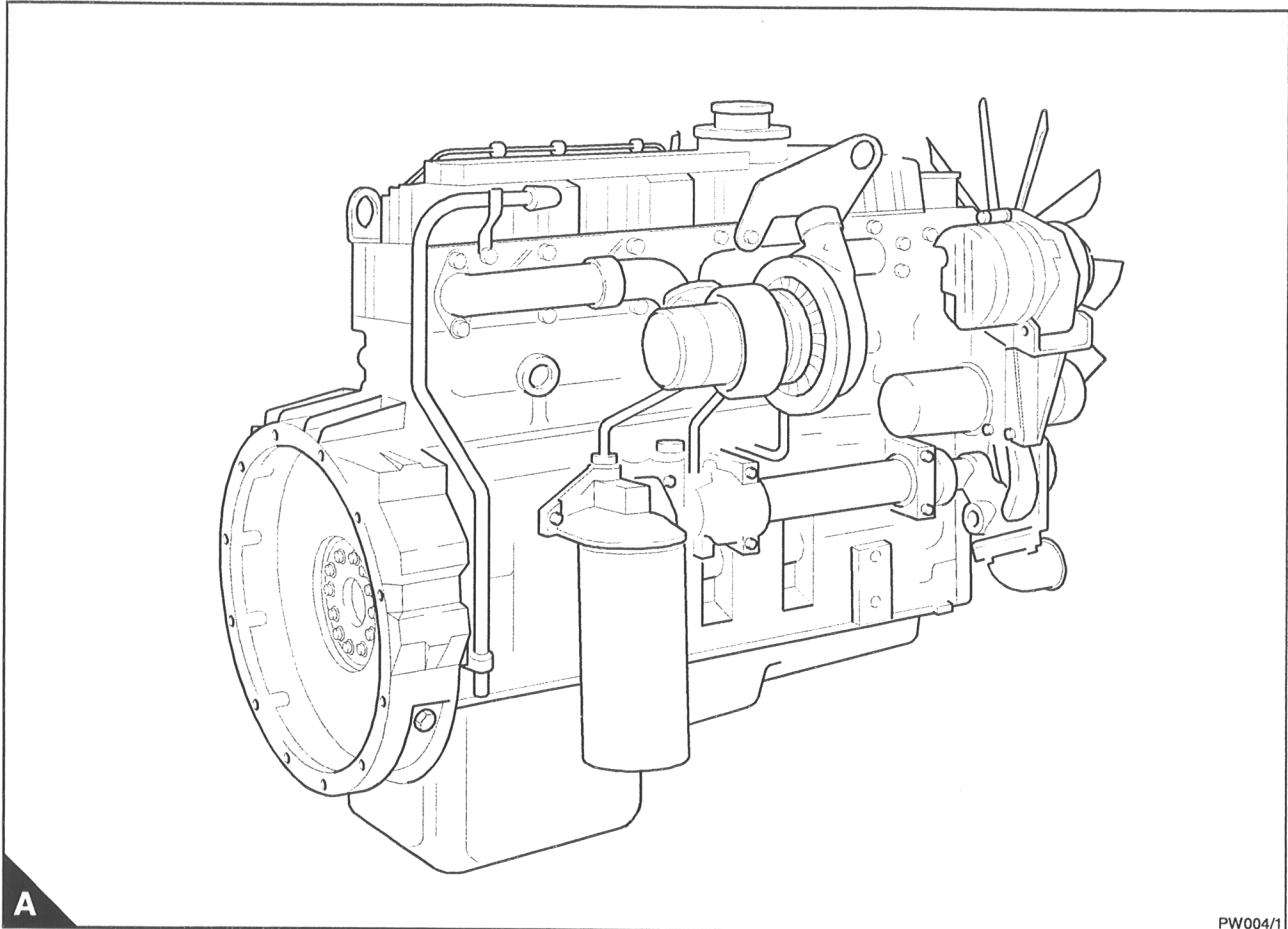
Read and remember the "Safety precautions". They are given for your protection and must be used at all times.

Danger is indicated in the text by two methods:

Warning! *This indicates that there is a possible danger to the person.*

Caution: *This indicates that there is a possible danger to the engine.*

Note: Is used where the information is important, but there is not a danger.





10A GENERAL INFORMATION

Engine identification

The New Generation Peregrine and 1300 Series of engines consists of a range of six cylinder in-line engines which are turbocharged / intercooled or turbocharged.

In this publication, the different engine types are indicated by their code letters, which are the first two letters of the engine number as indicated below:

Code letters	Capacity Ltrs (in ³)	Aspiration system
WD	6,7 (408)	Turbocharged
WE	6,7 (408)	Turbocharged/ intercooled
WF	7,6 (466)	Turbocharged
WG	7,6 (466)	Turbocharged/ intercooled
WH	8,6 (531)	Turbocharged
WJ	8,6 (531)	Turbocharged/ intercooled

The engine number is stamped on the left side of the cylinder block (A1), behind the fuel injection pump.

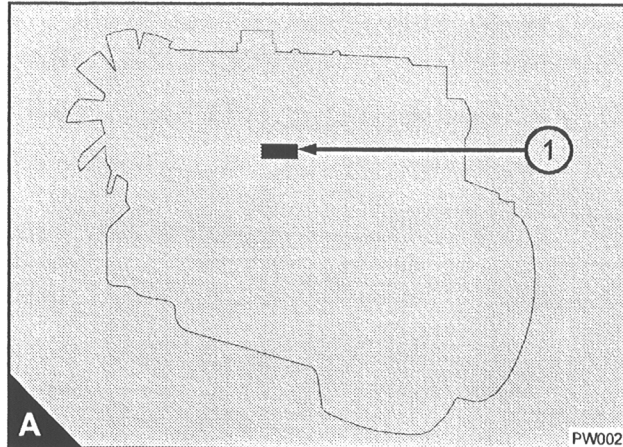
An example of an engine number is
WJ1296N123456.

The components of the engine number are as follows:

WJ1296N123456

WJ	Type code letters
1296	Build list number
N	Built in the USA
123456	Engine serial number

If you need parts, service or information for your engine, you must give the complete engine number to your Perkins distributor.





Safety

General Safety precautions

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

- Only use these engines in the type of application for which they have been designed.
- 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 care 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 auxiliary equipment is in operation.
- Do not permit loose clothing or long hair near moving parts.
- Keep away from moving parts during engine operation. **Warning!** 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 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 operators 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 of clothing.
- Discard used lubricating oil in a safe place to prevent contamination.
- Ensure that the control lever of the transmission drive is in the "out-of-drive" position before the engine is started.
- Use extreme care if emergency repairs must be made in adverse conditions.
- The combustible material of some components of the engine (for example certain seals) can become extremely dangerous if it is burned. Never allow this burnt material to come into contact with the skin or with the eyes.
- Read and use the instructions relevant to lift equipment which are given on 10A-06.
- Always use a safety cage to protect the operator when a component is to be pressure tested in a bath of water. Fit safety wires to secure the plugs which seal the hose connections of a component which is to be pressure tested.
- Do not allow compressed air to contact your skin. If compressed air enters your skin, obtain medical help immediately.
- Turbochargers operate at high speed and at high temperatures. Keep fingers, tools and other objects away from the inlet and outlet ports of the turbocharger and avoid contact with hot surfaces.
- Fit only genuine Perkins parts.
- The latest engines have a cover fitted to give some protection from the alternator fan and the drive belt. Ensure that this cover is fitted before the engine is started.
- Fit only genuine Perkins parts.



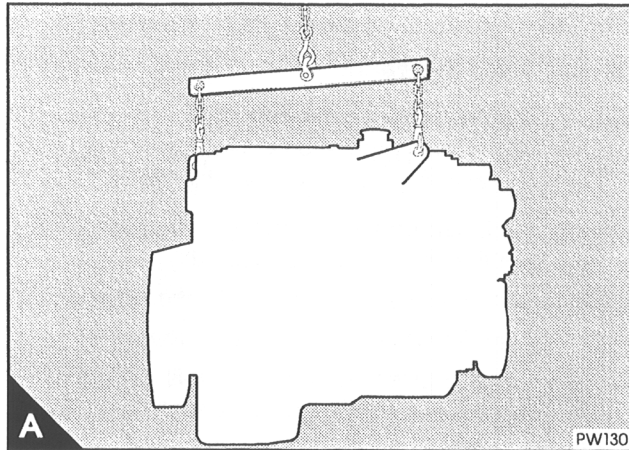
10A GENERAL INFORMATION

Asbestos joints

The New Generation Peregrine and 1300 Series of engines are asbestos free.

Engine lift equipment

- The maximum weight of the engine without coolant, lubricant or a gearbox fitted will vary for different applications, it is recommended that lift equipment of the minimum capacity of 770 Kg (1700 lbs) is used:
- Always use engine lift equipment of the approved type and of the correct capacity, to lift the engine. It is recommended that lift equipment of the type shown in (A) is used, to provide a vertical lift directly above the engine lift brackets (A1). Never use a single lift bracket to raise an engine.
- Check the engine lift brackets for damage and security before the engine is lifted.
- Use lift equipment or obtain assistance to lift heavy engine components such as the cylinder block, cylinder head, flywheel housing, crankshaft and flywheel.
- To avoid possible damage to the engine rocker cover by contact from the lift equipment; use the correct lift equipment (A) to raise the engine.



**POWERPART recommended consumable products**

Perkins have made available the products recommended below in order to assist in the correct operation, service and maintenance of your engine and your machine. The instructions for the use of each product are given on the outside of each container. These products are available from your Perkins distributor.

POWERPART Antifreeze

Protects the cooling system against frost, cavitation and corrosion. Part number 1 litre 21825166 or 5 litres 21825167.

POWERPART Easy Flush

Cleans the cooling system. Part number 2182501

POWERPART Jointing compound

Universal jointing compound which seals joints. Currently Hylomar. Part number 1861155 or 1861117.

POWERPART Silicone rubber sealant

Silicone rubber sealant which prevents leakage through gaps. Currently Hylosil Part number 1861108.

POWERPART Lay-Up 1

A diesel fuel additive for protection against corrosion. Part number 1772204.

POWERPART Lay-Up 2

Protects the inside of the engine and of other closed systems. Part number 1762811.

POWERPART Lay-Up 3

Protects outside metal parts. Part number 1734115, see page 7.02.

POWERPART Chisel

Allows easy removal of old gaskets and joints. Currently Loctite chisel. Part number 21825163.

POWERPART Repel

Dries damp equipment and gives protection against corrosion. Passes through dirt and corrosion to lubricate and to assist removal of components. Currently Loctite repel. Part number 21825164.

POWERPART Threadlock

To retain small fasteners where easy removal is necessary. Currently Loctite 222e. Part number 21820222.

POWERPART Nutlock

To retain and seal threaded fasteners and cup plugs where easy removal is necessary. Currently Loctite 242e. Part number 21820242

POWERPART Studlock

To permanently retain large fasteners and studs. Currently Loctite 270. Part number 21820270.

POWERPART Liquid gasket

To seal flat faces of components where no joint is used. Especially suitable for aluminium components. Currently Loctite 518. Part number 21820518

POWERPART Threadlock (hydraulic/pneumatic)

To retain and seal pipe connections with fine threads. Especially suitable for hydraulic and pneumatic systems. Currently Loctite 542. Part number 21820542

POWERPART Threadlock (pipe)

To retain and seal pipe connections with coarse threads. Pressure systems can be used immediately. Currently Loctite 575. Part number 21820575.

POWERPART Retainer (oil tolerant)

To retain components which have a transition fit. Currently Loctite 603. Part number 21820603.

POWERPART Retainer (high strength)

To retain components which have an interference fit. Currently Loctite 638. Part number 21820638.



Specifications **11**

Basic engine data **11A**

Recommended torque settings **11B**



Basic engine data

11A



11A BASIC ENGINE DATA

Basic engine data

Note: 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 the factory. The information applies to all engines, unless an engine type code is shown.

Number of cylinders 6

Cylinder arrangement In-line

Cycle Four stroke

Firing order 1, 5, 3, 6, 2, 4

Direction of rotation Clockwise from the front

Induction system:

- WD, WF and WJ engines Turbocharged
- WE, WF and WG engines Turbocharged / intercooled

Bore:

- WD, WE, WF and WG engines 109,2 mm (4.301 in)
- WH and WJ engines 116,5 mm (4.590 in)

Stroke:

- WD and WE engines 119,0 mm (4.685 in)
- WF, WG, WH and WJ engines 135,9 mm (5.350 in)

Compression ratios 16.5:1

Cubic capacity:

- WD and WE engines 6,68 litres (408.9 in³)
- WF and WG engines 7,64 litres (466 in³)
- WH and WJ engines 8,70 litres (531 in³)



Recommended torque settings **11B**

Standard torques 11B.02

Specific torques 11B.03



11B RECOMMENDED TORQUE SETTINGS

Recommended torque settings

Notes:

- The torque tensions below apply to components lubricated lightly with clean engine oil before they are fitted.
- The setscrew for the upper idler gear is supplied with a sealant on its thread. Do not put lubricating oil on the thread of this setscrew.

Standard torques

Thread size	Flanged head fasteners				Non-flanged head fasteners			
	Nm	lbf ft	kgf m	Spanner size mm	Nm	lbf ft	kgf m	spanner size mm
M6x1		8	0,11	8	8	6	0,08	10
M8x1,25	24	18	0,25	10	20	15	0,21	13
M10x1,5	49	36	0,50	13	40	30	0,41	16
M12x1,75	83	61	0,84	15	69	51	0,71	18
M16x2	208	154	2,13	21	173	128	1,77	24



Specific torques

Description	Nm	lbf ft	kgf m
Cylinder head assembly			
Setscrews, cylinder head	(see	chapter	12)
Setscrews, rocker cover	18	13	1,8
Nuts, exhaust manifold to cylinder head	81	60	0,83
Setscrews, engine lift brackets	60	44	6,0
Pistons and connecting rod assemblies			
Setscrews, connecting rods	156	115	15,9
Crankshaft assembly			
Setscrews, main bearings	156	115	15,9
Setscrews, pulley/ damper assembly	136	100	13,6
Setscrews, rear oil seal housing to cylinder block	24	18	2,5
Timing case and drive assembly			
Setscrews, timing case cover	26	19	2,6
Setscrews, timing case backplate	26	19	2,6
Setscrew, lower idler gear	673	470	65,6
Setscrew, upper lower gear	325	240	33,2
Setscrew, fuel injection pump gear	51	38	5,3
Setscrews, access cover to fuel injection pump gear	7	5.5	0,8
Aspiration system			
setscrew, turbocharger to exhaust manifold	68	50	6,9
Setscrew, turbocharger compressor housing to backplate	23	17	2,35
Setscrew, turbocharger turbine housing to bearing housing	13	9.6	1,3
Setscrew, breather pipe, top	83	61	8,4
Setscrew, breather pipe, bottom	49	36	5,0
Lubrication system			
Valve, oil temperature/ pressure control	13,5	10	1,35
Setscrews, sump with joint and load bars	23	17	2,35
Setscrews, sump without joint or load bars	18	13	1,8
Plug, sump	68	50	7,0
Setscrews, oil strainer and suction pipe	19	13	1,8
Fuel system			
Setscrew, atomiser	25	19	2,5
Union nuts, high pressure fuel pipes	40	30	4,0



11B RECOMMENDED TORQUE SETTINGS

Description	Nm	lbf ft	kgf m
End nut, fuel lift pump	42	31	4,3
Delivery valve assembly, fuel lift pump	42	31	4,3
Nut and bolt, bracket for the fuel injection pump	66	49	6,8
Setscrew, bracket for the fuel injection pump to the cylinder block	115	85	11,9
Nut, bracket for the fuel injection pump to the pump	115	85	11,9
Banjo bolt, pipe for the boost control to the rocker cover	18	13	1,8
Nuts, fuel lift pump to fuel injection pump	6	4	0,6
Cooling system			
Fasteners, water pump to timing case cover	7	5.5	0,8
Setscrews, fan drive pulley	7	5.5	0,8
Setscrews, fan drive	17	13	1,8
Flywheel and flywheel housing			
Setscrews, flywheel	136	100	13,8
Setscrews, flywheel housing	108	80	11,0
Auxiliary equipment			
Setscrews, air compressor to engine	62	46	6,4
Setscrew, air compressor to mounting bracket	66	49	6,7
Setscrews, air compressor mounting bracket to engine	115	85	11,9
Nut, air compressor drive gear	149	110	15.21



Cylinder head assembly **12A**

General description 12A.02

Rocker cover

12A-01 To remove and to fit 12A.03

Rocker assembly

12A-02 To remove 12A.05

12A-03 To dismantle and inspect 12A.06

12A-04 To assemble 12A.07

Cylinder head

12A-05 To remove and to fit 12A.08

Valves and valve springs

12A-06 To remove and to fit 12A.12

12A-07 To inspect and to correct 12A.13

12A-08 To inspect a valve rotator 12A.14

Valve guides

12A-09 To inspect a valve guide 12A.15

12A-10 To remove and to fit 12A.15

Cylinder head

12A-11 To inspect and to correct 12A.17

12A-12 To correct a valve seat with a valve seat cutter 12A.18

12A-13 To fit valve seat inserts 12A.19

12A-14 To renew atomiser sleeves 12A.20

12A-15 To set the valve tip clearance 12A.22

Data and dimensions 12A.24



12A CYLINDER HEAD ASSEMBLY

Cylinder head assembly

General description

All New Generation Peregrine and 1300 Series engines have the inlet manifold contained in the rocker cover. The rocker cover also contains the engine breather assembly.

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 assembly has two valves fitted for each cylinder, each fitted with a single valve spring, a valve seal assembly and a valve rotator.

Valve seat inserts and valve guides, which can be renewed, are fitted in the cylinder head for the inlet valves and the exhaust valves.

The face angle of the inlet valve seats is 30°, and is 45° on the exhaust valves seats. The face angle of the valves is 31° on the inlet valves, and is 46° on the exhaust valves.

Atomiser sleeves are fitted in the cylinder head to house and to seal the atomisers.

Caution: *The rocker shaft must not be removed without the complete removal of the cylinder head. The setscrews which retain the rocker shaft assembly also retain the cylinder head to the cylinder block. The cylinder head gasket might leak if only these setscrews are removed and then fitted. This is because the tightness of the cylinder head will not be even.*



Rocker cover

To remove and to fit

12A-01

Consumable products:

POWERPART Silicon rubber sealant

To remove

- 1 Remove the pipe for the air inlet from the rocker cover.
- 2 Remove the pipe for the boost control and discard the copper washers.
- 3 Put a cover on the union of the boost control to prevent the entry of dirt.
- 4 Remove the setscrews for the breather pipe.
- 5 Remove the setscrews for the rocker cover.
- 6 Lift the rocker cover and remove the breather pipe from the cover.

Caution: The oil deflectors and breather element of the engine breather system will be damaged if the breather pipe is removed from the rocker cover before the rocker cover is lifted from the engine.

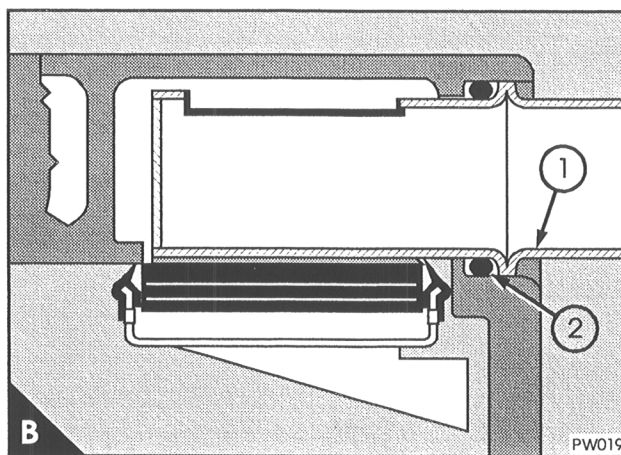
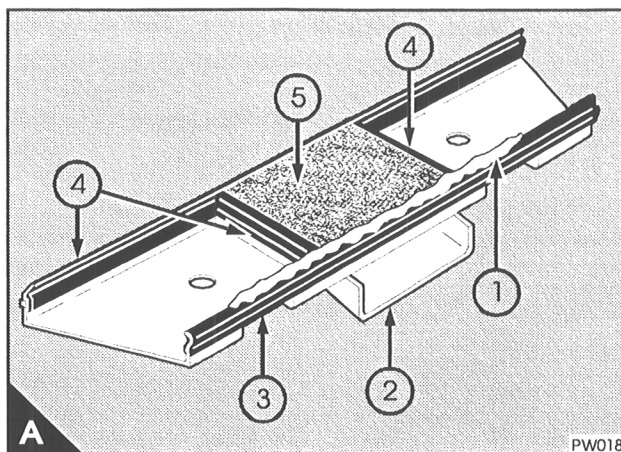
- 7 Remove the rocker cover from the engine.

To fit

Cautions:

- Engine lubricating oil can be lost through the breather system if:
- The oil deflector (A3) is pushed from its seat by the breather tube during assembly.
- There is distortion or damage to the breather element (A5) during assembly.

- 1 Renew the gasket for the rocker cover, if necessary.
- 2 Fit new or usable deflectors (A4) to the baffle plate (A2).
- 3 Fit the breather element (A5) with the nylon netting at the top.
- 4 Apply POWERPART Silicon rubber sealant (A1) to the deflector (A3) which is on the push rod side of the engine.
- 5 Fit a new "O" ring (B2) onto the breather tube (B1).
- 6 Apply clean lubricating oil to the "O" ring.
- 7 Hold the rocker cover over the engine.
- 8 Fit the breather pipe into the cover.
- 9 The breather tube must be fitted into the cover before the cover is fitted to the engine.





12A CYLINDER HEAD ASSEMBLY

10 Carefully put the cover and tube into position on the engine.

Caution: *If the cover is put onto the POWERPART Silicon rubber sealant and then lifted again, the oil deflector will be lifted from the baffle.*

11 Fit the pipe for the air inlet to the rocker cover.

12 Fit and tighten the cover setscrews to 18 Nm (13 lbf ft) 1,8 kgf m.

13 Fit and tighten the top and bottom setscrews of the beather tube.

14 Fit new copper washers to the pipe for the boost control, then fit the pipe to the rocker cover and to the fuel injection pump. Tighten the banjo bolt to 18 Nm (13 lbf ft) 1,8 kgf m.



Rocker assembly

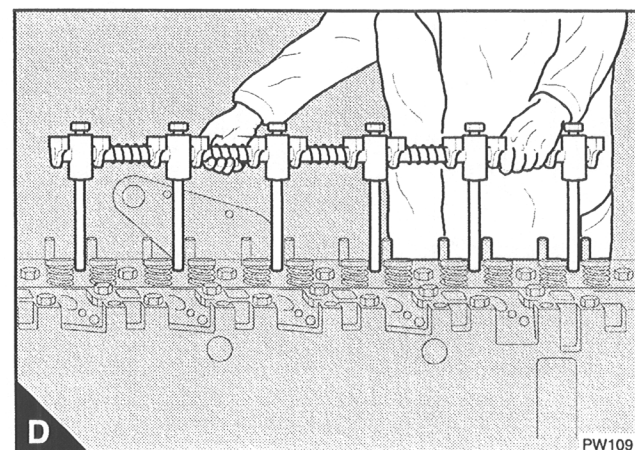
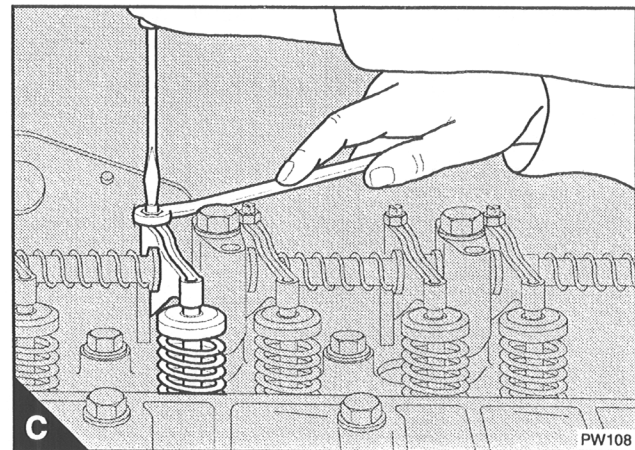
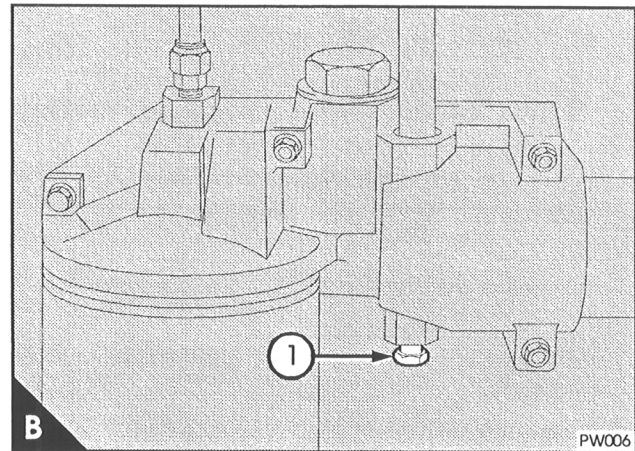
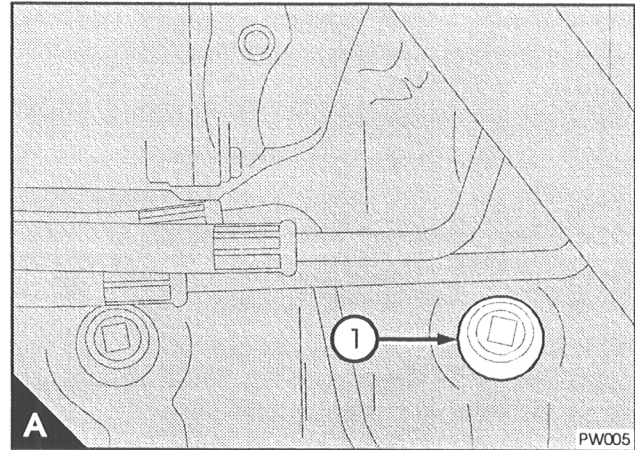
To remove

12A-02

Caution: The rocker shaft must not be removed without the complete removal of the cylinder head. The setscrews which retain the rocker shaft assembly also retain the cylinder head to the cylinder block. The cylinder head gasket might leak if only these setscrews are removed and then fitted. This is because the tightness of the cylinder head will not be even.

To remove

- 1 Remove the rocker cover, see [operation 12A-01](#)
- 2 Remove the rocker cover gasket from the cylinder head.
- 3 Drain the cooling system.
 - Remove the drain plug (A1) from the side of the cylinder block (below the rear of the fuel injection pump), and the drain plug (B1) from the lubricating oil cooler in order to drain the engine.
 - Open the tap or remove the drain plug at the bottom of the radiator in order to drain the radiator. If the radiator does not have a tap or drain plug, disconnect the hose at the bottom of the radiator.
- 4 Loosen the adjustment screws on the rocker levers one turn (C).
- 5 Remove the baffle plate. Remove the spacers for the baffle plate.
- 6 Release the rocker shaft setscrews evenly and gradually in the sequence 1-3-5-2-4-6 from the front of the engine, to avoid damage to the rocker assembly.
- 7 Release the setscrews and remove the rocker assembly, complete with its setscrews and their washers (D).



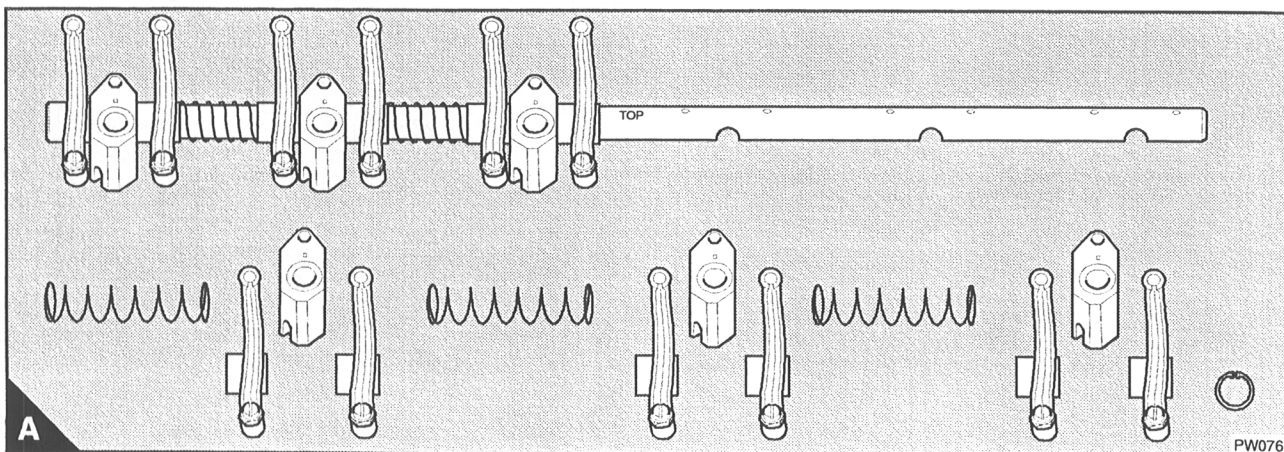


12A CYLINDER HEAD ASSEMBLY

To dismantle and inspect

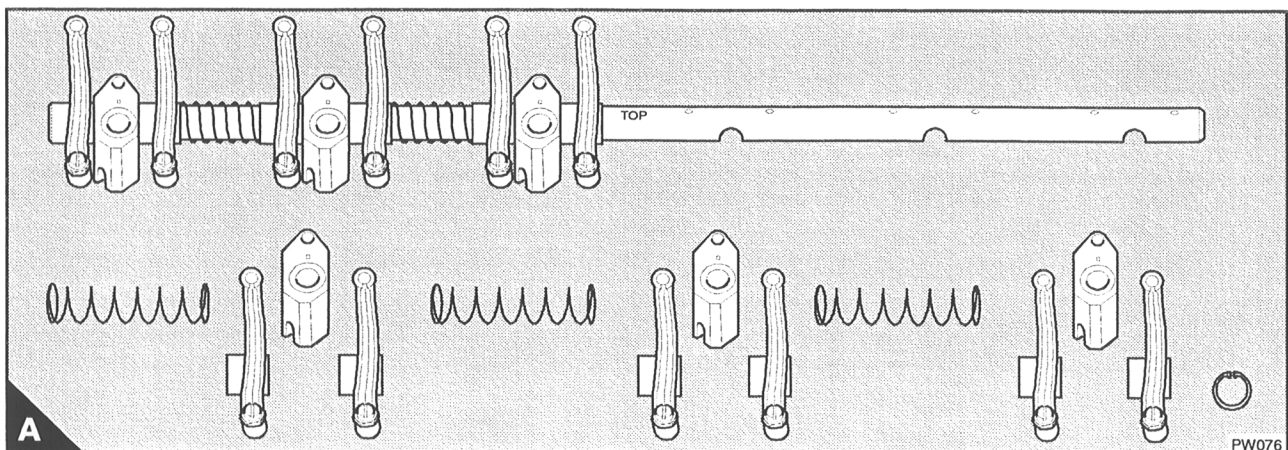
12A-03

- 1 Remove the circlip from the end of the rocker shaft.
- 2 Slide all of the components from the shaft and put them on a bench in the correct sequence.
- 3 Inspect all of the components for signs of damage.
- 4 Check the rocker shaft, the rockers and the bushes for deep scratches or signs of excessive wear.
- 5 The bushes of the rocker lever have a groove to assist with lubrication.
- 6 Measure the internal diameter of the bushes at two places 90° apart and record the readings.
- 7 Measure the external diameter of the rocker shaft at two places 90° apart where it contacts the bushes of the rocker levers. Record the readings.
- 8 If the difference between the measurements is greater than 0,13mm (0.005 in) renew the component that is worn, either the shaft or the bushes.
- 9 Ensure that all the lubricating oil holes and passages of the rocker shaft assembly are free of debris.
- 10 Check the plugs at the ends of the rocker shaft for leaks or damage.
- 11 Measure and record the free length of the rocker shaft springs.
- 12 Measure and record the length of the springs when a load of 31N (7 lbf) 3,2 kgf is applied. Compare both measurements with the measurements given in data and dimensions.
- 13 Renew any springs that are not within the tolerance.



**To assemble****12A-04**

- 1** Apply clean lubricating oil to the bushes of the rocker levers.
- 2** Ensure that a circlip is fitted to one end of the rocker shaft.
- 3** The rocker shaft is marked "TOP" at the centre of its length. Ensure that this mark is at the top. Slide the components onto the rocker shaft in the correct sequence, ensure that the lubricating oil holes are aligned correctly.
- 4** Ensure that the setscrew holes in the rocker shaft brackets align with the recesses in the shaft.
- 5** Compress the rocker shaft springs and fit the second circlip to the rocker shaft.





12A CYLINDER HEAD ASSEMBLY

Cylinder head

To remove and to fit

12A-05

Special tools:

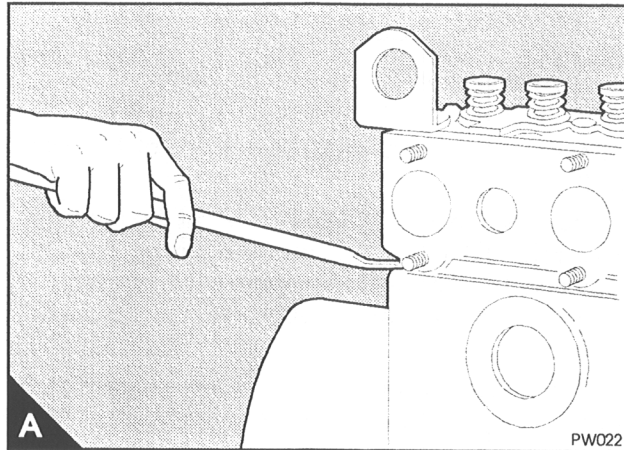
Spanner PD.233

Slide hammer PD.232

To remove

Warning! The cylinder head weighs 77 kg (170 lbs). Use lift equipment or obtain assistance to lift the cylinder head.

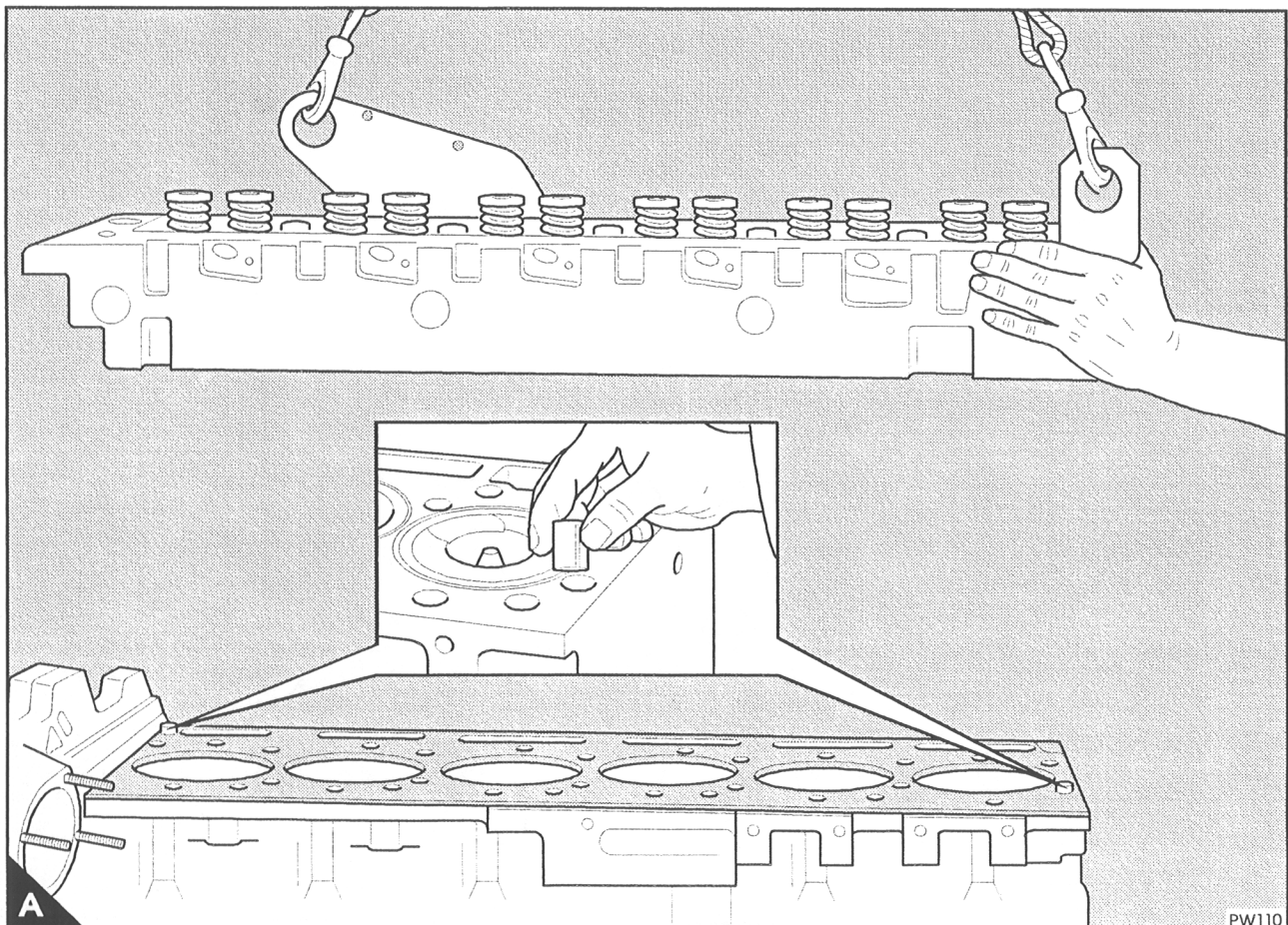
- 1 Drain the cooling system.
- 2 Remove the rocker cover, see operation 12A-01.
- 3 Remove the rocker assembly, see operation 12A-02.
- 4 Remove all the push rods and note their relative positions.
- 5 Use the spanner PD.233 to remove the high pressure pipes. Remove the leak-off pipes.
- 6 Remove the atomisers, see operation 20A-02.
- 7 Remove all the pipes and hoses from the turbocharger.
- 8 Remove the exhaust manifold setscrews and remove the exhaust manifold and turbocharger as an assembly. Remove the gasket for the exhaust manifold.
- 9 Release evenly and gradually then remove the cylinder head setscrews and washers.
- 10 Carefully separate the cylinder head from the cylinder block with a suitable lever (A).
- 11 Remove the cylinder head and put it on a surface that will not damage the face of the head.



**To fit**

Warning! The cylinder head weighs 77 kg (170 lbs).
Use lift equipment or obtain assistance to lift the
cylinder head.

- 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. Ensure that the holes for the cylinder head setscrews are dry and free from debris.
- 2 Fit the thermostat, if it was removed for operation 12A-11.
- 3 Check the cylinder liner protrusion, see operation 16A-03.
- 4 Fit the dowels into the cylinder block (A).
- 5 Fit a new cylinder head gasket onto the dowels (A).
- 6 Put the cylinder head in position (A).





12A CYLINDER HEAD ASSEMBLY

7 Put the push rods and the rocker shaft assembly in position. Check that the push rods fit correctly in the sockets of the tappets. Check that the ends of the adjustment screws fit correctly in the sockets of the push rods.

8 Inspect the setscrews for damage and excessive wear. Renew any setscrews that are damaged or excessively worn.

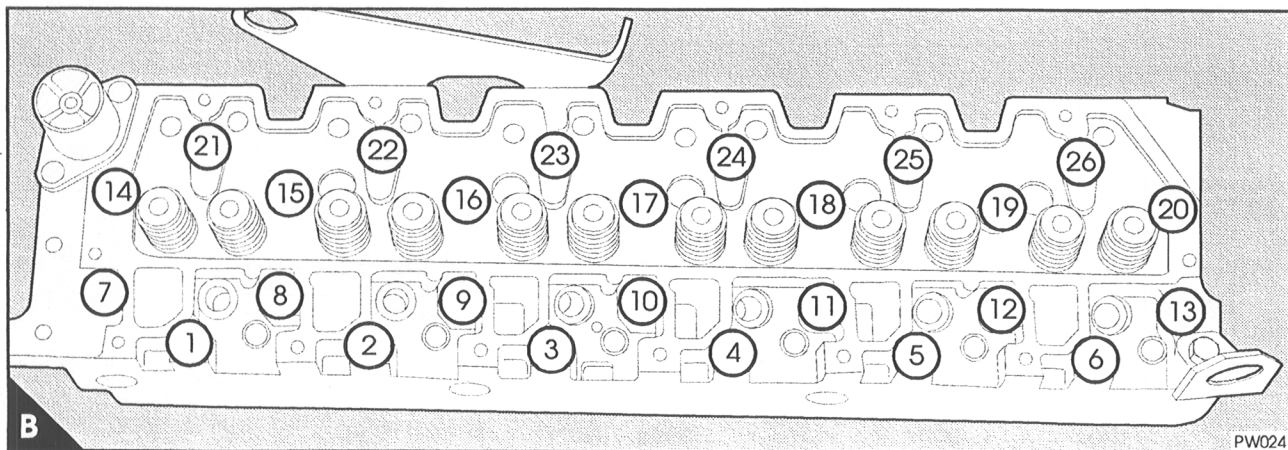
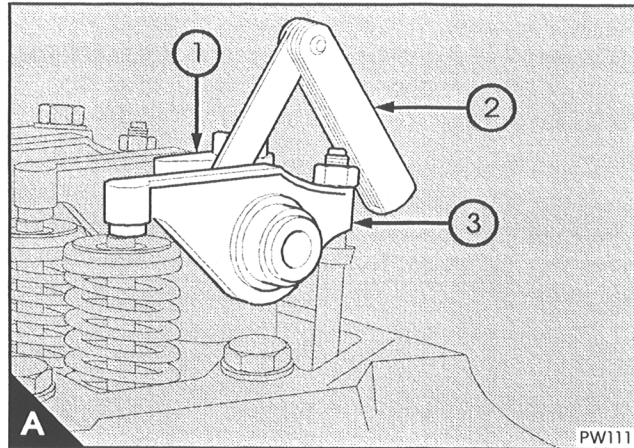
9 Lightly lubricate the threads and the thrust faces of the cylinder head setscrews with clean engine lubrication oil.

10 Engage all the setscrews in their correct positions, except the setscrews (B21 and B26), and tighten the setscrews finger tight.

11 It is necessary to position the rocker shaft correctly when the setscrews are tightened. To do this:

- Put a 0,13 mm (0.005 in) feeler gauge (A2) between the rocker lever (A3) for the inlet valve of number one cylinder and the first mounting bracket (A1) of the rocker shaft.
- Put another 0,13 mm (0.005 in) feeler gauge between the rocker lever for the exhaust valve of number six cylinder and the last bracket of the rocker shaft.

12 Fit and tighten the end setscrews (B21) and (B26) of the rocker shaft assembly. Tighten the setscrews finger-tight.





13 Tighten evenly and gradually all the cylinder head setscrews as follows:

- 150 Nm (110 lbf ft) 15 kgf m in the sequence shown in (A).
- 210 Nm (155 lbf ft) 21,5 kgf m in the sequence shown in (A).
- 225 Nm (165 lbf ft) 23 kgf m in the sequence shown in (B).

14 Remove both of the feeler gauges.

15 Check the rocker levers for free movement.

16 Set the valve tip clearance, see [operation 12A-15](#).

17 Ensure that the spacers are fitted under the baffle plate. Put the breather assembly onto the rocker shaft. Fit and tighten the setscrews.

18 Fit the valve cover, see [operation 12A-01](#).

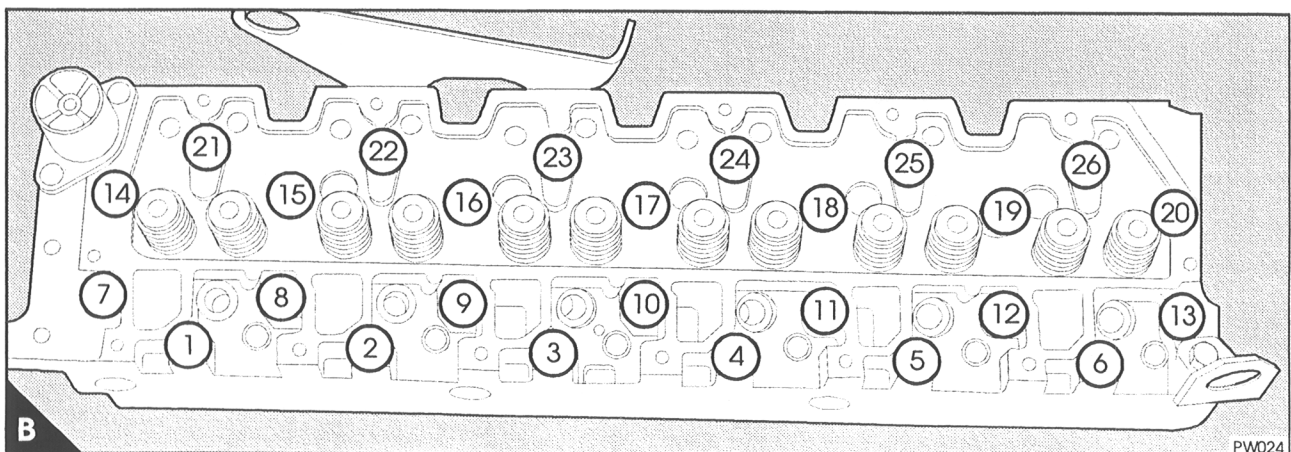
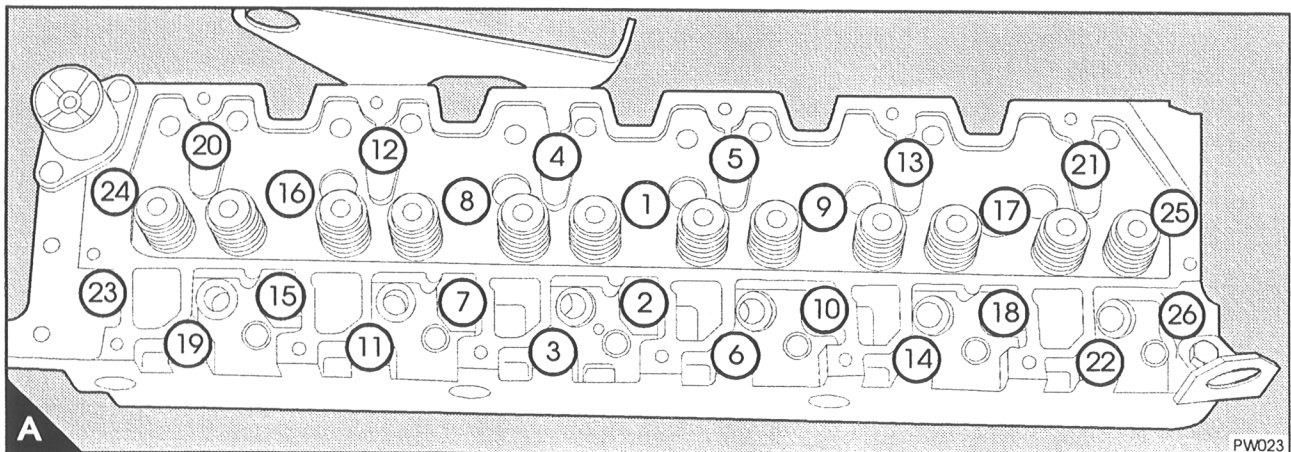
19 Fit the atomisers, see [operation 20A-02](#).

20 Fit the leak-off pipes. Use the spanner PD.233 to fit the high pressure pipes.

21 Fit the gasket for the exhaust manifold. Fit the exhaust manifold and turbocharger assembly. Fit and tighten the setscrews for the exhaust manifold to 81 Nm (60 lbf ft) 8,3 kgf m.

22 Fit all the pipes and hoses removed earlier from the turbocharger.

23 Fill the cooling system.





12A CYLINDER HEAD ASSEMBLY

Valves and valve springs

To remove and to fit

12A-06

To remove

Warning! Protect your eyes when a valve spring is compressed.

- 1 Remove the cylinder head, see [operation 12A-05](#), and put it on a surface that will not damage the face of the head, ensure that the face of the head can be seen for inspection.
- 2 Use a valve spring compressor to compress the valve spring.
- 3 Remove the collets (A1).
- 4 Release and remove the valve spring compressor.
- 5 Remove the valve rotator (A2), valve rotator seal (A3), valve spring (A4), valve seal assembly (A5) and valve (A6).
- 6 Separate the inlet valve springs from the exhaust valve springs. They are rated differently.
- 7 Discard the valve seal assemblies.

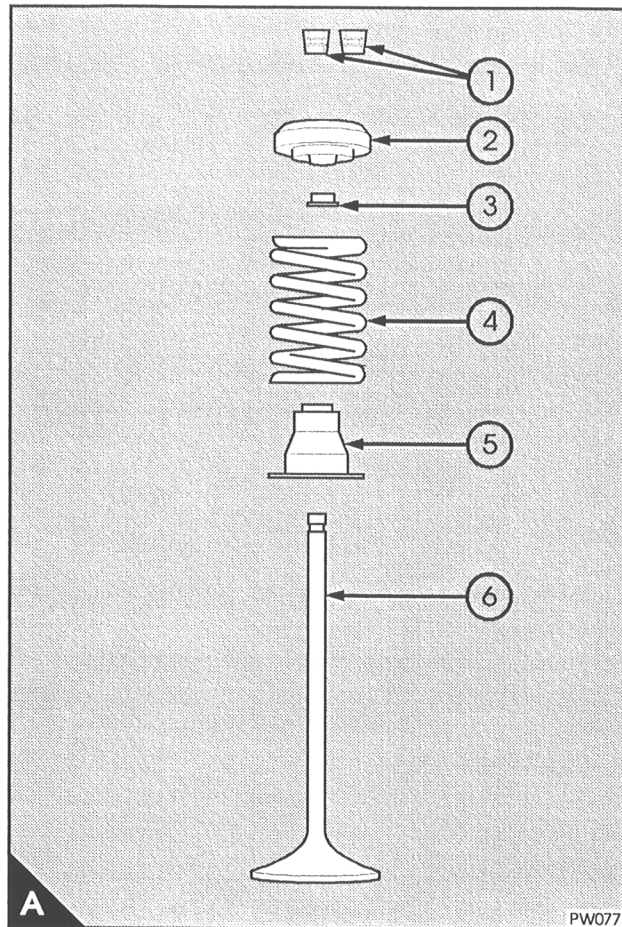
To fit

Warning! Protect your eyes when a valve spring is compressed.

- 1 Ensure that the valve guides are clean.
- 2 Apply clean lubricating oil to the valve stems and fit the valves (A6) into the valve guides.
- 3 Apply clean lubricating oil to the inside of new valve seal assemblies (A5) and fit them to the valve stems. Ensure that each valve seal assembly seats against its valve spring recess in the cylinder head.
- 4 Put the valve springs (A4) into position on the valve seal assemblies.

Caution: Ensure that the inlet valve springs are fitted to inlet valves and that the exhaust valve springs are fitted to exhaust valves. They are rated differently.

- 5 Fit new seals (A3) to the valve rotators (A2) and put the rotators onto the valve springs.
- 6 Use a valve spring compressor to compress each valve springs and fit the collets (A1).
- 7 Release and remove the valve spring compressor.





To inspect and to correct

12A-07

Special tools:

Valve depth gauge PD.208 and PD.41D.

- 1 Remove the cylinder head, see [operation 12A-05](#).
- 2 Put a small amount of low viscosity oil, for example calibration fluid, into the inlet and exhaust ports to check for valve leakage.
- 3 Wait five minutes.
- 4 Visually inspect the valve seats for leaks.

Note: If no oil leaks past the valve seat, it does not need to be reground.

- 5 Ensure that the heads of the valves and the face of the cylinder head are clean.

- 6 Check the depth of the valves (A) below the face of the cylinder head before the valve springs are removed. Put the valve depth gauge on the face of the cylinder head and zero the dial gauge. Carefully put the valve depth gauge in position over the head of each valve (A) and compare the measurement with the specification.

- 7 If a valve is below the depth limit, check the valve depth with a new valve in position.

- 8 If the valve depth is still below the limit, the valve seat insert must be renewed, see [operation 12A-13](#).

- 9 Remove the valves and valve springs, see [operation 12A-06](#).

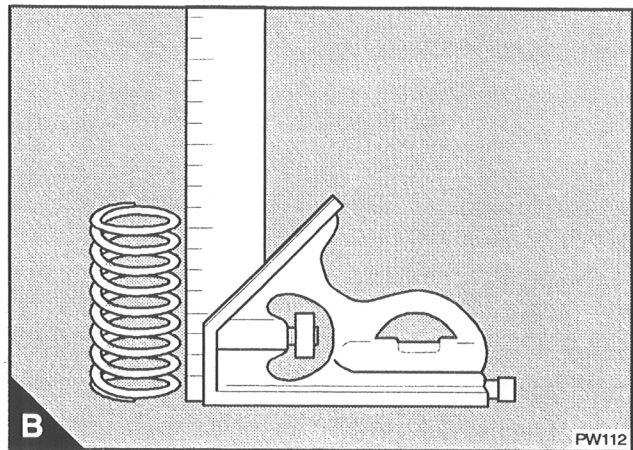
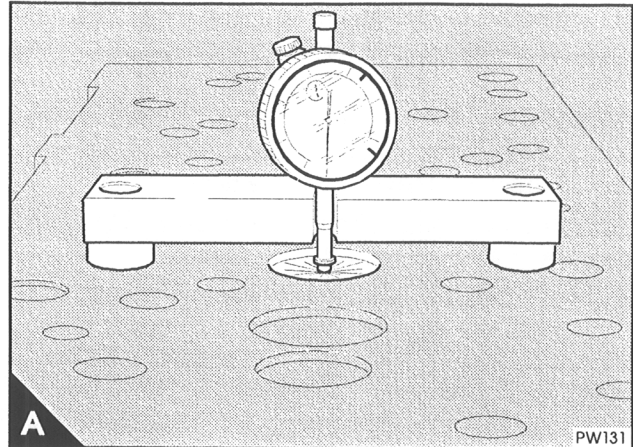
- 10 Visually inspect the condition of the collets.

- 11 Visually inspect the valve springs for corrosion, for damage or distortion.

- 12 Check that the end faces of the springs are square and flat.

- 13 Measure the free length of the valve springs (B) and compare it with data and dimensions.

Continued





12A CYLINDER HEAD ASSEMBLY

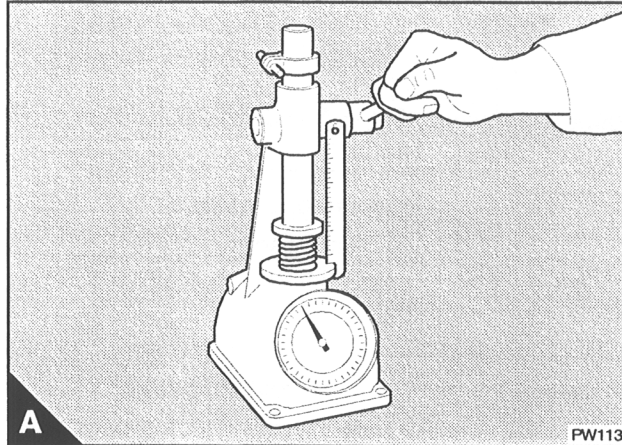
14 Measure the springs under a load (A) of 356/391 N (80/88 lbf) 36/40 kgf and compare it with data and dimensions. This is the valve closed length.

15 Measure the springs under a load of 952/996 N (214/224 lbf) 97/102 kgf and compare it with the data and dimensions. This is the valve open length.

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

17 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 a little damage can be lapped to their valve seats. When new valves are fitted, the valve depths must be checked, see paragraph 6.

18 Measure the valve dimensions and compare them with data and dimensions.



To inspect a valve rotator

12A-08

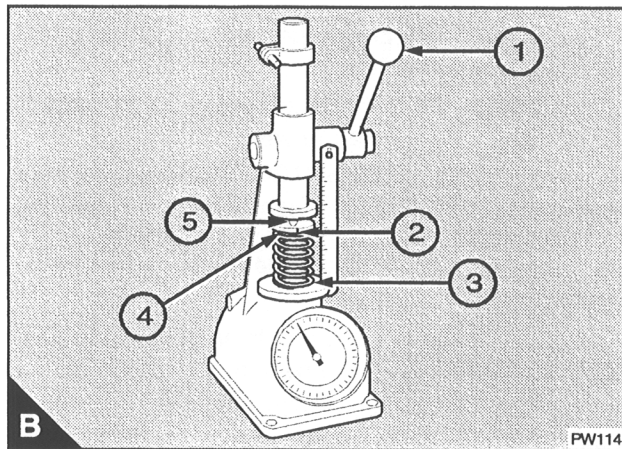
1 Visually inspect the valve rotator for corrosion, damage or distortion.

2 To test the operation of the rotator (B4), put a valve spring (B3), the valve rotator and a steel ball bearing (B5) in a valve spring tester (B1).

3 Mark the rotator with a reference line (B2).

4 Compress the valve spring rapidly several times and check that the rotator rotates.

5 Replace any rotator that does not rotate.





Valve guides

To inspect a valve guide

12A-09

Check the valve guides for wear. The maximum clearance between the valve stem and the bore of the guide is 0,15 mm (0.006 in) for the inlet valves and the exhaust valves. If the clearance with new valves fitted is more than the limit, then a new valve guide must be fitted.

To remove and to fit

12A-10

Special tools:

Remover/replacer for valve guides (main tool), PD.1D

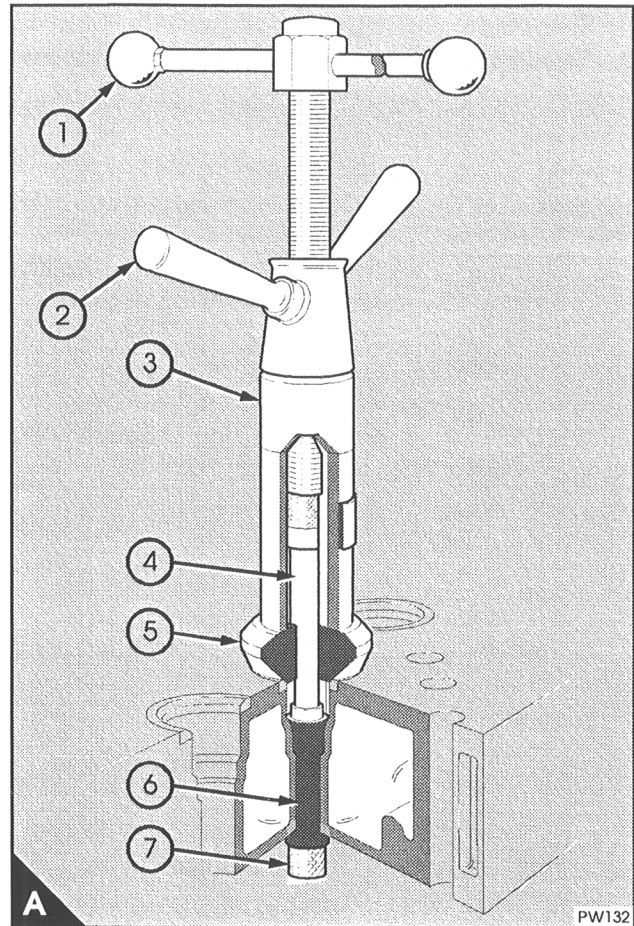
Adaptor PD.1D-1A

Adaptor PD.1D-11

To remove

1 Fit the adaptor PD.1D-1A (A4) into the remover/replacer tool PD.1D (A3). Pass the tool and adapter through the spacer (A5) and the cylinder head, from the bottom face. Fully fit the attachment (A7) to secure the adapter in the valve guide (A6).

2 Turn the top handle (A1) to take up the excess movement in the tool and turn the bottom handle (A2) to pull the valve guide out of the cylinder head.



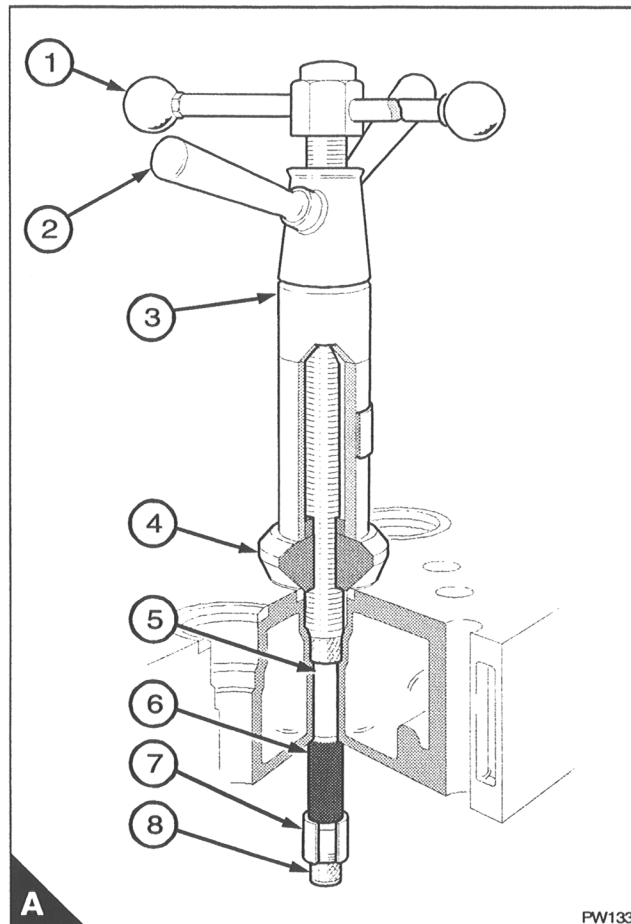


12A CYLINDER HEAD ASSEMBLY

To fit

- 1 Clean the parent bore for the valve guide (A4).
- 2 Lubricate the outer surface of the new guide with clean engine lubricating oil.
- 3 Fit the adaptor PD.1D-1A (A5) into the remover/replacer tool PD.1D (A3). Pass the tool and adapter through the spacer (A4) and the cylinder head, from the bottom face. Fully fasten the valve guide, with the large 15° chamfer at the bottom, and the distance piece (A7), PD.1D-11, onto the adapter with the attachment (A8).
- 4 Turn the top handle (A1) to take up the excess movement in the tool and turn the bottom handle (A2) to pull the valve guide into the cylinder head.

Caution: Do not ream new valve guides. They are supplied in a finished condition.





Cylinder head

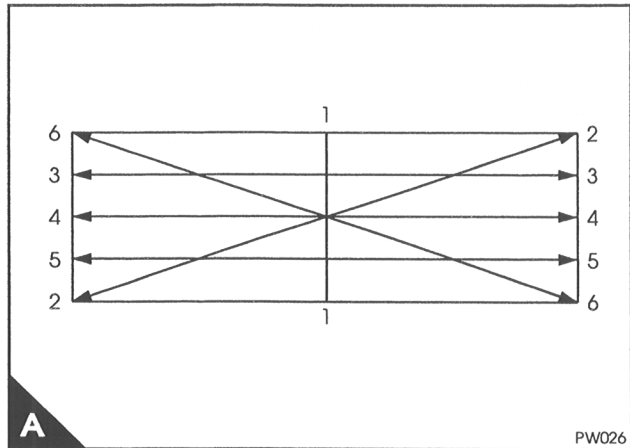
To inspect and to correct

12A-11

- 1 Remove the cylinder head assembly, operation 12A-05.
 - 2 Remove the valve springs and the valves, operation 12A-06.
 - 3 Remove the thermostat.
 - 4 Inspect the cylinder head for signs of gas or coolant leakage.
 - 5 Clean the face of the cylinder head, the passages for coolant and the passages for the lubricating oil.
 - 6 The water jacket can be cleaned with a special solvent which must be used in accordance with the manufacturer's instructions.
 - 7 Pressure test the cylinder head to a pressure of 124/138 kPa (18/20 lbf in²) 1,27/1,41 kgf cm² and inspect the cylinder head for leaks.
- Warning!** Always use a safety cage to protect the operator when a component is to be pressure tested in a bath of water. Fit safety wires to secure the plugs which seal the hose connections of a component which is to be pressure tested.
- 8 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 atomisers.
 - 9 The bottom face of the cylinder head can be machined if:
 - there is distortion, see paragraph 10
 - there are deep scratches.
 - 10 Use a straight edge and feeler gauges to check the cylinder head for distortion (A) across and along its bottom face, see data and dimensions. If the distortion is more than the limit given in data and dimensions, the bottom face can be machined.

Cautions:

- Remove only the minimum material and ensure that the thickness of the cylinder head will not be less than 106,17 mm (4.180 in) after the cylinder head has been machined.
 - After the cylinder head has been machined the valve seats must be corrected to give the correct valve head depth, see operation 12A-12. 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, new valve guides must be fitted, operation 12A-10.





12A CYLINDER HEAD ASSEMBLY

13 Where there is little damage, the valve and valve seat can be lapped. When the valve seats are lapped keep the seat to the measurements shown in data and dimensions. Ensure that all the compound used to lap the valve seat and the seat is removed.

14 Badly damaged valve seats can be corrected with a valve seat cutter, operation 12A-12.

To correct a valve seat with a valve seat cutter

12A-12

Special tools:

Cutter for 46° inlet valve seats, MS.281*

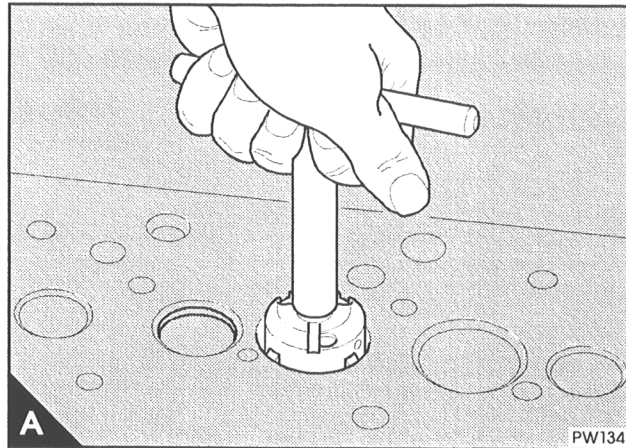
Cutter for 31° inlet valve seats, MS.642

Cutter for exhaust valve seats, MS.275*

Pilot for use with valve seat cutters, MS.150-9.5*

Handle set for use with valve seat cutters, MS.67B*

* Included in set of adjustable cutters for valve seats, MS.73A



1 Before work is done on the valve seats, new valve guides must be fitted, [operation 12A-10](#).

2 Fit the pilot in the valve guide and tighten the pilot.

3 Select the relevant cutter. Set the blades of the cutters to the diameter of the valve seat to be cut. Fit the cutter on the pilot and fit the handle. Ensure that the cutter is not allowed to fall on to the seat as this can damage the blades.

4 Carefully turn the cutter in a clockwise direction (A). Remove only the minimum material to ensure a good seat. Keep the seat as narrow as possible.

5 When the seat is cut, remove the cutter and the pilot. Remove any debris from the area of the valve seat and the port.

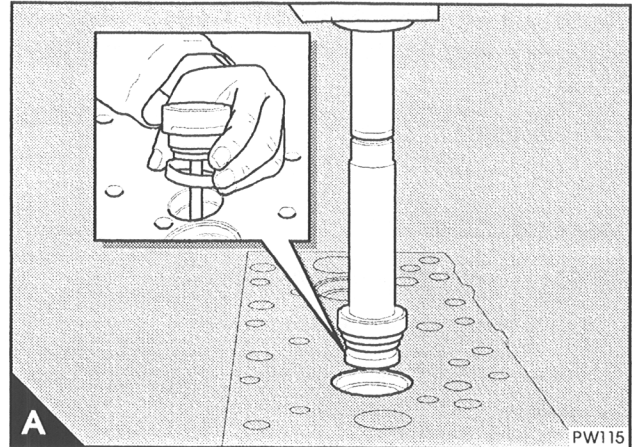
6 Fit the valve and lightly lap the valve and the seat.

7 Check that the valve depth is within limits, see [operation 12A-07](#).

8 If a valve seat has become too damaged or too worn to correct, a valve seat insert can be fitted, see [operation 12A-13](#).

**To fit valve seat inserts****12A-13**

- 1 Fit new valve guides, see [operation 12A-10](#).
- 2 With the bore of the new valve guide used as a pilot, machine out the old insert. Remove all debris and clean the insert recess.
- 3 If the bottom face of the cylinder head has been machined, the insert will have to be surface ground on the back face to ensure that there is no protrusion of the insert above the bottom face of the cylinder head. After the back of the insert has been ground, ensure that the outer edge of the back face has a 0,9/1,3 mm (0.035/0.051 in) chamfer at 30° to the vertical.
- 4 Put the valve seat inserts in a deep freeze unit for 30 minutes. This will reduce the size of the valve seat inserts to allow them to fit more easily.
- 5 With the bore of the valve guide used as a pilot, and with the rear face of the insert towards the cylinder head, press in the insert (A). Use a hydraulic press or a hand press in one continuous movement. Do not use a hammer on the insert and do not use lubrication. Ensure that the bottom of the insert is in contact with the bottom of the recess.
- 6 Cut the valve seat at an included angle of 90° for 45° valve seats or 120° for 30° valve seats, see [operation 12A-12](#), and lap the valve on to the valve seat. Ensure that the depth of the valve head below the face of the cylinder head is within the production limits, see [operation 12A-07](#). Work as near as possible to the minimum figure to allow for future wear on the valve seat.





12A CYLINDER HEAD ASSEMBLY

To renew atomiser sleeves

12A-14

Special tools:

Atomiser puller PD.232

Spanner PD.233

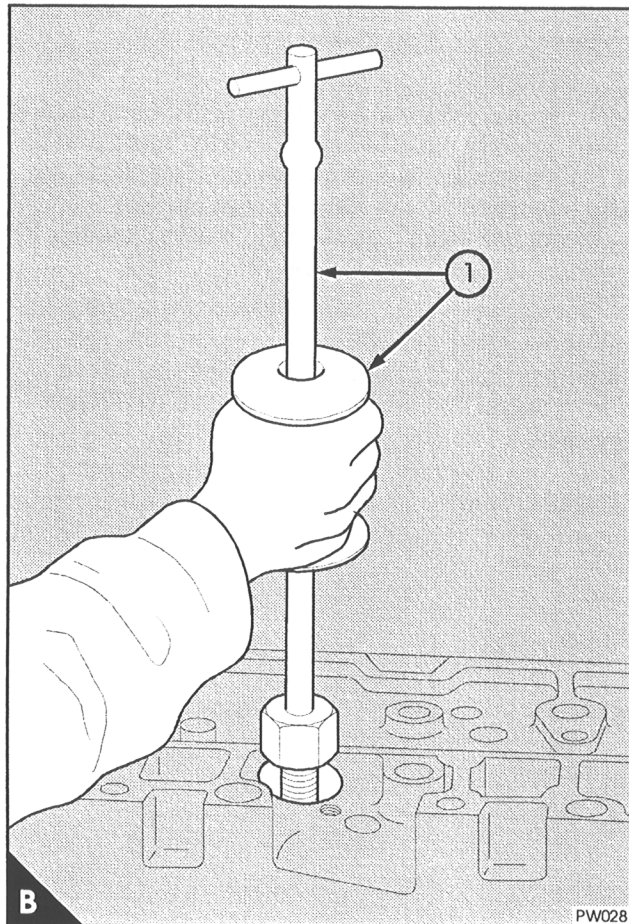
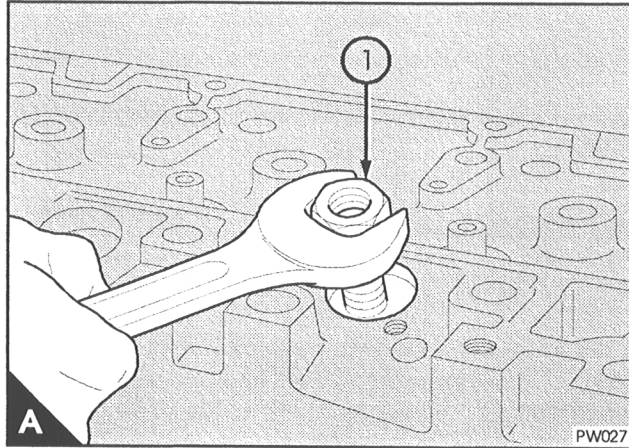
Slide hammer PD 235

Adapter PD.235/1, for use with PD.235

Tool to fit the atomiser sleeve PD.236

To remove

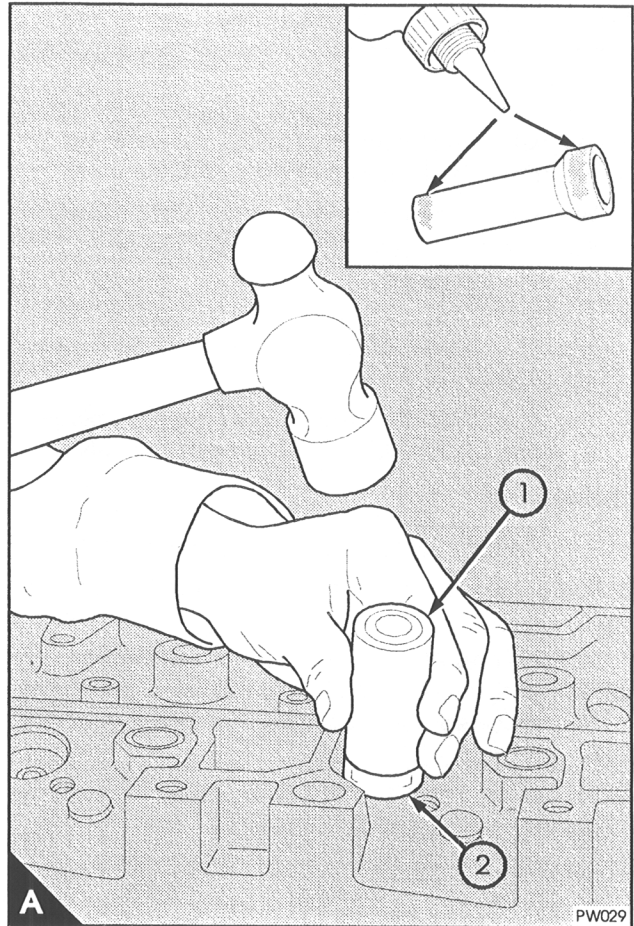
- 1 Drain the cooling system.
- 2 Use the spanner PD.232 to release the high pressure pipes from the atomiser. Remove the high pressure pipes from the engine.
- 3 Use the atomiser puller PD.232 to remove the atomiser.
- 4 Fit the adapter PD.235/1 (A1) into the atomiser sleeve then fit the slide hammer PD.235 (B1) to the adapter.
- 5 Use the slide hammer to remove the atomiser sleeve from the cylinder head (B).



**To fit**

Caution: Ensure that the piston is at the bottom of the cylinder or the tool used to fit the atomiser sleeve might hit the piston. Do not allow debris to fall into the cylinder.

- 1 Use a wire brush to clean the top and bottom of the bore for the atomiser sleeve.
- 2 Remove any debris.
- 3 Put Loctite 262 on the top and bottom contact faces (A) of the atomiser sleeve.
- 4 Put the atomiser sleeve (A2) onto the tool PD.236 (A1). Put the atomiser sleeve and the tool into the bore for the atomiser in the cylinder head.
- 5 Hit the tool PD.236 with a hammer to drive the atomiser sleeve into position at the bottom of the bore.
- 6 Remove the tool.
- 7 Fit the atomiser and fit the high pressure pipes.
- 8 Fill the cooling system.





12A CYLINDER HEAD ASSEMBLY

To set the valve tip clearance

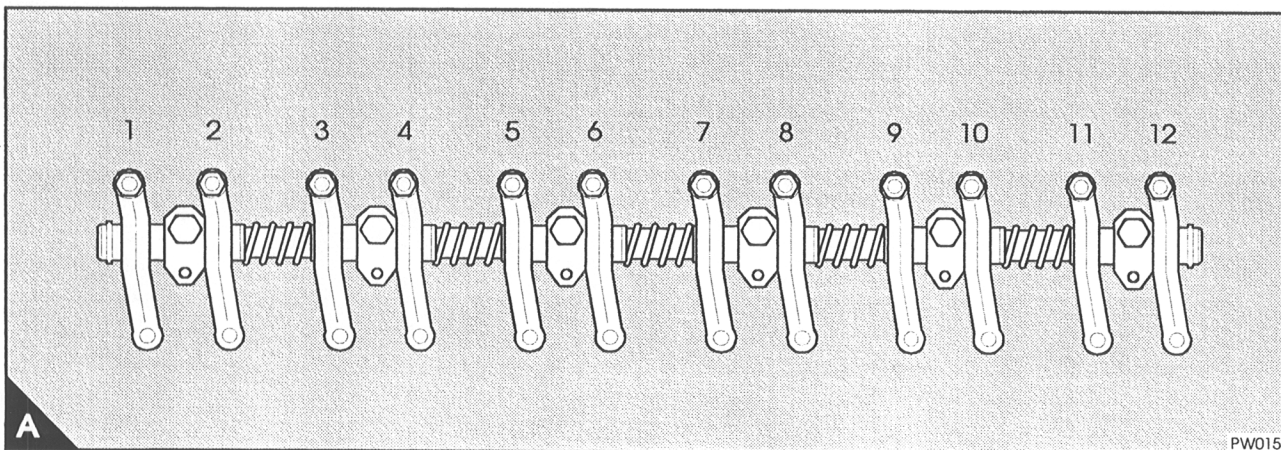
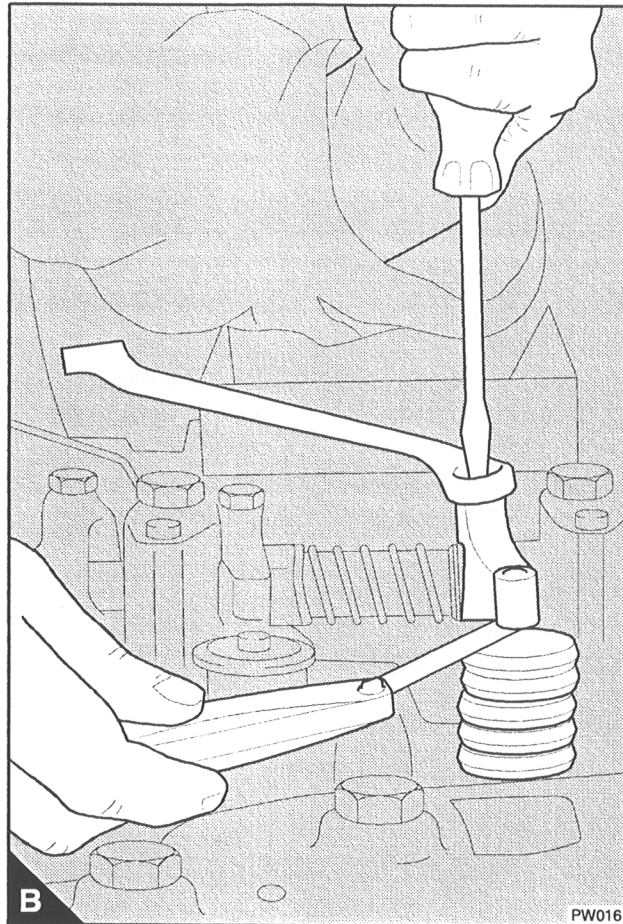
12A-15

Notes:

- The valve tip clearance is measured between the top of the valve stem and the rocker lever (A).
- With the engine hot or cold, the correct clearances are 0,64 mm (0.025 in) for the inlet valves and for the exhaust valves.
- The sequence and positions of the valves are shown at (B). Number 1 cylinder is at the front of the engine.
- The arrangement of the valves for each cylinder, in sequence, is inlet valve then exhaust valve.

Method one

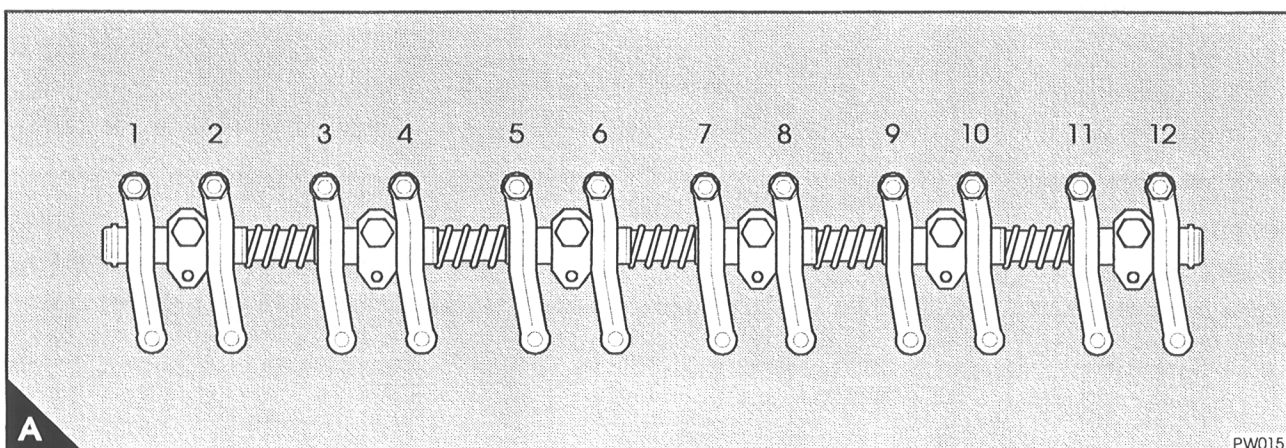
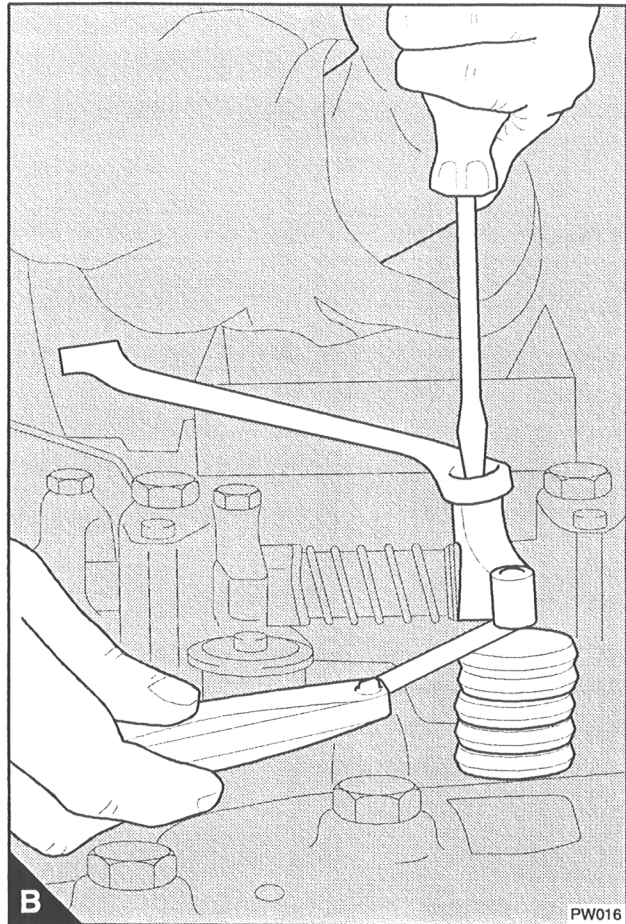
- 1 Remove the rocker cover, see [operation 12A-01](#).
- 2 Remove the baffle plate. Remove the spacers for the baffle plate.
- 3 Turn the crankshaft in the normal direction of rotation until valve 11 (A) has just opened and valve 12 has not closed fully. Check/adjust the clearances of valves 1 and 2.
- 4 Set valves 3 and 4 as indicated above then check/adjust the clearances of valves 9 and 10.
- 5 Set valves 7 and 8 then check/adjust the clearances of valves 5 and 6.
- 6 Set valves 1 and 2 then check/adjust the clearances of valves 11 and 12.
- 7 Set valves 9 and 10 then check/adjust the clearances of valves 3 and 4.
- 8 Set valves 5 and 6 then check/adjust the clearances of valves 7 and 8.
- 9 Fit the baffle plate. Ensure that the spacers are fitted under the baffle plate.
- 10 Fit the rocker cover, see [operation 12A-01](#).





Method two

- 1 Remove the rocker cover, see [operation 12A-01](#).
- 2 Remove the baffle plate. Remove the spacers for the baffle plate.
- 3 Turn the crankshaft in the normal direction of rotation until the number 1 cylinder is at top dead centre until the inlet valve (A11) of number 6 cylinder has just opened and the exhaust valve (A12) of the same cylinder has not closed fully.
- 4 Check the clearances of the valves (A1, A2, A3, A6, A7, and A10) and adjust them, if necessary.
- 5 Turn the crankshaft in the normal direction of rotation until the number 6 cylinder is at top dead centre; until the inlet valve (A1) of number 1 cylinder has just opened and the exhaust valve (A2) of the same cylinder has not closed completely.
- 6 Check the clearances of the valves (A4, A5, A8, A9, A11, and A12) and adjust them, if necessary.
- 7 Fit the baffle plate. Ensure that the spacers are fitted under the baffle plate.
- 8 Fit the rocker cover, see [operation 12A-01](#).





12A CYLINDER HEAD ASSEMBLY

Data and dimensions

Note: 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 the factory. The information applies to all engines, unless an engine type code is shown.

Cylinder head

Angle of valve seat:

- Exhaust 45° (90° included angle)
- Inlet 30° (120° included angle)

Diameter of parent bore for valve guide 50,70/50,72 mm (1.996/1.997 in)

Leak test pressure 200 kPa (29 lbf/in²) 2,04 kgf/cm²

Head thickness 106,43/106,93 mm (4.190/4.180 in)

Minimum permissible thickness after head face has been machined 106,17 mm (4.180 in)

Maximum permissible distortion of cylinder head 0,01 mm (0.004 in) in any 228,6 mm (9 in)

..... 0,15 mm (0.006 in) overall

Inlet valves

Diameter of valve stem 7,920/7,938 mm (0.3118/0.3125 in)

Maximum clearance in valve guide 0,15 mm (0.006 in)

Angle of valve face 30°

Depth of valve head below the face of cylinder head 0,35 mm (0.014 in)

Seal arrangement Rubber seal assembly fitted to valve guide

Exhaust valves

Diameter of valve stem 7,920/7,938 mm (0.3118/0.3125 in)

Maximum clearance in valve guide 0,15 mm (0.006 in)

Diameter of valve head 37,26/37,52 mm (1.467/1.477 in)

Angle of valve face 45°

Depth of valve head below the face of cylinder head 0,35 mm (0.014 in)

Valve guides

Inside diameter 7,976/8,019 mm (0.3140/0.3157 in)

Outside diameter 14,341/14,361 mm (0.5646/0.5654 in)

Interference fit of valve guide in cylinder head 0,053/0,038 mm (0.0021/0.0015 in)

Overall length:

- Inlet 60,73 mm (2.391 in)

- Exhaust 60,73 mm (2.391 in)

Protrusion from bottom of recess 22,05/22,56 mm (0.868/0.888 in)

Inlet valve springs

Free length 58,22 mm (2.292 in)

Valve closed length 50,29 mm (1.980 in) under a load of, 556/391 N (80/88 lbf) 36,3/39,9 kgf

Valve open length 37,59 mm (1.480 in) under a load of, 952/996 N (214/224 lbf) 97/102 kgf

Exhaust valve springs

Free length 62,18 mm (2.448 in)

Valve closed length 50,29 mm (1.980 in) under a load of, 538/574 N (80/88 lbf) 36,3/39,9 kgf

Valve open length 38,86 mm (1.530 in) under a load of, 1063/1117 N (239/251 lbf) 108,4/113,9 kgf



Tappets

Diameter of tappet	28,435/28,448 mm (1.1195/1.1200 in)
Length of tappet.....	74,24/75,01 mm (2.923/2.953 in)
Clearance of tappet in cylinder block.....	0,064/0,102 mm (0.0025/0.0040 in)
Clearance of roller to tappet wall	0,666 mm (0.026 in)

Rocker shaft

Outside diameter	21,567/21,593 mm (0.8491/0.8501 in)
------------------------	-------------------------------------

Rocker shaft springs

Quantity	5
Free length	103,1 mm (4.06 in)
Length under load of 31 N (7 lbf) 3,18 kgf.....	56,6 mm (2.07 in)
Diameter	25,9 mm (1.02 in)

Rocker levers and bushes

Internal diameter of bush.....	21,69 mm (0.854 in)
Clearance between rocker lever bush and rocker shaft	0,048/0,124 mm (0.0019/0.0049 in)
Push rod length	268,980/269,743 mm (10.5898/10.6198 in)



Piston and connecting rod assemblies **13A**

General description 13A.02

Big end bearing

13A-01 To remove and to fit 13A.03
13A-02 To inspect 13A.04

Piston and connecting rod assembly

13A-03 To remove and to fit 13A.05
13A-04 To dismantle and assemble (WD, WE, WF and WG engines) 13A.07
13A-05 To dismantle and assemble (WH and WJ engines) 13A.08
13A-06 To inspect 13A.09

Connecting rod

13A-07 To inspect 13A.10

Small end bush

13A-08 To remove and to fit 13A.10

Piston rings

13A-09 To remove and to fit 13A.11
13A-10 To inspect 13A.11

Data and dimensions 13A.12



13A PISTON AND CONNECTING ROD ASSEMBLIES

Piston and connecting rod assemblies

General description

The aluminium alloy pistons of the WD, WE, WF and WG engines have a cast iron insert for the top piston ring.

The pistons of the WH and WJ engines have an aluminium alloy skirt and a steel piston crown. The steel crown compensates for increased combustion pressures, and can be removed from the piston skirt, when the piston assembly is dismantled.

Both types of piston have recesses in the crown to allow clearance for the inlet valve and the exhaust valve. The combustion bowl is off-centre to allow the atomiser tip to enter it.

A variation in the aluminium alloy of the piston skirt controls expansion of the piston.

Each piston has two tapered compression rings and an oil control ring. The grooves for the piston rings have the same shape as their rings. The top compression ring is marked "TOP-UP" on its upper face, the second compression ring is marked "2nd-UP" on its upper face. The oil control ring is not marked and may be fitted either way up. The top compression ring has a round edge, the edge of the second compression ring is at an angle.

Combustion pressure is allowed to pass through the ring gaps to the underside of the compression rings. This maintains the correct contact between the face of the piston rings and the cylinder bore, to improve performance and reduce oil loss.

Axial location of the fully floating gudgeon pin is by circlips.

The connecting rods are "H" section forgings of steel. The small end is wedge shaped to raise strength and improve reliability. The overall size of the connecting rod is reduced by an angle of tilt to the big end bearing.

Jets fitted in the cylinder block spray lubricating oil onto the inner surface of the piston to cool the piston.



Big end bearing

To remove and to fit

13A-01

To remove

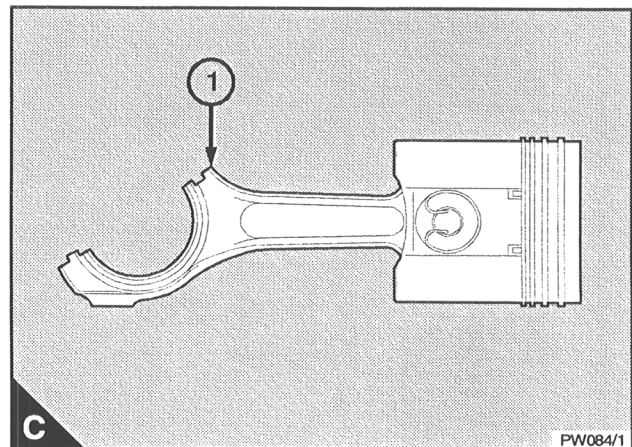
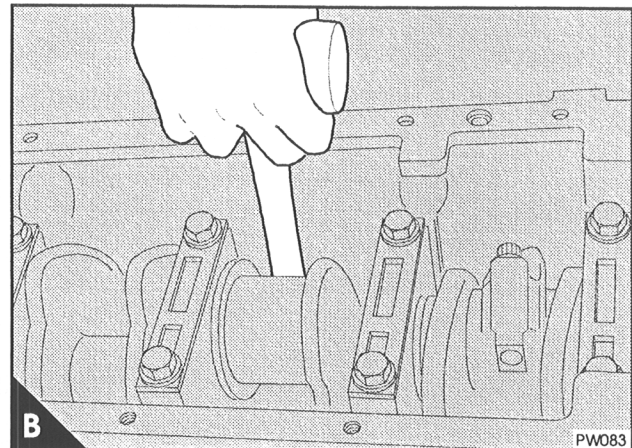
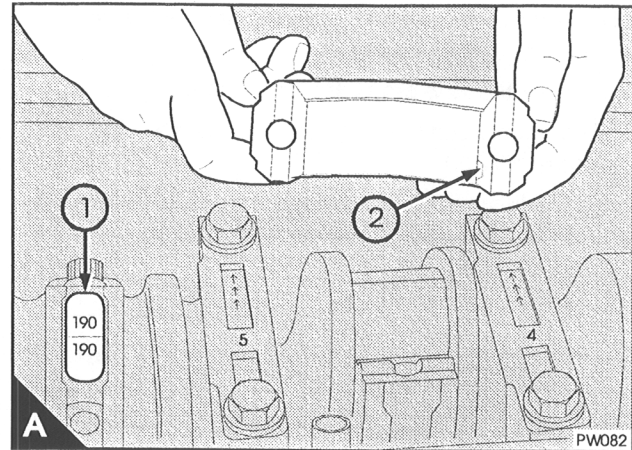
- 1 Drain the engine lubricating oil.
- 2 Remove the lubricating oil sump, see [operation 19A-08](#).
- 3 Remove the lubricating oil strainer and suction pipe, see [operation 19A-09](#).
- 4 Rotate the crankshaft until access to the relevant connecting rod setscrews is possible.
- 5 Remove the setscrews from the connecting rod.
- 6 Remove the bearing cap (A) together with the lower shell-bearing.
- 7 Carefully push the connecting rod up the cylinder bore, just enough to allow access to the upper shell-bearing (B).
- 8 Remove the bearing from the connecting rod. Keep the bearings of the connecting rods and caps together, for correct assembly.

To fit

- 1 Clean the bearing faces of the connecting rod and the crank pin. Clean the threads of the connecting rod and the threads of the setscrews.
- 2 Clean the complete bearing and lubricate the bearing surface and the crank pin with clean engine lubricating oil.
- 3 Fit the upper half bearing to the connecting rod, ensure that the locating tag is fitted correctly in its recess.
- 4 Fit the connecting rod to the crankpin; ensure that the short side (C1) of the connecting rod is toward the camshaft side of the engine.
- 5 Fit the lower shell-bearing into the cap, ensure that the locating tag (A2) is fitted correctly in its recess.
- 6 Lubricate lightly the threads of the setscrews with clean engine lubricating oil.
- 7 Hold the bearing cap in position on the connecting rod. Ensure that the assembly number on the cap is the same as the number on the connecting rod and that both of the assembly numbers are on the same side (A1).
- 8 Fit the setscrews by hand. If they do not fit freely by hand, fit new setscrews. If the new setscrews do not fit freely by hand, renew the connecting rod.

Caution: Do not to tap a new thread in the connecting rod. If the threads are damaged, renew the connecting rod.

Continued





13A PISTON AND CONNECTING ROD ASSEMBLIES

9 Tighten the setscrews gradually and evenly to 156 Nm (115 lbf ft) 15,9 kgf m.

10 Ensure that the crankshaft rotates freely.

11 Fit the lubricating oil strainer and suction pipe, see operation 19A-09.

12 Fit the lubricating oil sump, see operation 19A-08.

13 Fill the sump to the correct level with lubricating oil of an approved grade.

To inspect

13A-02

Check the bearings and the crank pin for wear or other damage.

Measure the crank pins and compare the measurements with data and dimensions.



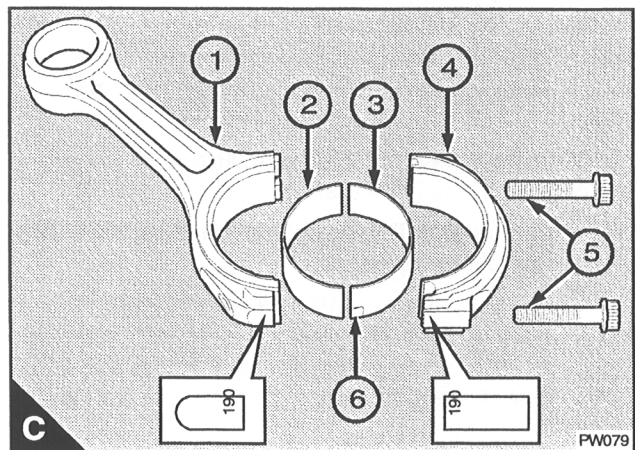
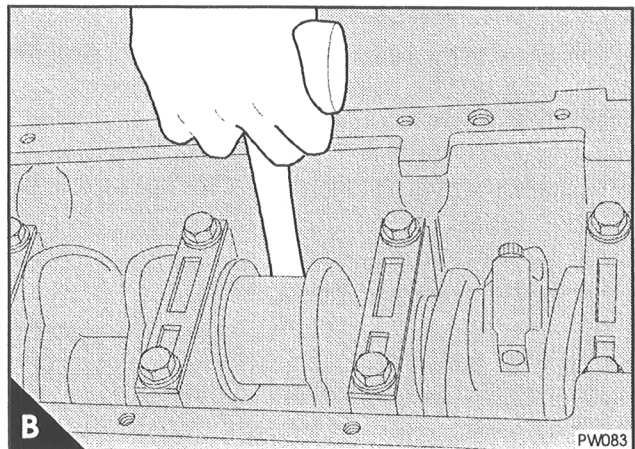
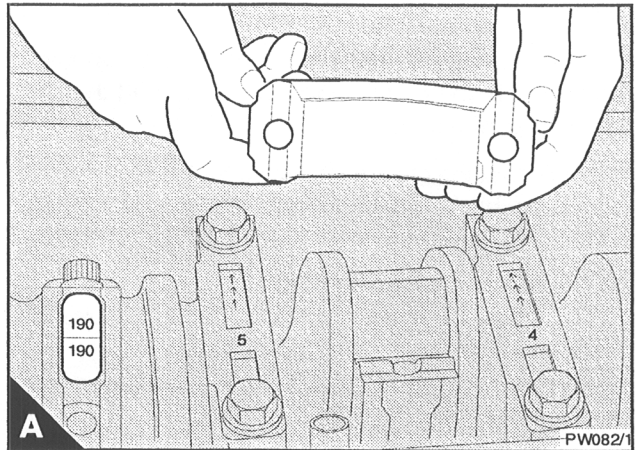
Piston and connecting rod assembly

To remove and to fit

13A-03

To remove

- 1 Drain the lubricating oil.
- 2 Drain the cooling system.
- 3 Remove the cylinder head assembly, see [operation 12A-05](#).
- 4 Remove all carbon from the top of the bores of the cylinder liners.
- 5 Remove the lubricating oil sump, see [operation 19A-08](#).
- 6 Remove the lubricating oil strainer and suction pipe, see [operation 19A-09](#).
- 7 Remove the setscrews (C5) for the big end bearing caps and remove the big end bearing caps (A).
- 8 Push the piston and the connecting rod assemblies (B) out through the top of their cylinders.
- 9 Put the shell-bearings (C2 and C3) and the bearing caps (C4) with their pistons and connecting rod (C1) assemblies; mark the components to ensure that they are returned to the correct cylinder.
- 10 Inspect the crank pins for damage.





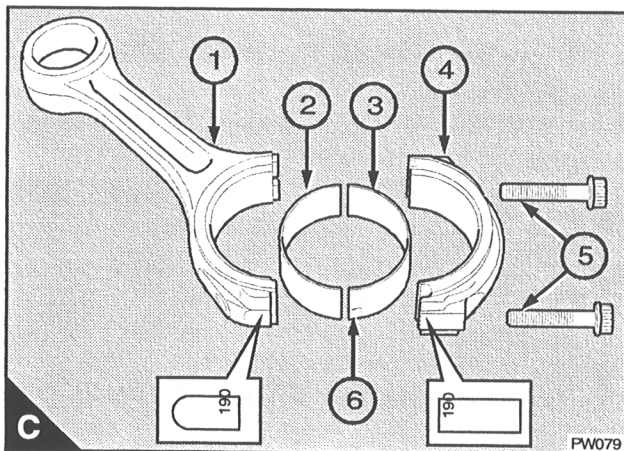
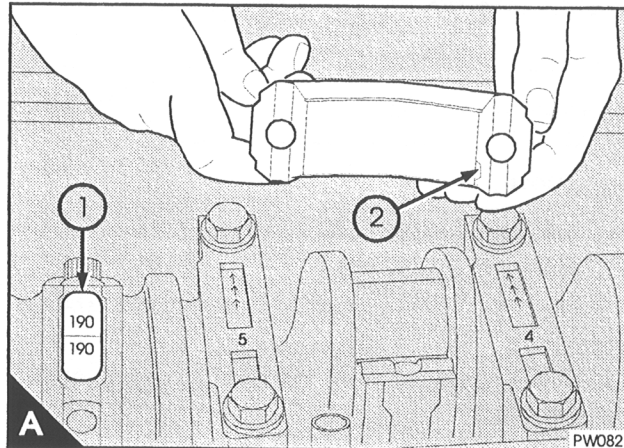
13A PISTON AND CONNECTING ROD ASSEMBLIES

To fit

Note: If the original piston is used, ensure that it is assembled to the correct connecting rod and that it is used in the original cylinder.

- 1 Ensure that the pistons, the cylinder bore, the crank pin and the big end of the connecting rods are clean.
- 2 Clean the threads of the connecting rods (C1) and the threads of the setscrews (C5).
- 3 The pistons have drain holes for the lubricating oil, check that these holes are free of debris.
- 4 Lubricate the pistons and the cylinder liner with clean engine lubricating oil.
- 5 Rotate the crankshaft until access to fit the connecting rod setscrews is possible.
- 6 Clean the shell bearings (C2 and C3) and lubricate the bearing surface and the crank pin with clean engine lubricating oil.
- 7 Fit the upper shell-bearing (C2) to the connecting rod, ensure that the locating tag is fitted correctly in its recess.
- 8 Put the piston ring gaps 120° apart and compress the rings with a suitable tool.
- 9 Pass the connecting rod and piston assembly into the cylinder. Ensure that the "camside" mark on the piston crown is towards the camshaft side of the engine.
- 10 Push the piston and connecting rod assembly through the piston ring clamp and onto the crank pin. Ensure that the short side (13A.03/C1) of the connecting rod is towards the camshaft side of the engine.
- 11 Fit the lower shell-bearing onto its cap, ensure that the locating tag is fitted correctly in its recess (A2).
- 12 Lubricate lightly the threads of the setscrews with clean engine lubricating oil.
- 13 Hold the bearing cap in position on the connecting rod. Ensure that the assembly number on the cap is the same as the number on the connecting rod and that both of the assembly numbers are on the same side (A1).

Continued





14 Fit the setscrews by hand. If they do not fit freely by hand, fit new setscrews. If the new setscrews do not fit freely by hand, renew the connecting rod.

Caution: *Do not tap a new thread in the connecting rod. If the thread sare damaged, renew the connecting rod.*

15 Tighten the setscrews gradually and evenly to 156 Nm (115 lbf ft) 15,9 kgf m.

16 Ensure that the crankshaft rotates freely.

17 Check the side clearance of the connecting rod big-end, see data and dimensions.

18 Fit the lubricating oil strainer and suction pipe, see operation 19A-09.

19 Fit the lubricating oil sump, see operation 19A-08.

20 Fit the cylinder head assembly, see operation 12A-05.

21 Fill the sump to the correct level with lubricating oil of an approved grade.

22 Fill the cooling system.



13A PISTON AND CONNECTING ROD ASSEMBLIES

To dismantle and assemble
(WD, WE, WF and WG engines) **13A-04**

To dismantle

Note: Mark the components to ensure that they return to the correct cylinder.

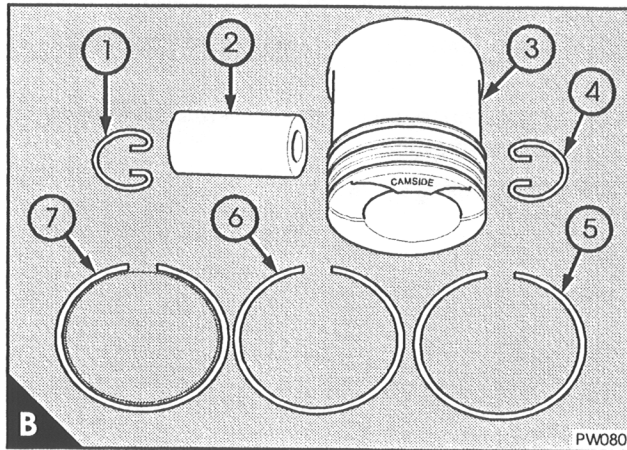
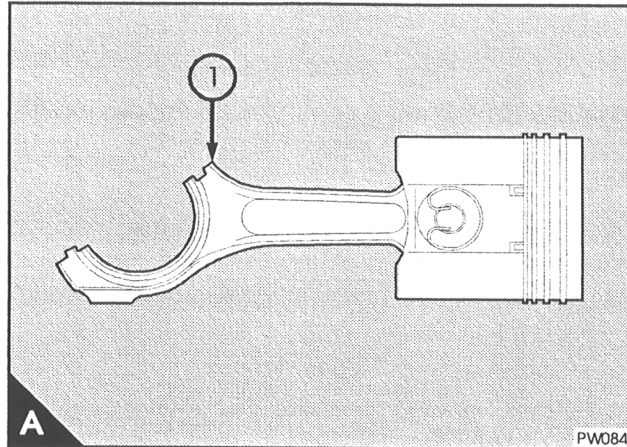
- 1 Remove the piston rings (B5, B6 and B7), see operation 13A-09.
- 2 Remove the circlips (B1 and B4) which retain the gudgeon pin (B2) and push the gudgeon pin out of the piston (B3) by hand.
- 3 Separate the connecting rod from the piston.

To assemble

- 1 Clean the bore of the small end bush and lubricate it with clean engine lubricating oil.
- 2 Fit a circlip (B1) in the circlip groove of one of the gudgeon pin bosses. Ensure that it fits correctly in the groove.
- 3 With the piston (B3) upside down, put the connecting rod in position. Ensure that the short side of the connecting rod (A1) is on the same side as the "camside" mark (B) on the piston crown.

Note: If the original piston is used, ensure that it is assembled to the correct connecting rod and that it is used in the original cylinder.

- 4 Lubricate the gudgeon pin bosses with clean engine lubricating oil and push in the gudgeon pin (B2) towards the circlip.
- 5 Fit the other circlip (B4) in the groove in the other gudgeon pin boss. Ensure that it fits correctly in the groove.
- 6 Fit the piston rings, see operation 13A-09.





To dismantle and assemble (WH and WJ engines)

13A-05

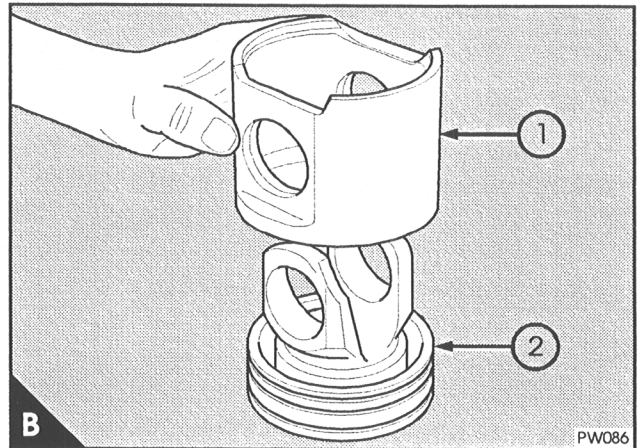
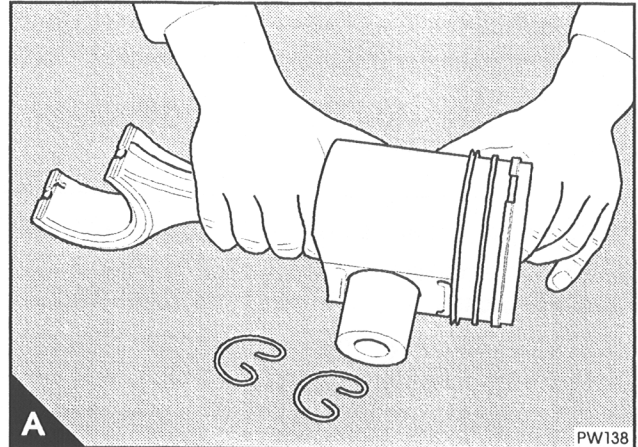
To dismantle

Note: Mark the components to ensure that they return to the correct cylinder. Mark the piston skirt and the piston crown to ensure correct assembly.

- 1 Remove the piston rings, see operation 13A-09.
- 2 Remove the circlips which retain the gudgeon pin and push the gudgeon pin out of the piston by hand (A).
- 3 Separate the connecting rod from the piston.
- 4 Remove the piston skirt (B1) from the piston crown (B2).

To assemble

- 1 Clean the bore of the small end bush and lubricate it with clean engine lubricating oil.
 - 2 Put the piston skirt (B1) on the piston crown (B2), ensure that the marks made earlier are aligned.
 - 3 Fit a circlip (A) in the circlip groove of one of the gudgeon pin bosses. Ensure that it fits correctly in the groove.
 - 4 With the piston upside down, put the connecting rod in position. Ensure that the short side of the connecting rod is on the same side as the "camside" mark on the piston crown.
- Note:** If the original piston is used, ensure that it is assembled to the correct connecting rod and that it is used in the original cylinder.
- 5 Lubricate the gudgeon pin bosses with clean engine lubricating oil and push in the gudgeon pin towards the circlip.
 - 6 Fit the other circlip in the groove in the other gudgeon pin boss. Ensure that it fits correctly in the groove.
 - 7 Fit the piston rings, see operation 13A-09.





13A PISTON AND CONNECTING ROD ASSEMBLIES

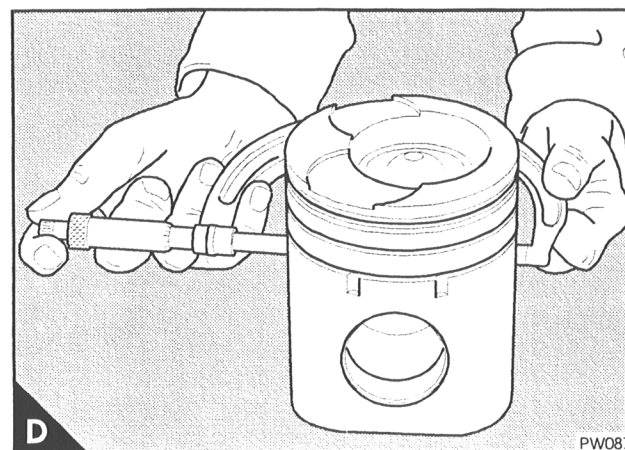
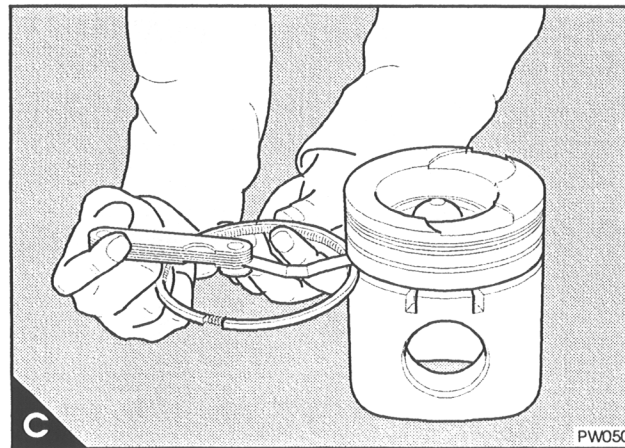
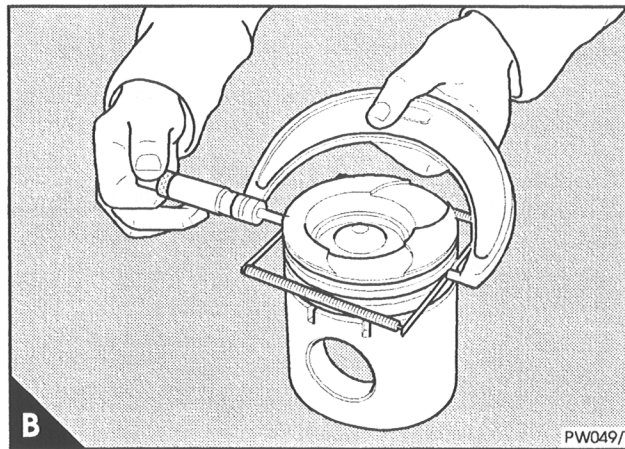
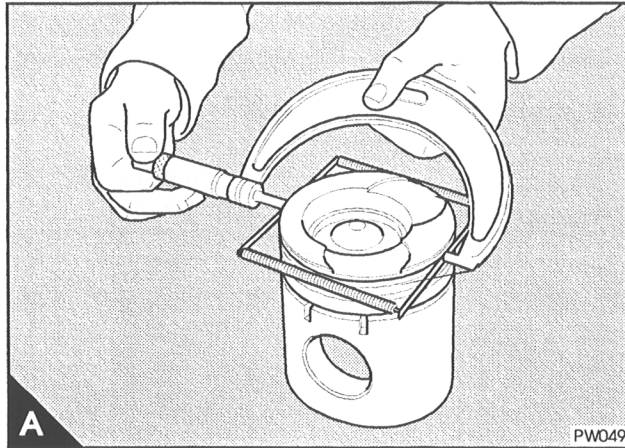
To inspect

13A-06

Special tools:

Piston groove gauges PD.230

- 1 Check the piston for wear and other damage.
- 2 Check that the piston rings are free to move in their grooves and that the piston rings are not broken.
- 3 Remove the piston rings, see [operation 13A-09](#).
- 4 Clean the piston ring grooves and the piston rings.
- 5 Fit the piston groove gauge PD.230 to the top compression ring groove, measure and record the overall diameter of the piston and the gauge (A).
- 6 Fit the piston groove gauge PD.230 to the second compression ring groove, measure and record the overall diameter of the piston and the gauge (B).
- 7 Fit a new oil control ring in its groove and check for wear of the ring groove with feeler gauges (C).
- 8 Measure and record the diameter of the piston skirt (D). Measured at 90° from the gudgeon pin, at a point 27,43 mm (1.08 in) below the oil control ring.





Connecting rod

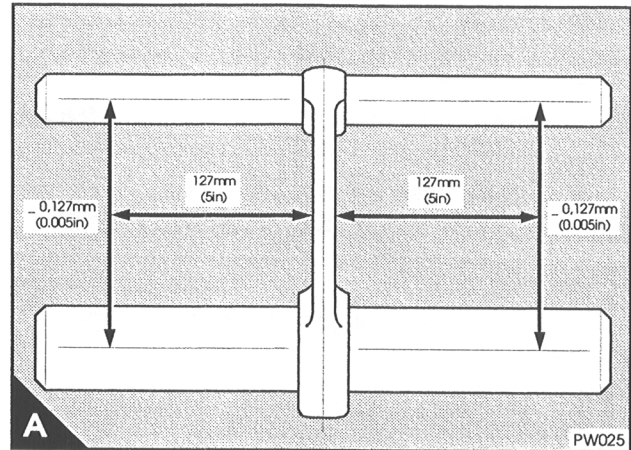
To inspect

13A-07

- 1 Check the connecting rod for distortion (A).

Note: The large and small end bores must be square and parallel with each other within the limits of $\pm 0,127$ mm (0.005 in) measured 127 mm (5.0 in) each side of the connecting rod axis on a test mandrel.

- 2 Check the small end bush for wear or for other damage and renew it, if necessary.
- 3 Check the fit of the gudgeon pin in the small end bush and check the gudgeon pin for wear, see data and dimensions.



Small end bush

To remove and to fit

13A-08

- 1 Press out the old bush with a suitable adaptor.
- 2 Clean the connecting rod bore and remove any sharp edges.
- 3 Press in the new bush. Ensure that the lubrication hole in the bush is on the same side as, and is aligned with, the hole in the top of the connecting rod.
- 4 On all New Generation Peregrine and 1300 Series engines the small end is wedge shaped. After the small end bush has been fitted, machine the bush to the shape of the small end and remove any sharp edges.



13A PISTON AND CONNECTING ROD ASSEMBLIES

Piston rings

To remove and to fit

13A-09

Note: Only increase the ring gaps enough to ensure that the ends of the rings do not damage the piston.

To remove

1 Remove the piston rings with a suitable ring expander (A1).

To fit

1 Use a suitable ring expander (A1) to fit the piston rings. Keep the rings with their relevant pistons, for correct assembly.

2 Ensure that the coil spring is fitted into the oil control ring. Ensure that the gap in the coil spring and the gap in the latch pin of the coil spring are 180° apart

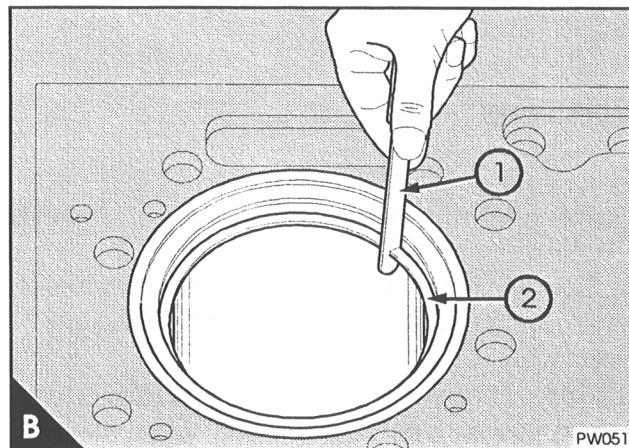
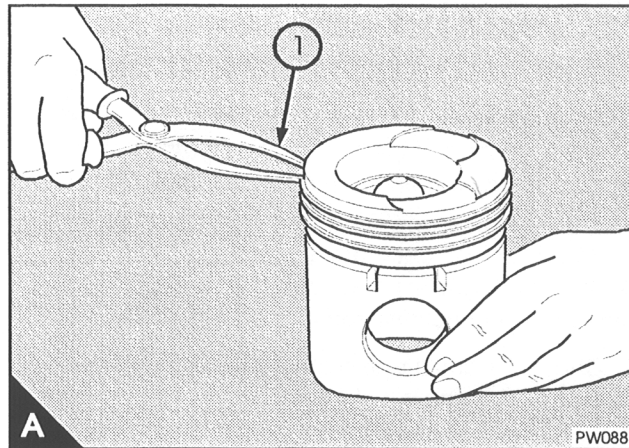
To inspect

13A-10

1 Clean all carbon from the top of the cylinder liners.

2 Fit each piston ring (B2) in the top part of the cylinder liner, measure and record the ring gap with feeler gauges (B1).

Note: The coil spring must be fitted to the oil control ring when the gap is measured.





Data and dimensions

Note: 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 the factory. The information applies to all engines, unless an engine type code is shown.

Pistons

Type:

- WD, WE, WF and WG engines One piece, all aluminium. "Toroidal" combustion bowl
- WH and WJ engines..... Two piece, high-pressure. Steel crown. "Toroidal" combustion bowl
- Diameter of the bore the for gudgeon pin 48,856/46,380 mm (1.9255/1.9235 in)
- Cooling jets per piston 2

Piston rings

- Oil control ring to groove clearance 0,102/0,0508 mm (0.0040/0.0020 in)
- Top ring groove width, measured over (0.1150 in) gauge pins:
 - WD, WE, WF and WG 109,519/108,697 mm (4.3118/4.2794 in)
 - WH and WJ engines..... 114,338/113,477 mm (4.5015/4.4676 in)
- Second ring width, measured over (0.1150 in) gauge pins:
 - WD, WE, WF and WG engines 109,519/108,697 mm (4.3118/4.2794 in)
 - WH and WJ engines..... 116,967/116,108 mm (4.6050/4.5712 in)
- Ring gap with new cylinder liner:
 - Top ring 0,66/0,356 mm (0.026/0.014 in)
 - Second ring 1,91/1,65 mm (0.075/0.065 in)
 - Oil control ring for WD, WE, WF and WG engines..... 0,56/0,31 mm (0.022/0.012 in)
 - Oil control ring for WH and WJ engines 0,66/0,356 mm (0.026/0.014 in)

Connecting rods

- Type..... 'H' section, wedge shape small end
- Length between centres 219,050/219,100 mm (8.624/8.626 in)
- Small end:
 - Diameter of parent bore 48,900/48,856 mm (1.9255/1.9235 in)
 - Diameter of bush (fitted) 46,380/46,373 mm (1.8260/1.8257 in)
- Big end:
 - Side clearance to crankshaft 0,300/0,419 mm (0.0120/0.0165 in)
 - Diameter of parent bore 85,131/85,000 mm (3.3516/3.3516 in)
 - Diameter of bearing (fitted)..... 80,100/80,000 mm (3.1544/3.1524 in)
- Gudgeon pins :
 - Type Fully floating
 - Outside diameter 46,358/46,352 mm (1.8251/1.8249 in)
 - Clearance fit in piston boss 0,0028/0,015 mm (0.0011/0.0006 in)



Crankshaft assembly

14A

General description 14A.02

Crankshaft pulley/damper assembly

14A-01 To remove and to fit 14A.03

14A-02 To inspect 14A.04

Rear oil seal housing assembly

14A-03 To remove and to fit the oil seal housing 14A.05

14A-04 To renew the rear oil seal and wear sleeve assembly 14A.08

Crankshaft

14A-05 To remove and to fit 14A.10

14A-06 To inspect 14A.14

Crankshaft gear

14A-07 To renew 14A.15

Thrust bearing

14A-08 To check crankshaft end-float 14A.16

14A-09 To remove and to fit 14A.16

Main bearings

14A-10 To remove and to fit 14A.18

14A-11 To inspect 14A.19

Data and dimensions 14A.20



14A CRANKSHAFT ASSEMBLY

Crankshaft assembly

General description

The crankshaft is a steel forging with seven main journals. All the crankshaft journals and the crank pins are induction hardened.

End-float is controlled by thrust washers that are an integral part of the rear main bearing, and shall be referred to as thrust bearings in this manual. The area of the bearing surfaces of the seven main bearings is the same. All the main bearings have location tags.

An integral damper, with a rubber insert is built into the crankshaft pulley. The location of the pulley / damper assembly is by a key in the crankshaft nose. The assembly is held in position by an interference fit, and by a retainer plate and three setscrews. The pulley / damper assembly must be heated before it is fitted on the crankshaft.

The rear oil seal can be renewed without removing the flywheel housing.



Crankshaft pulley/damper assembly

To remove and to fit

14A-01

Special tools:

Crankshaft pulley puller PD.240

To remove

Note: Before removing the pulley/ damper assembly check for alignment, see [operation 14A-02](#).

- 1 Drain the lubricating system.
- 2 Remove the drive belt, see [operation 21A-07](#).
- 3 Release and remove the three setscrews (A) which hold the retainer plate of the pulley/ damper assembly.
- 4 Remove the retainer plate (A).
- 5 Use the puller PD.240 to remove the pulley/ damper assembly (C).

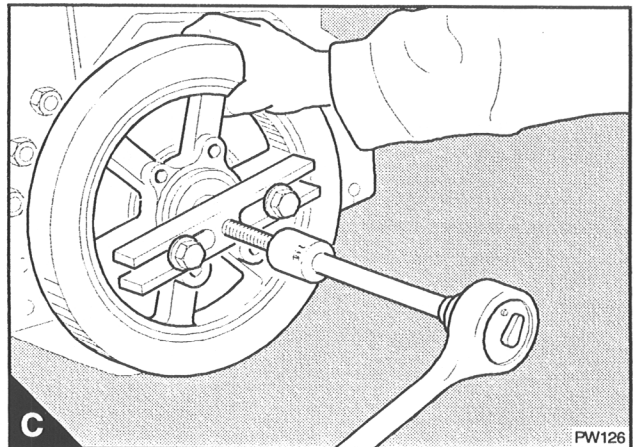
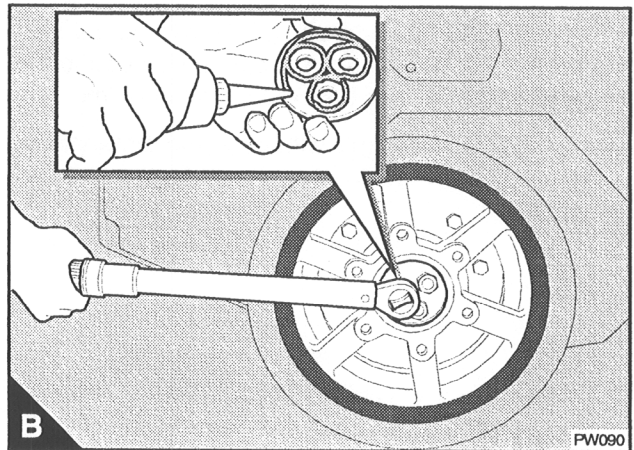
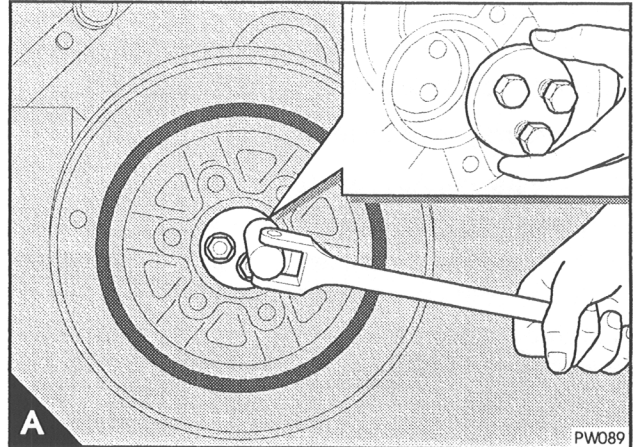
To fit

Warning! Use suitable gloves to protect the hands from heat.

- 1 Heat the pulley/ damper assembly. Do not exceed 198° C (338° F).

Caution: Do not try to fit a cold pulley/damper assembly as this will damage the crankshaft.

- 2 Put the assembly on the crankshaft, engage the drive key and push the pulley fully towards the rear.
- 3 Clean off the old sealant from the retainer plate and from the pulley/damper assembly.
- 4 Put Hylosil on the inner face of the retainer plate and fit the retainer plate (B).
- 5 Lubricate lightly the threads of the setscrews for the retainer plate with clean engine lubricating oil.
- 6 Fit and tighten the setscrews gradually and evenly to 136 Nm (100 lbf ft) 13,6 kgf m.
- 7 Fit the drive belt, see [operation 21A-07](#).
- 8 Fill the lubricating system to the correct level with an approved lubricating oil.





14A CRANKSHAFT ASSEMBLY

To inspect

14A-02

Clean the components and check for damage.

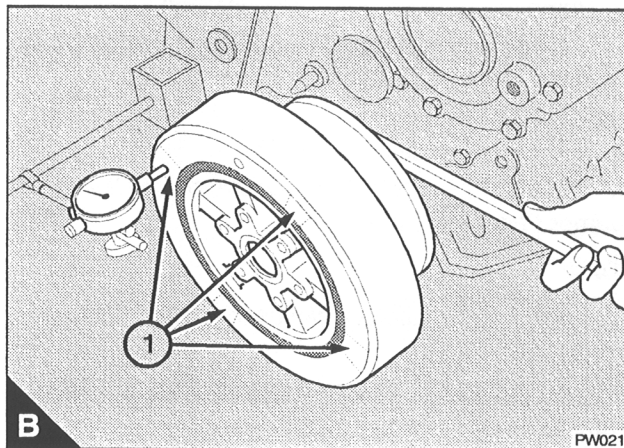
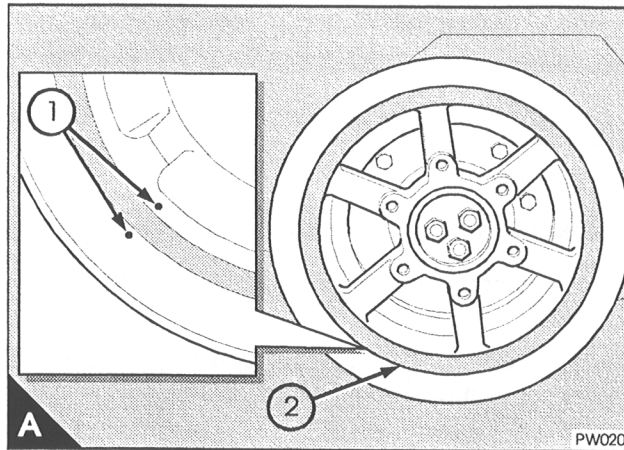
The assembly must be renewed if:

- there are cracks in the rubber (A2)
- the rubber is damaged by oil
- the component alignment marks (A1) exceed the tolerance in data and dimensions.

Measure and record damper alignment (B) at four places (B1) 90° apart on the damper face. Ensure that the crankshaft is at the same end of its axial movement for each measurement. This eliminates crankshaft end-float from the measurement.

When the pulley/ damper assembly is removed from the crankshaft, measure and record the run-out of the damper mounting face on the crankshaft palm.

Compare all the readings with data and dimensions.





Rear oil seal housing assembly

Cautions:

- If the oil seal housing is removed, the rear oil seal and its wear sleeve must be renewed.
- Renew the rear oil seal and the wear sleeve as a unit, do not separate them.
- The flywheel housing does not have to be removed to renew the rear oil seal.

To remove and to fit the oil seal housing

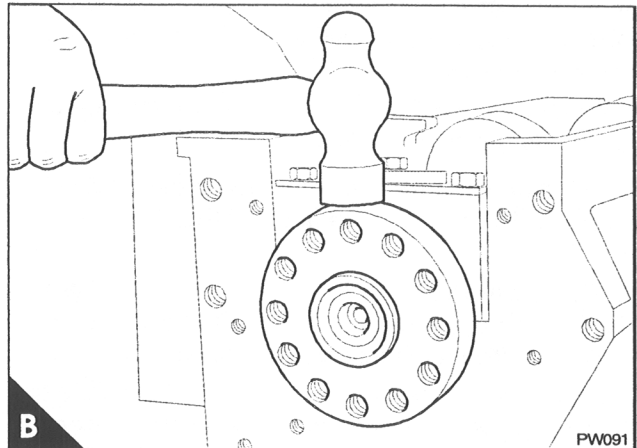
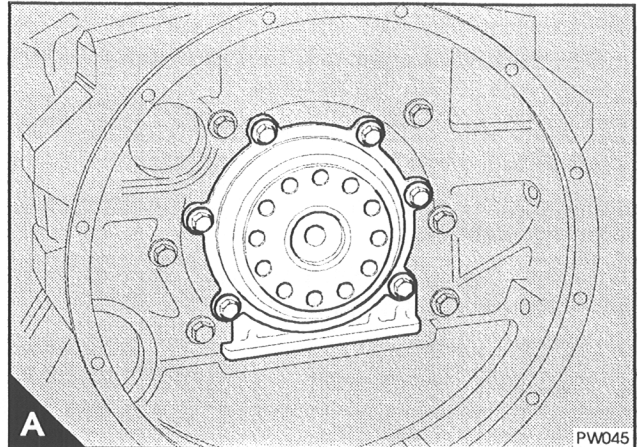
14A-03

Special tools:

Rear oil seal installer PD.237

To remove

- 1 Drain the lubricating oil.
- 2 Remove the lubricating oil sump, see [operation 19A-08](#).
- 3 Remove the drive components from the rear end of the engine.
- 4 Remove the flywheel, see [operation 22A-01](#).
- 5 Remove the four setscrews which pass through the flange of the sump and into the bottom of the seal housing.
- 6 Remove the six setscrews which retain the seal housing to the cylinder block.
- 7 Remove the rear oil seal and housing assembly (A). Remove and discard the old length of seal from between the housing and the cylinder block.
- 8 Hit carefully the face of the wear sleeve with a hammer to loosen the wear sleeve from the crankshaft.(B)
- 9 Remove the wear sleeve from the crankshaft.





14A CRANKSHAFT ASSEMBLY

To fit

- 1 Clean the faces of the cylinder block, the oil seal housing and the crankshaft palm.
- 2 Fit a new length of seal to the oil seal housing, allow a little excess at each end of the seal length.
- 3 Fit the guide adaptor from tool PD.237 to the end of the crankshaft (A).
- 4 Put the housing (B2) into position on the engine, fit and tighten the setscrews finger tight.
- 5 Lubricate the main lip of the seal with clean engine lubricating oil. The lubrication of the seal is necessary to prevent damage to the seal when the engine is first started.
- 6 Apply Loctite Forma Gasket number 2 to the outer diameter of the oil seal and to the inner diameter of the wear sleeve.

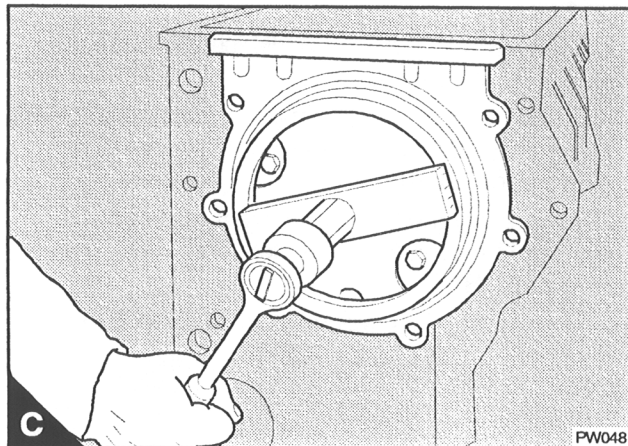
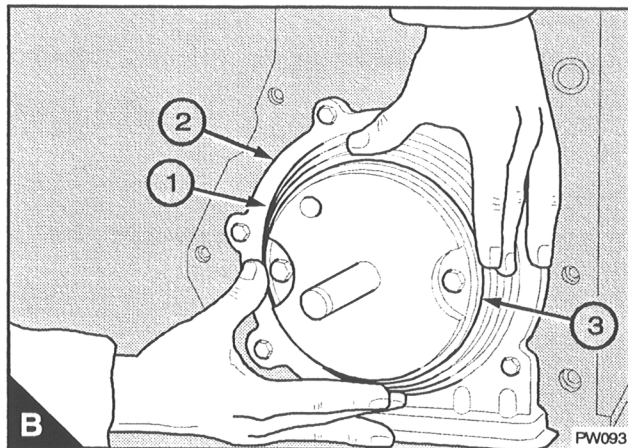
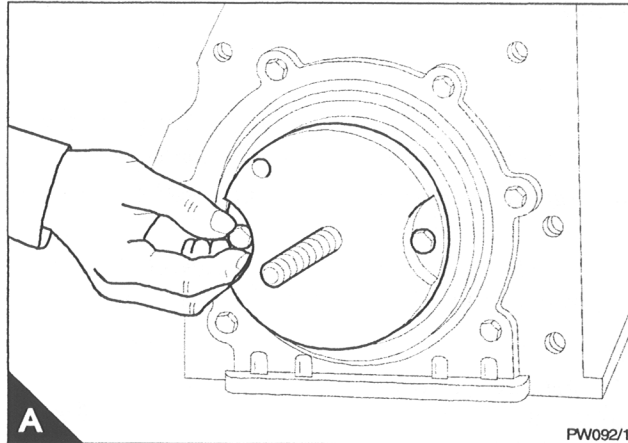
Caution: Fit the rear oil seal and the wear sleeve as a unit, do not separate them.

- 7 Put a new oil seal and wear sleeve assembly into position (B1) on the guide adaptor (B3) from tool PD.237.

- 8 Fit the plate from tool PD.237 to the guide adaptor. Tighten the nut of the tool (C) until the plate comes into contact with the face of the housing.

Note: When the plate from tool PD.237 contacts the face of the seal housing, the oil seal and the wear sleeve are in their correct positions.

Continued





9 Use a straight edge to check that the seal housing is level with the cylinder block face (A).

10 Tighten the setscrews to 24 Nm (18 lbf ft) 2,5 kgf m.

11 Cut off the excess seal length (B1) so that it is level with the face of the cylinder block (B).

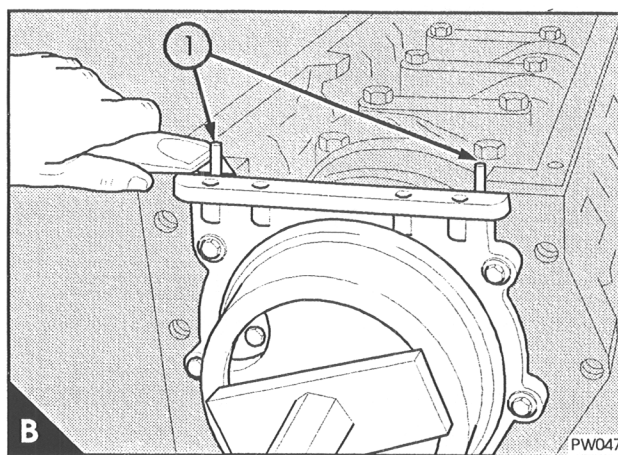
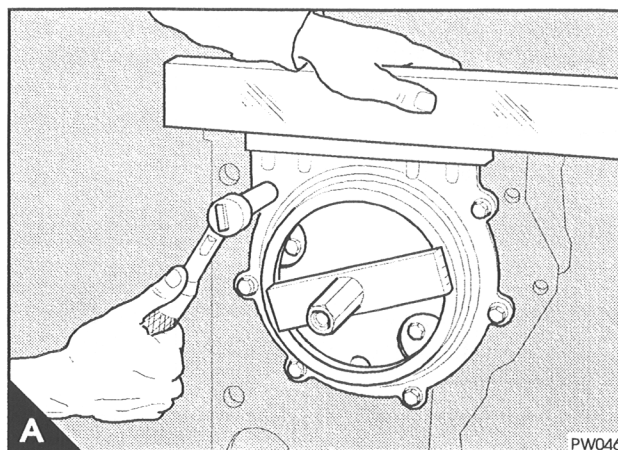
12 Remove the tool PD.237.

13 Fit the lubricating oil sump, see operation 19A-08.

14 Fit the flywheel, operation 22A-01.

15 Fit the drive components to the rear end of the engine.

16 Fill the lubricating oil sump to the correct level with an approved lubricating oil.





14A CRANKSHAFT ASSEMBLY

To renew the rear oil seal and wear sleeve assembly

14A-04

Special tools:

Rear oil seal installer PD.237

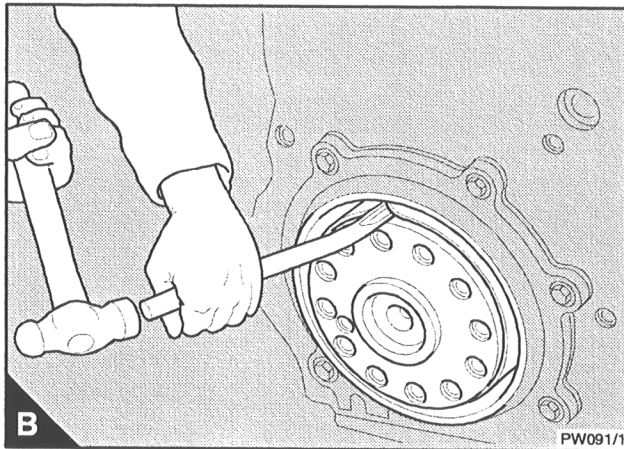
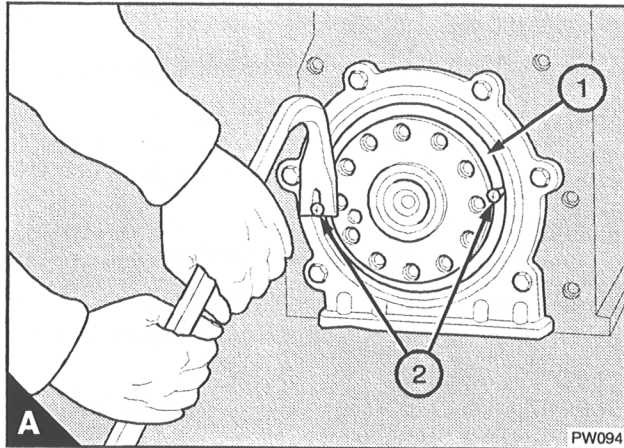
Notes:

- The oil seal housing does not have to be removed to renew the rear oil seal and wear sleeve assembly.
- The flywheel housing does not have to be removed to renew the rear oil seal and wear sleeve assembly.
- Renew the rear oil seal and the wear sleeve as a unit, do not separate them.

To renew

- 1 Drain the lubricating oil.
 - 2 Remove the drive components from the rear end of the engine.
 - 3 Remove the flywheel, see [operation 22A-01](#).
 - 4 Fit two screws (A2) into the front face (A1) of the oil seal.
 - 5 Carefully lever the seal from the seal housing (A).
- Caution:** Do not damage the seal housing.
- 6 Use a suitable chisel and hammer to remove the wear sleeve of the oil seal from the crankshaft (B).
- Caution:** Do not scratch or damage the crankshaft with the chisel or the hammer. If the crankshaft is scratched or damaged it will have to be reground or renewed.
- 7 Discard the oil seal and wear sleeve assembly.
 - 8 Clean the oil seal housing and the crankshaft palm.

Continued





9 Fit the guide adaptor (A) from tool PD.237 to the end of the crankshaft.

10 Lubricate the main lip of a new oil seal and wear sleeve assembly with clean engine lubricating oil. The lubrication of the seal is necessary to prevent damage to the seal when the engine is first started.

11 Apply Loctite Forma Gasket number 2 to the outer diameter of the oil seal and to the inner diameter of the wear sleeve.

Caution: Fit the rear oil seal and the wear sleeve as a unit, do not separate them.

12 Put the oil seal and wear sleeve assembly (B1) into position on the guide adaptor (B3) from tool PD.237.

13 Fit the plate from tool PD.237 to the guide adaptor. Tighten the nut of the tool until the plate comes into contact with the face of the housing (C).

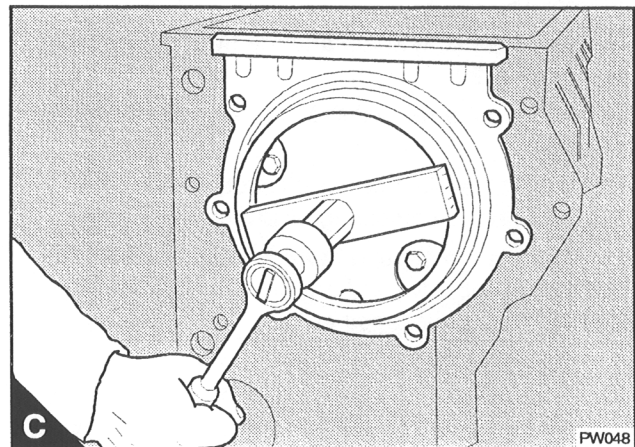
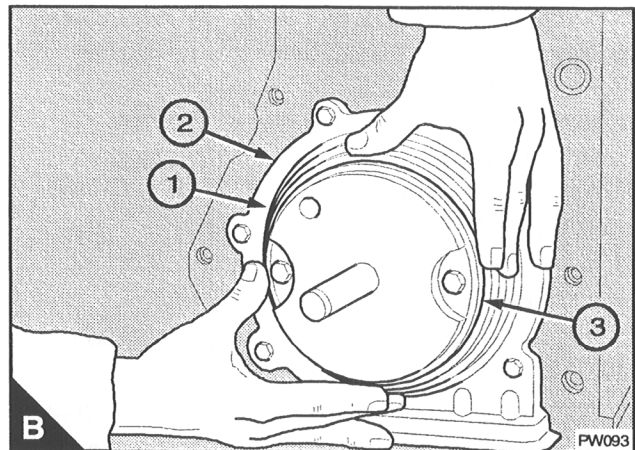
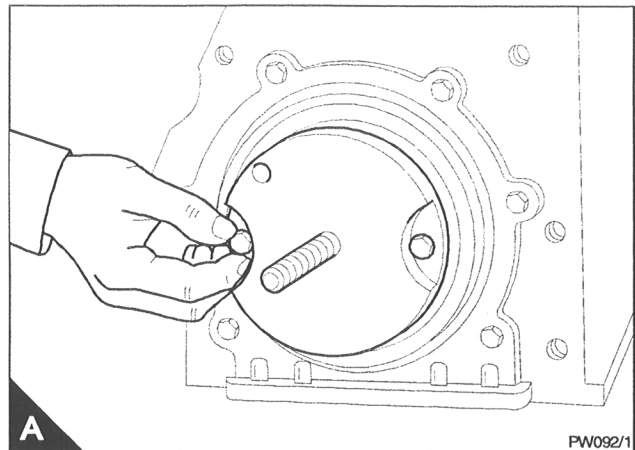
Note: When the plate from tool PD.237 comes into contact with the face of the seal housing, the oil seal and the wear sleeve are in their correct positions.

14 Fit the lubricating oil sump, see [operation 19A-08](#).

15 Fit the flywheel, see [operation 22A-01](#).

16 Fit the drive components to the rear end of the engine.

17 Fill the lubricating oil sump to the correct level with an approved lubricating oil.





14A CRANKSHAFT ASSEMBLY

Crankshaft

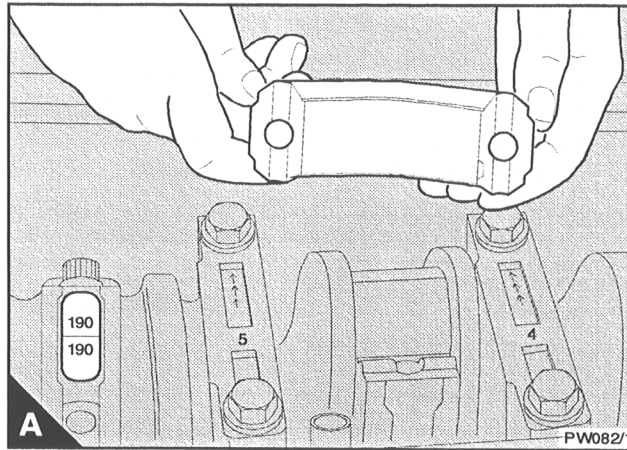
To remove and to fit

14A-05

Warning! Use lift equipment or obtain assistance to lift heavy engine components such as the flywheel housing, flywheel and crankshaft.

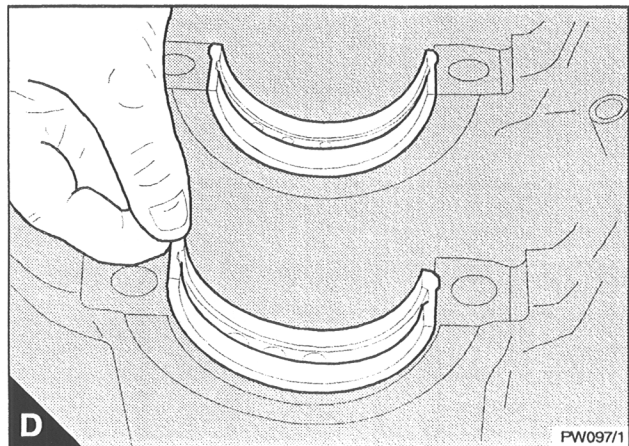
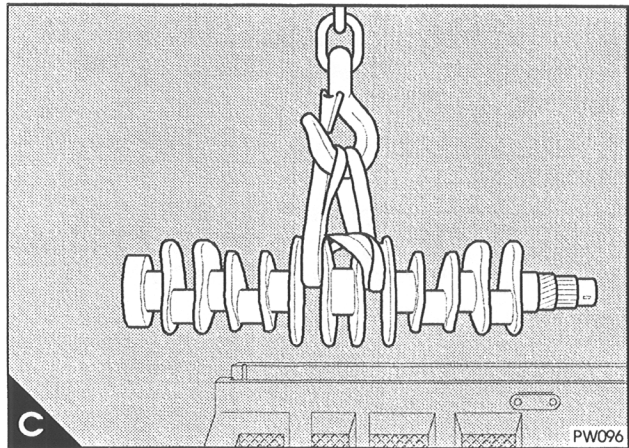
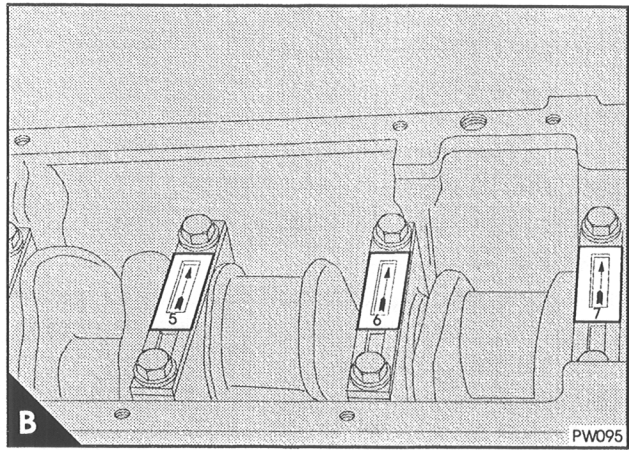
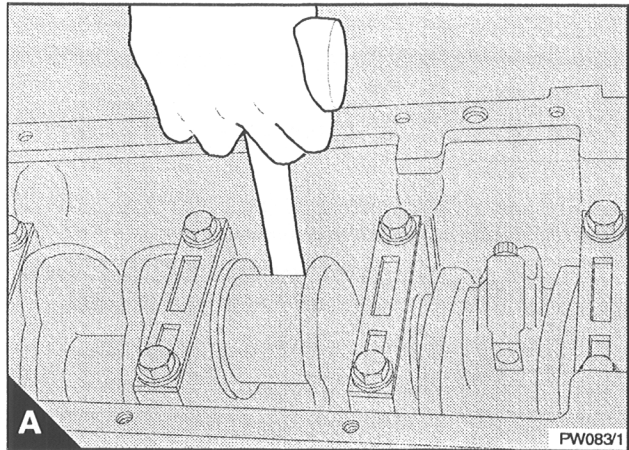
To remove

- 1 Before the engine is removed from the vehicle or from the machine, drain the lubricating oil and the coolant.
- 2 Remove the lubricating oil sump, see [operation 19A-08](#).
- 3 Remove the fan, the drive belt, the fan drive pulley and housing, and the coolant pump, see [chapter 21](#).
- 4 Remove the pulley/damper assembly, see [operation 14A-01](#).
- 5 Remove the alternator and its mounting bracket, see [chapter 23](#).
- 6 Remove the compressor and its drive assembly, if one is fitted, see [chapter 24](#).
- 7 Remove the timing case cover, see [operation 15A-01](#).
- 8 Remove the fuel injection pump, see [chapter 20](#).
- 9 Remove the timing gears and the timing case, see [chapter 15](#).
- 10 Remove the flywheel and the flywheel housing, see [chapter 22](#).
- 11 Remove the rear oil seal carrier, see [operation 14A-03](#).
- 12 Remove the lubricating oil suction pipe and strainer and the lubricating oil pump, see [chapter 19](#).
- 13 Remove the big end bearing caps (A) from the connecting rods. Keep the shell-bearings and their shell-bearing caps together.





- 14** Carefully push the pistons into their bores (A).
- 15** Ensure that the tops of the main bearing caps are stamped with their relevant position number (B).
- 16** Remove the main bearing caps and the lower shell-bearings. Keep the bearings with their relevant bearing caps.
- 17** Lift out the crankshaft (C).
- 18** Remove the upper shell-bearings (D) and keep each bearing with its relevant lower shell-bearing and bearing cap.





14A CRANKSHAFT ASSEMBLY

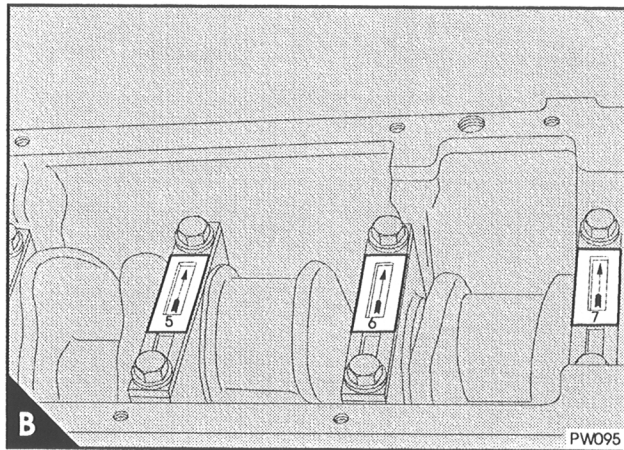
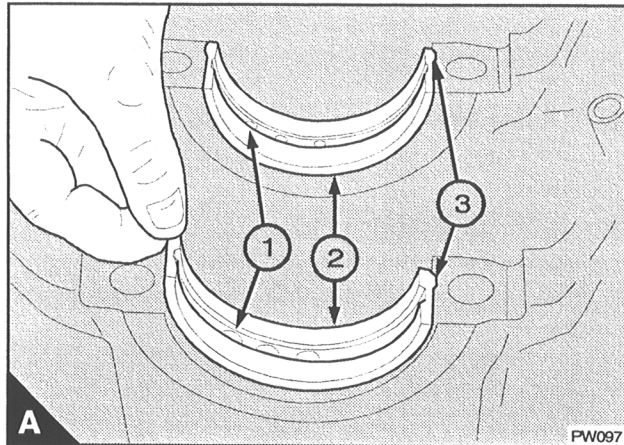
To fit

- 1 Ensure that all lubricating oil passages are clean and free from restriction.
- 2 Clean the main bearing housings and the upper shell-bearings.
- 3 Fit the upper shell-bearings (A2) with the location tags (A3) fitted correctly in their recesses.
- 4 Ensure that the large lubricating oil hole (A1) in the bearing is toward the camshaft side of the engine.
- 5 Lubricate the bearings with clean engine lubricating oil.
- 6 Ensure that the main journals of the crankshaft are clean.
- 7 Put the crankshaft in position on the upper shell-bearings.
- 8 Clean the bearing caps and the lower shell-bearings.
- 9 Fit the bearings to the caps with the location tags fitted correctly in their recesses (B).
- 10 Lubricate the bearings with clean engine lubricating oil.
- 11 Fit the bearing caps numbers 1 to 6 in their correct positions, as shown by the position number stamped on the top of the cap .

Caution: Ensure that the arrows (B) stamped on the bearing caps are facing toward the camshaft side of the engine.

- 12 Clean and inspect the setscrews for the main bearings. If the setscrews are damaged, fit new setscrews.
- 13 Lightly lubricate the setscrews with clean engine lubricating oil.
- 14 Fit the setscrews for the main bearing caps numbers 1 to 6, and tighten the setscrews gradually and evenly to 155 Nm (115 lbf ft) 16,0 kgf m.

Continued





15 Fit the bearing cap number 7 (A3) in position on the rear main journal (A).

Caution: Ensure that the arrow (A2) stamped on the bearing cap is facing toward the camshaft side of the engine.

16 To centre the thrust bearing, move the crankshaft to the front or to the back with a suitable lever.

17 Fit the setscrews to the main bearing cap number 7, and tighten the setscrews gradually and evenly to 155 Nm (115 lbf ft) 15,9 kgf m.

18 Rotate the crankshaft two turns to ensure free movement.

19 Fit the piston and connecting rod assemblies, see operation 13A-03.

20 Check the crankshaft end-float, see operation 14A-08.

21 Fit the lubricating oil suction pipe and strainer, see operation 19A-09.

22 Fit the rear oil seal carrier, operation 14A-03.

23 Fit the lubricating oil sump, operation 19A-10.

24 Fit the flywheel and the flywheel housing, see chapter 22.

25 Fit the timing gears and the timing case, see chapter 15.

26 Fit the compressor and its drive assembly, see chapter 24.

27 Fit the alternator and its mounting bracket, see chapter 23.

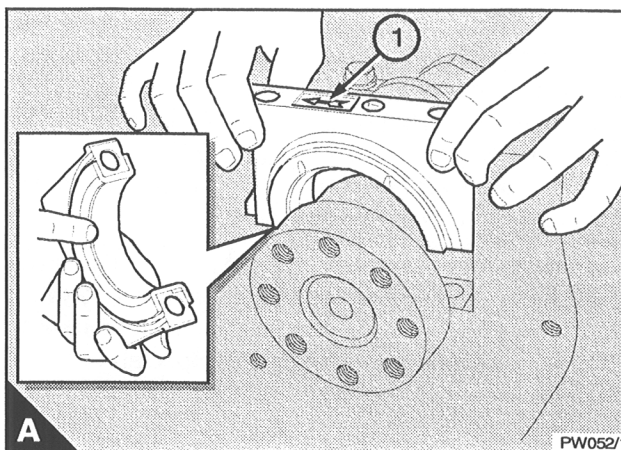
28 Fit the lubricating oil pump, see operation 19A-10.

29 Fit the pulley/ damper assembly, see operation 14A-01.

30 Fit the fan, the drive belt, the fan drive pulley and housing and the coolant pump, see chapter 21.

31 After the engine has been installed, fill the lubricating oil sump to the correct level with an approved oil.

32 Fill the cooling system.





14A CRANKSHAFT ASSEMBLY

To inspect

14A-06

Check the crankshaft for wear and other damage. The maximum permissible wear and ovality on the crankshaft journals is 0,05 mm (0.002 in). The maximum permissible wear and ovality on the crank pins is 0,0075 mm (0.00025 in).

The main journals and the crank pins of standard size crankshafts can be machined to 0,25mm (0.010 in), 0,50mm (0.020 in) or 0,75 mm (0.030 in) undersize on diameter, see data and dimensions. Special undersize bearings are available.



Crankshaft gear

To renew

14A-07

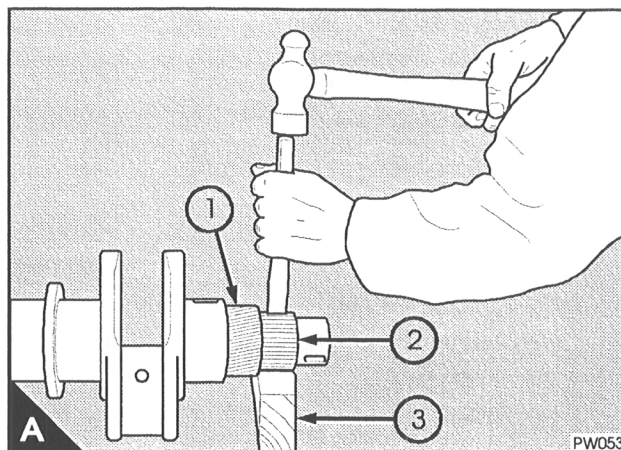
Warning! Use suitable gloves to protect the hands from heat.

Caution: If the crankshaft gear is to be renewed the drive spline of the oil pump has to be renewed also.

- 1 Remove the crankshaft, see [operation 14A-05](#).
- 2 Put a suitable support (A3) under the crankshaft nose.
- 3 Use a hammer and chisel to break the drive spline (A2) of the oil pump, and to break the crankshaft gear (A1).

Caution: Do not scratch or damage the crankshaft with the chisel or the hammer. If the crankshaft is scratched or damaged it will have to be reground or renewed.

- 4 Remove the drive spline of the oil pump, and remove the crankshaft gear.
 - 5 Clean the crankshaft nose.
 - 6 Heat a new crankshaft gear to 370-395° F (188-202° C)
- Caution:** Do not fit a cold crankshaft gear, it will be damaged.
- 7 Press the crankshaft gear onto the crankshaft. Ensure that the locating pin engages in the crankshaft gear.
 - 8 Heat a new drive spline for the lubricating oil pump to 370-395° F (188-202° C).
- Caution:** Do not fit a cold drive spline, it will be damaged.
- 9 Press the drive spline of the oil pump onto the crankshaft.
 - 10 Fit the crankshaft, see [operation 14A-05](#).





14A CRANKSHAFT ASSEMBLY

Thrust bearing

The axial movement of the crankshaft is controlled by a thrust bearing (A1) in the rear (number 7) main bearing cap (A4). The end-float can be checked with a dial test indicator on one end of the crankshaft.

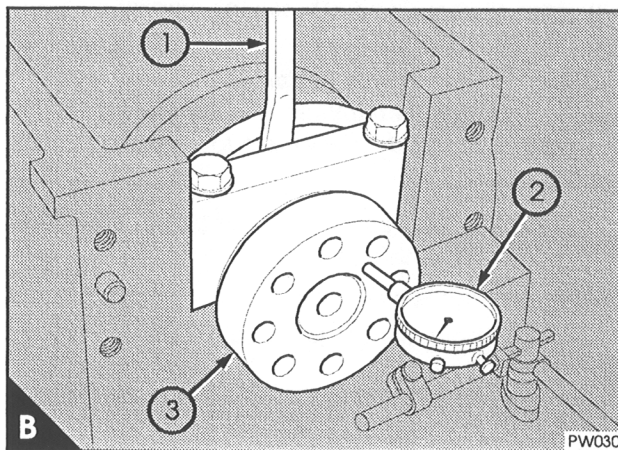
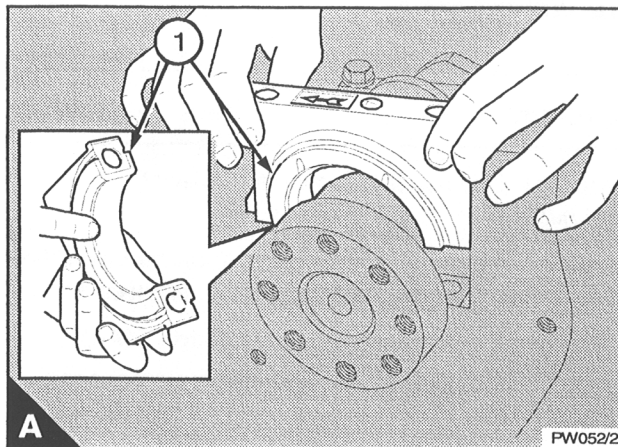
To check crankshaft end-float **14A-08**

- 1 Put a dial test indicator (B2) against the face of the crankshaft flange (B3).
- 2 Use a lever (B1) to move the crankshaft fully toward the front of the engine and zero the indicator.
- 3 Use a lever to move the crankshaft fully toward the rear of the engine and note the indicator reading.
- 4 Renew the thrust bearing if the end-float is more than the tolerance given in data and dimensions.

To remove and to fit **14A-09**

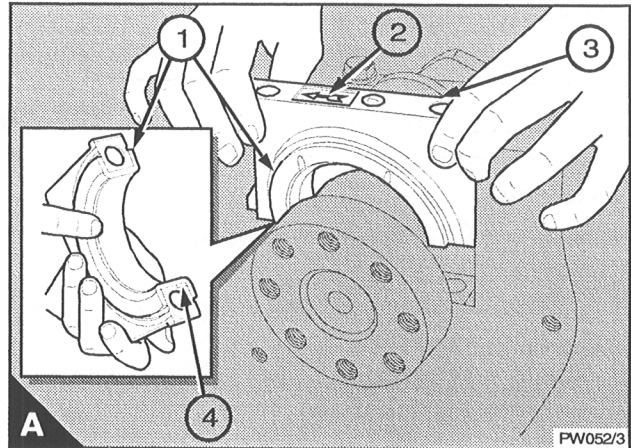
To remove

- 1 Drain the lubricating oil.
- 2 Remove the lubricating oil sump, see [operation 19A-08](#).
- 3 Release the setscrews of the rear main bearing and remove the main bearing cap (A) complete with the lower half thrust bearing (A1).
- 4 Push one end of the upper half of the thrust bearing, with a suitable tool made of a soft material, to slide the bearing out. Where necessary, move the crankshaft to the front or to the rear to loosen a tight bearing.



**To fit**

- 1** Lubricate the thrust bearing with clean engine lubricating oil.
- 2** Slide the upper-half of the thrust bearing into position with the location tag fitted correctly in its recess. Ensure that the large lubricating oil hole in the bearing is toward the camshaft side of the engine.
- 3** Fit the lower-half of the thrust bearing (A1) to the main bearing cap (A3) with the location tag (A4) in its recess. Ensure that the bearing is fitted correctly in the cap and that the bearing and the crankshaft journal are clean. Lubricate the bearing with clean engine lubricating oil.
- 4** Put the bearing cap in position. Ensure that the arrow (A2) stamped on the bearing cap is toward the camshaft side of the engine.
- 5** Clean and inspect the setscrews for the main bearings. If the setscrews are damaged, fit new setscrews.
- 6** Lightly lubricate the setscrews with clean engine lubricating oil.
- 7** Fit the setscrews to the main bearing cap and tighten the setscrews gradually and evenly to 156 Nm (115 lbf ft) 15,9 kgf m.
- 8** Check the crankshaft end-float, see operation 14A-08.
- 9** Fit the lubricating oil sump, see operation 19A-08.
- 10** After the engine has been installed, fill the lubricating oil sump to the correct level with an approved oil.





14A CRANKSHAFT ASSEMBLY

Main bearings

To remove and to fit

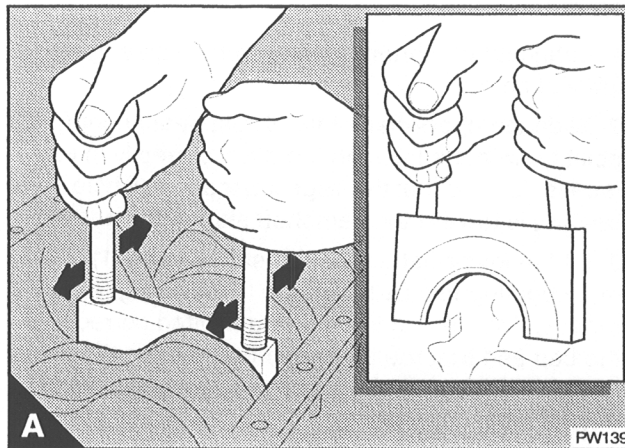
14A-10

To remove

- 1 Drain the lubricating oil and remove the sump, operation 19A-08.
- 2 Remove all necessary components to get access to the specific bearing cap.
- 3 Release the setscrews of the bearing cap and remove the bearing cap (A).
- 4 Remove the lower shell-bearing from the cap.
- 5 With a suitable tool, push the upper shell-bearing from the side opposite to the location tag to remove the bearing tag from its recess in the bearing housing.
- 6 Carefully rotate the crankshaft to release the bearing from its housing.
- 7 Keep the halves of the shell-bearing in their relevant positions.

To fit

- 1 Clean the upper shell-bearing and lubricate the bearing surface with clean engine lubricating oil.
- 2 Fit the plain end of the upper shell-bearing between the crankshaft journal and the side of the bearing housing which has the recess for the location tag. Slide the bearing into its housing until the tag on the bearing is fitted correctly in its recess in the housing.
- 3 Clean the lower shell-bearing and the cap, lubricate the bearing surface with clean engine lubricating oil.
- 4 Fit the bearing into the cap with the tag of the bearing fitted correctly in the recess in the cap.
- 5 Fit the bearing cap with the location tags of both shell-bearings on the same side.
- 6 Inspect the setscrews for damage and for distortion and renew them if necessary. Lightly lubricate the setscrew threads with clean engine lubricating oil.
- 7 Fit the setscrews and tighten the setscrews gradually and evenly to 156 Nm (115 lbf ft) 15,9 kgf m.
- 8 Ensure that the crankshaft rotates freely. If the thrust bearing (number 7) has been removed and fitted, check the crankshaft end-float, see operation 14-08.
- 9 Fit all the components which were removed for access to the main bearing caps.
- 10 Fit the lubricating oil sump, see operation 19-08.
- 11 Fill the sump to the correct level with an approved lubricating oil.





To inspect**14A-11**

Inspect the bearings for wear and for other damage. If a bearing is worn or damaged, renew both shell-bearings and check the condition of the other bearings.

If the thrust bearing (number 7) has been removed and fitted, check the crankshaft end-float, see operation 14A-08.



14A CRANKSHAFT ASSEMBLY

Data and dimensions

Note: 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 the factory. The information applies to all engines, unless an engine type code is shown.

Crankshaft

Number of main bearings.....	7
Thrust bearing position	Rear main (number 7)
Crankshaft end-float.....	0,152/0,305 mm (0.006/0.012 in)
Maximum permissible end-float	0,51 mm (0.020 in)
Crankshaft flange diameter.....	140,97 mm (5.550 in)
Crankshaft gear backlash	0,076/0,406 mm (0.003/0.016 in)
Run-out of the mounting face for:	
- Rear oil seal (Maximum).....	0,0762 mm (0.003 in)
- Damper assembly (Maximum).....	0,0127 mm (0.0005 in)
- Flywheel (Maximum).....	0,0508 mm (0.002 in)

Main bearing journals

Width (Except thrust bearing journal).....	32,664 +/- 0,015 mm (1.286 +/- 0.0006 in)
Width of thrust bearing journal.....	34,404 +/- 0,254 mm (1.355 +/- 0.0100 in)
Ovality (Maximum)	0,0508 mm (0.002 in)
Thrust face, out of alignment (Maximum)	0,0508 mm (0.002 in)
Taper (Maximum).....	0,0071 mm (0.0028 in)
Fillet radius.....	5,72/1,27 mm (0.225/0.050 in)
Clearance, bearing to crankshaft.....	0,127/0,046 mm (0.0050/0.0018 in)
Diameter of main journals:	
- New.....	89,789 +/- 0,015 mm (3.535 +/- 0.0006 in)
- 0.010 in undersize	89,535 +/- 0,015 mm (3.525 +/- 0.0006 in)
- 0.020 in undersize	89,281 +/- 0,015 mm (3.515 +/- 0.0006 in)
- 0.030 in undersize	89,027 +/- 0,015 mm (3.505 +/- 0.0006 in)

Crank pins

Width.....	35,179 mm (1.385 in)
Ovality (Maximum)	0,00635mm (0.00025 in)
Taper (Maximum).....	0,00686 mm (0.00027 in)
Fillet radius.....	5,72/1,27 mm (0.225/0.050 in)
Diameter of crank pins:	
- New.....	80,010 +/- 0,015 mm (3.1500 +/- 0.0006 in)
- 0.010 in undersize	79,756 +/- 0,015 mm (3.1400 +/- 0.0006 in)
- 0.020 in undersize	79,502 +/- 0,015 mm (3.1300 +/- 0.0006 in)
- 0.030 in undersize	79,248 +/- 0,015 mm (3.1200 +/- 0.0006 in)



Timing case and drive assembly **15A**

General description 15A.02

Timing case cover

15A-01 To remove and to fit 15A.04

Idler gears

15A-02 To remove and to fit 15A.05

Fuel injection pump gear

15A-03 To remove and to fit 15A.07

Timing case backplate

15A-04 To remove and to fit 15A.08

Camshaft and tappets

15A-05 To remove and to fit 15A.10

15A-06 To inspect 15A.11

Camshaft bushes

15A-07 To renew 15A.12

Data and dimensions 15A.13



15A TIMING CASE AND DRIVE ASSEMBLY

Timing case and drive assembly

General description

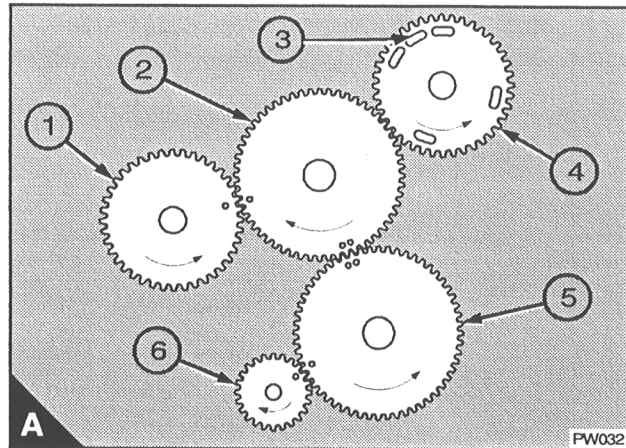
The aluminium timing case, which is a two piece casting, containing the drive gears. There are two idler gears, the lower idler gear (A5) and the upper idler gear (A2). The lower idler gear is driven by the crankshaft gear (A6) and drives the upper idler gear and, if fitted, the compressor. The upper idler gear drives the gears for the camshaft (A1) and for the fuel injection pump (A4). All of the gears have timing marks except for the gear for the fuel injection pump. There is a separate gear on the crankshaft nose to drive the lubricating oil pump.

The idler gears are supported on taper roller bearings.

The camshaft gear and the fuel injection pump rotate at half engine speed.

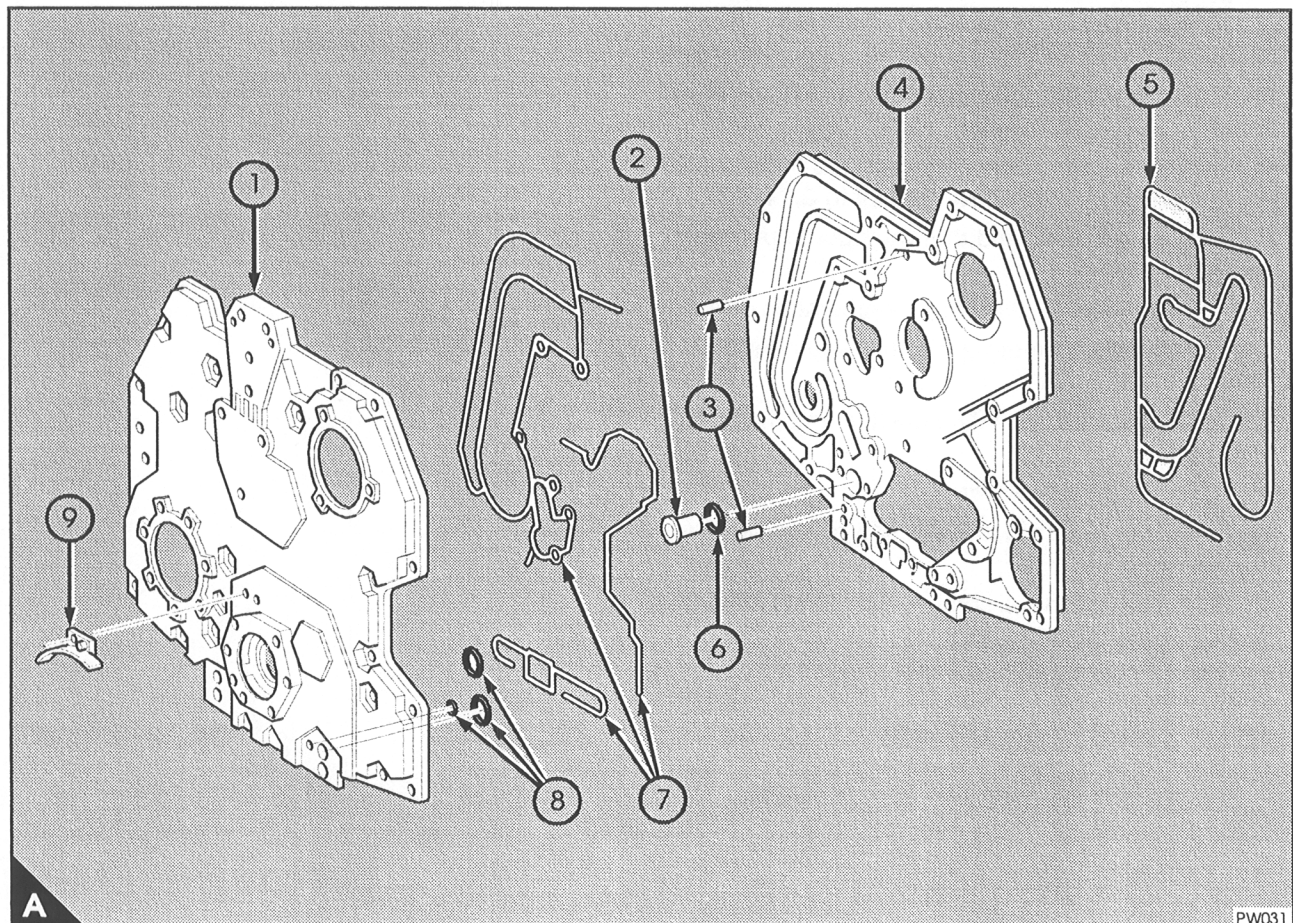
The timing case assembly has channels and ports for the coolant and for the lubricating oil. This reduces the need for external pipes and improves engine reliability.

The camshaft rotates in four bushes that can be renewed.



**Components of the timing case (A).**

- 1 Timing case cover
- 2 Pressure relief valve
- 3 Dowels
- 4 Timing case backplate
- 5 Joint
- 6 'O' ring
- 7 Joints
- 8 'O' rings
- 9 Timing indicator





15A TIMING CASE AND DRIVE ASSEMBLY

Timing case cover

To remove and to fit	15A-01
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to remove

- 1 Drain the engine lubricating oil.
- 2 Drain the cooling system.
- 3 Remove the fan, fan belt, drive pulley and fan mounting, see [section 21](#).
- 4 Remove the fan belt tensioner.
- 5 Remove the alternator and its mounting bracket.
- 6 Remove the pulley / damper assembly, see [operation 14A-01](#).
- 7 Remove the water pump pulley and the water pump, see [operation 21A-04](#).
- 8 Remove the lubricating oil pump, see [operation 19A-10](#).
- 9 Release the nuts, bolts and setscrews of the timing case cover and remove the timing case cover.
- 10 Remove and discard the 'O' rings ([15A.02/A8](#)) and joints ([15A.02/A7](#)).

To fit

- 1 Clean the faces of the timing case cover ([15A.02/A1](#)).
- 2 Put new joints and 'O' rings on the cover and put the cover in position on its dowels ([15A.02/A3](#)). The dowels are at the 1 o'clock and the 7 o'clock positions.
- 3 Loosely fit two opposite setscrews to hold the cover in place.
- 4 Fit the remainder of the fasteners and tighten all of the cover fasteners to 26 Nm (19 lbf ft) 2,7 kgf m.
- 5 Fit the water pump and the water pump pulley, [operation 21A-04](#).
- 6 Fit the lubricating oil pump, see [operation 19A-10](#).
- 7 Fit the pulley / damper assembly, see [operation 14A-01](#).
- 8 Fit the alternator mounting bracket and the alternator.
- 9 Fit the fan belt tensioner.
- 10 Fit the fan mounting, drive pulley, fan belt and fan, see [section 21A](#).
- 11 Fill the lubricating oil sump to the correct level with an approved lubricating oil.
- 12 Fill the cooling system to the correct level.



Idler gears

To remove and to fit

15A-02

Note: The setscrew for the upper idler gear (A1) enters the water jacket. To prevent leakage of coolant the setscrew is supplied with a sealant on its thread.

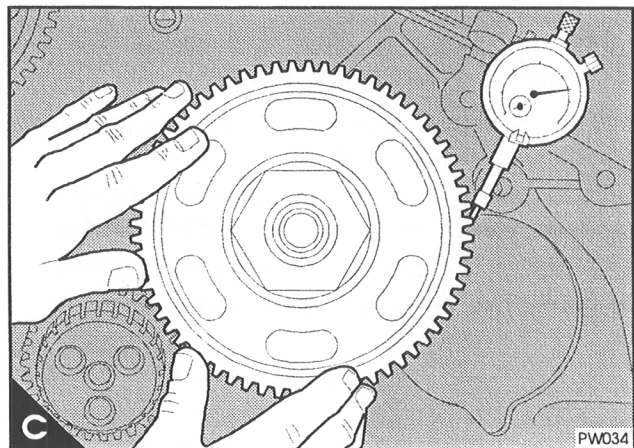
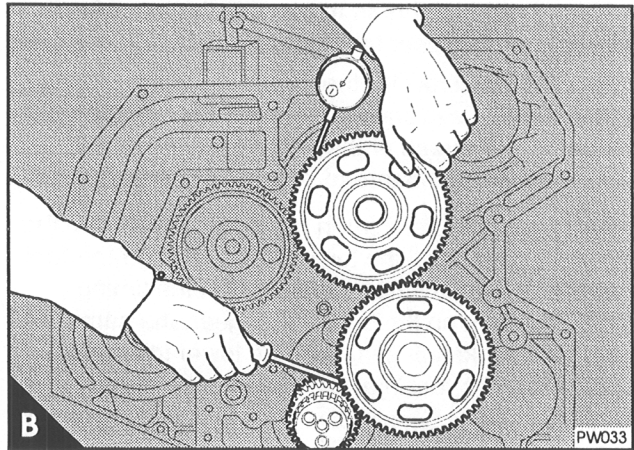
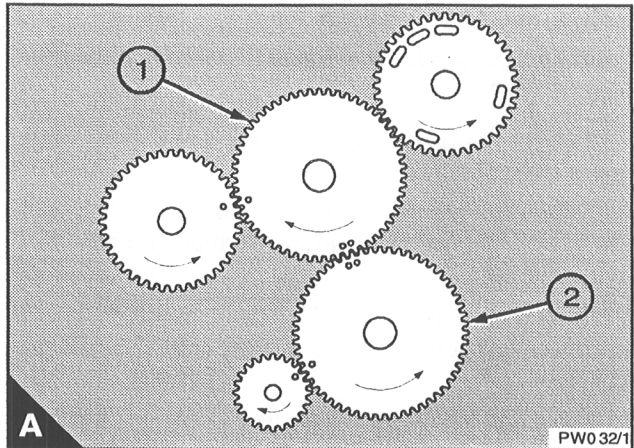
Caution: The setscrew for the upper idler gear must be renewed when it is removed from the engine.

To remove

- 1 Set number one cylinder to TDC on the compression stroke, see operation 17A-01.
- 2 Drain the cooling system.
- 3 Remove the timing case cover, see operation 15A-01.
- 4 Measure and record the backlash of the upper idler gear (B). Measure and record the backlash of the lower idler gear (C). Compare the results with the data and dimensions. Renew any gear that is out of tolerance.
- 5 Remove and discard the setscrew of the upper idler gear. Remove the upper idler gear.
- 6 Remove the setscrew of the lower idler gear and remove the lower idler gear (A2).

Caution: If the crankshaft is rotated with one or both of the idler gears removed, the timing of the engine will be incorrect.

- 7 Inspect the gears and their bearings for wear and other damage and renew them as necessary. The gear and their taper roller bearings must be renewed as a unit.





15A TIMING CASE AND DRIVE ASSEMBLY

To fit

Caution: Ensure that the piston of number 1 cylinder is set to TDC.

1 Lubricate the bearings of the idler gears with clean engine lubricating oil.

2 Lightly lubricate the threads and shoulder of the setscrew for the lower idler gear with clean engine lubricating oil.

3 Put the lower idler gear (A5) in position in mesh with the crankshaft gear (A6) so that the timing marks align (A).

4 Fit and tighten the setscrew to 673 Nm (470 lbf ft) 65,6 kgf m.

5 Ensure that the thread in the cylinder block for the setscrew of the upper idler gear is clean and dry.

Note: The setscrew for the upper idler gear (A2) is supplied with a sealant on its thread. Do not add more sealant to the thread of the setscrew. Do not put lubricating oil on the thread of the setscrew.

6 Put the upper idler gear in position in mesh with the camshaft gear (A1), the lower idler gear and the fuel injection pump gear (A4). Ensure that the timing marks (A) align on the upper idler gear, the camshaft gear, the crankshaft gear and the lower idler gear. Ensure that the fuel injection pump gear is fitted correctly.

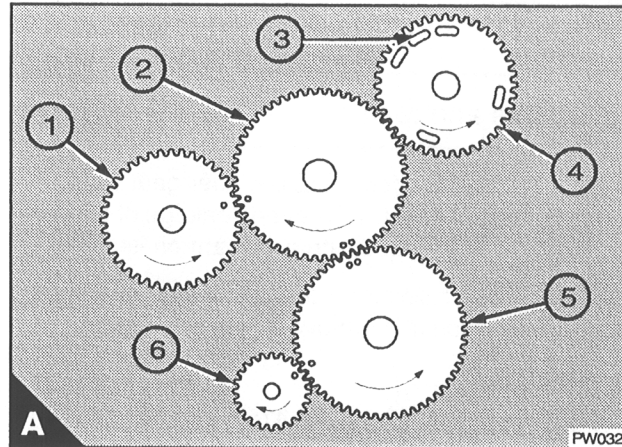
Note: There are no timing marks on the fuel pump gear. The centre hole (A3) in the group of three holes in the gear face must be at the 10-o'clock position, for correct timing of the fuel injection pump.

7 Fit and tighten the new setscrew for the upper idler gear to 325 Nm (240 lbf ft) 33,2 kgf m.

8 Check that the backlash of the gears is still within tolerance. Renew any gear that is out of tolerance.

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

10 Fill the cooling system to the correct level.





Fuel injection pump gear

Caution: If the crankshaft is rotated with fuel injection pump gear removed, the timing of the engine will be incorrect. If the crankshaft has to be rotated while the fuel injection pump is disconnected, the drive gear must be retained. If the drive gear is not retained, the timing case cover will be damaged.

Notes:

- There are no timing marks on the fuel pump gear (B3), the centre hole (A1) in the group of three holes in the gear face must be at the 10-o'clock position for correct timing of the fuel injection pump.
- The fuel injection pump can be disconnected from the drive gear through an access cover (A2) in the timing case cover (A4), by removal of the four setscrews (A3).

To remove and to fit

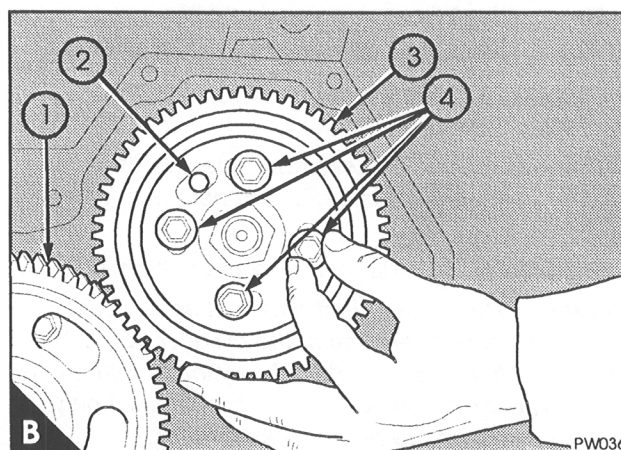
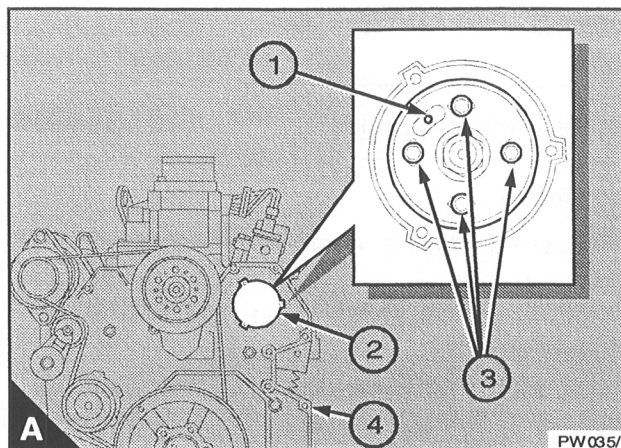
15A-03

To remove

- Set number one cylinder to TDC on the compression stroke, see [operation 17A-01](#).
- Ensure that the centre hole (B2) in the group of three holes in the pump gear face is at the 10 o'clock position.
- Remove the timing case cover, see [operation 15A-01](#).
- Measure and record the backlash of the fuel injection pump gear. Compare the result with the data and dimensions. Renew the gear if it is out of tolerance.
- Remove the setscrews (B4) of the drive gear (B3) and remove the gear.
- Inspect the gear for wear and other damage and renew it if necessary.

To fit

- Put the pump gear (B3) in position in mesh with the upper idler gear (B1). Ensure that the centre hole (B2) in the group of three holes in the gear face is at the 10-o'clock position.
- Lubricate the fuel injection pump gear with clean engine lubricating oil.
- Lightly lubricate the threads and shoulders of the setscrews for the fuel injection pump gear with clean engine lubricating oil.
- Fit and tighten the setscrews (B4) to 51 Nm (38 lbf ft) 5,3 kgf m.
- Check that the backlash of the gear is still within tolerance. Renew the gear if it is out of tolerance.
- Check the timing of the fuel injection pump, see [operation 17A-04](#).



- Fit the timing case cover, see [operation 15A-01](#).



15A TIMING CASE AND DRIVE ASSEMBLY

Timing case backplate

To remove and to fit

15A-04

To remove

- 1 Remove the timing case cover, see operation 15A-01.
 - 2 Remove the fuel injection pump and its drive gear, see section 20.
 - 3 Remove the power steering pump, the compressor and their mounting brackets, if these auxiliaries are fitted, see section 24.
 - 4 Remove and discard the coolant filter.
 - 5 Remove the idler gears, see operation 15A-02.
 - 6 Remove the oil pressure relief valve (15A.02/A2) from the crankcase.
 - 7 Remove the rocker assembly, see operation 12A-02. Remove all the push rods and note their relative positions.
 - 8 Remove the cylinder head, see operation 12A-05.
- Caution:** *The rocker shaft must not be removed without complete removal of the cylinder head. The rocker shaft setscrews retain the cylinder head to the block. The cylinder head gasket might leak if only these setscrews are removed and fitted.*
- 9 Remove the tappets from their bores and note their relative positions.
 - 10 Remove the camshaft, see operation 15A-05.
 - 11 Remove the setscrews and remove the timing case backplate. The backplate is located on two dowels (15A.02/A3).
 - 12 Remove the timing case backplate (15A.02/A4).

To fit

- 1 Clean and inspect all components for wear or damage. Inspect the timing case for cracks, especially around the channels for the engine fluids.
- 2 Fit a new joint (15A.02/A5) to the backplate.
- 3 Engage the backplate dowels (15A.02/A3) and push the backplate onto the engine.
- 4 Lightly lubricate the threads and shoulders of the setscrews for the backplate with clean engine lubricating oil.
- 5 Fit and tighten the setscrews to 26 Nm (19 lbf ft) 2,6 kgf m.
- 6 Fit the camshaft, see operation 15A-05.
- 7 Fit the tappets into their original bores.
- 8 Fit the cylinder head, see operation 12A-05.
- 9 Fit the oil pressure relief valve together with its 'O' ring (15A.02/A6).

Continued



- 10 Fit the idler gears, see operation 15A-02.
- 11 Fit a new coolant filter.
- 12 Fit the power steering pump, the compressor and their mounting brackets, if removed earlier, see section 24.
- 13 Fit the fuel injection pump and its drive gear, see section 20.
- 14 Fit the timing case cover, see operation 15A-01.
- 15 Fill the cooling system to the correct level.
- 16 Fill the lubricating system to the correct level with an approved oil.



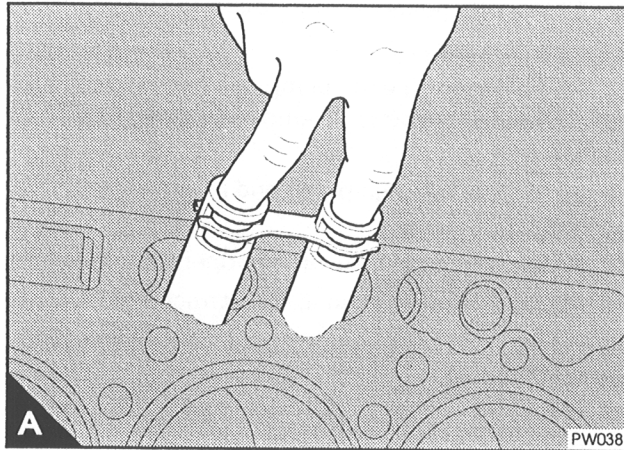
15A TIMING CASE AND DRIVE ASSEMBLY

Camshaft and tappets

Caution: The camshaft gear is an interference fit to the camshaft and must not be removed unless it is to be renewed. A new gear must be heated to 206°C (400°F) to fit onto the camshaft.

Notes:

- The four camshaft bushes can be renewed.
- The internal diameters of the bushes are the same but the external diameters are different for each bush, see data and dimensions. The front bush is removed toward the rear of the engine, the other three bushes are removed toward the front of the engine.



To remove and to fit

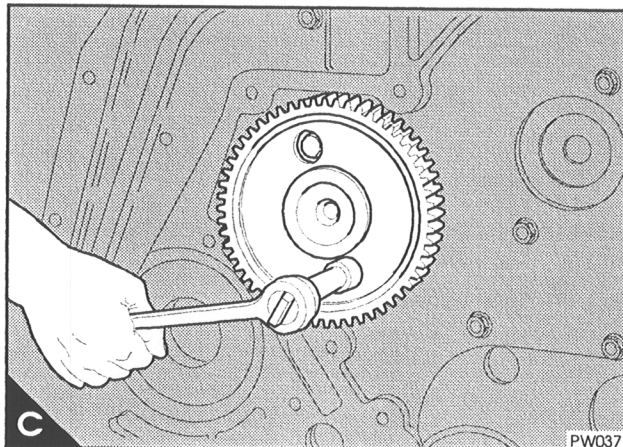
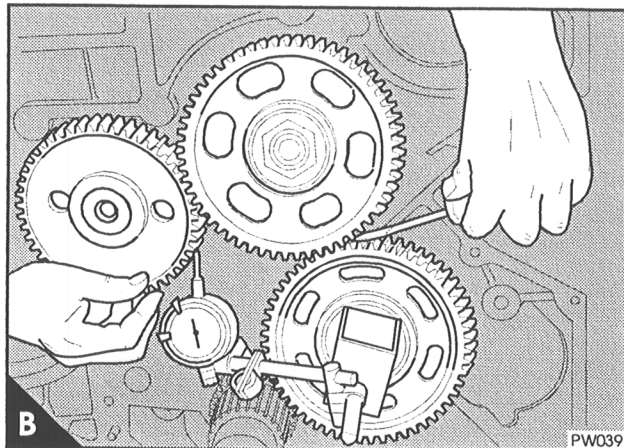
15A-05

To remove

- 1 Set number one cylinder to TDC on the compression stroke, see [operation 17A-01](#).
- 2 Drain the engine lubricating oil.
- 3 Drain the cooling system.
- 4 Remove the timing case cover, see [operation 15A-01](#).
- 5 Remove the cylinder head, see [operation 12A-05](#).

Caution: The rocker shaft must not be removed without complete removal of the cylinder head. The rocker shaft setscrews clamp the cylinder head to the block. The cylinder head gasket might leak if only these setscrews are removed and fitted.

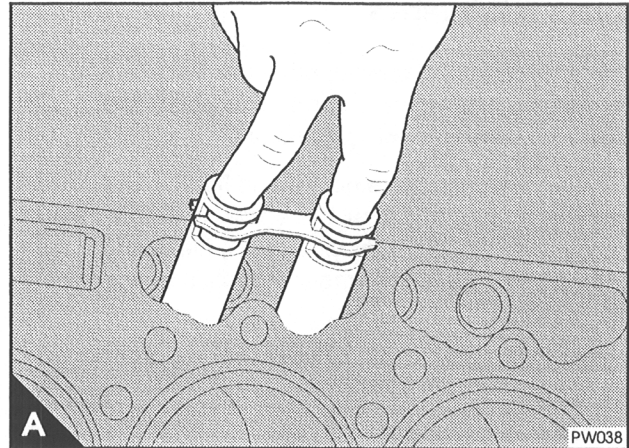
- 6 Remove the tappets (A) from their bores and note their relative positions.
- 7 Measure the backlash of the camshaft gear (B) and compare the reading with data and dimensions. If the backlash is incorrect, renew the gear.
- 8 Remove the setscrews from the camshaft thrust plate, access to the setscrews is through the two holes in the gear face (C).
- 9 Carefully remove the camshaft.





To fit

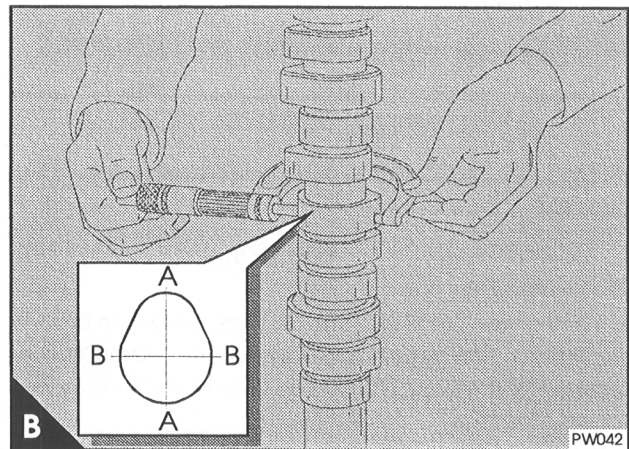
- 1 Ensure that all components are clean and are lubricated with clean engine lubricating oil.
- 2 Carefully fit the camshaft. Ensure that the timing marks on the upper idler gear and the camshaft gear align. If a new gear is fitted, measure the backlash ([15A.09/B](#)).
- 3 Fit the tappets (A) into their original bores.
- 4 Fit the cylinder head, see [operation 12A-05](#).
- 5 Fit the timing case cover, see [operation 15A-01](#).
- 6 Fill the cooling system to the correct level.
- 7 Fill the lubricating system to the correct level with an approved oil



To inspect

15A-06

With the camshaft removed from the engine, measure the camshaft lobes at line AA and at line BB in illustration (B) and record the readings. Measure the tappets, the thrust plate and the camshaft bushes. Compare all the readings with data and dimensions. Renew damaged or worn components as necessary.





15A TIMING CASE AND DRIVE ASSEMBLY

Camshaft bushes

The four camshaft bushes have the same internal diameter but all of the external diameters are different, see data and dimensions.

The bushes must be removed and fitted in the correct sequence, and they shall be referred to in this manual as number 1 bush, number 2 bush, number 3 bush and number 4 bush. Number 1 bush is at the front of the engine.

To renew

15A-07

Special tools:

camshaft bush remover and replacer ZTSE 2893A

1 Remove the camshaft, see [operation 15A-05](#).

Note: Use Tool ZTSE 2893A to remove and to fit the bushes.

2 To remove number 4 bush (A4), pull it toward the rear of the engine.

3 To remove the other three bushes, pull them toward the front of the engine in the sequence: number 1 bush (A1), number 2 bush (A2) then the number 3 bush (A3).

4 Clean and inspect the bush housings for damage. Ensure that all the lubricating oil holes are free of debris.

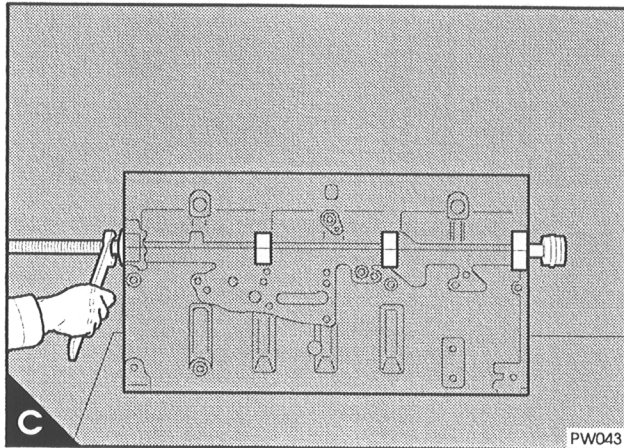
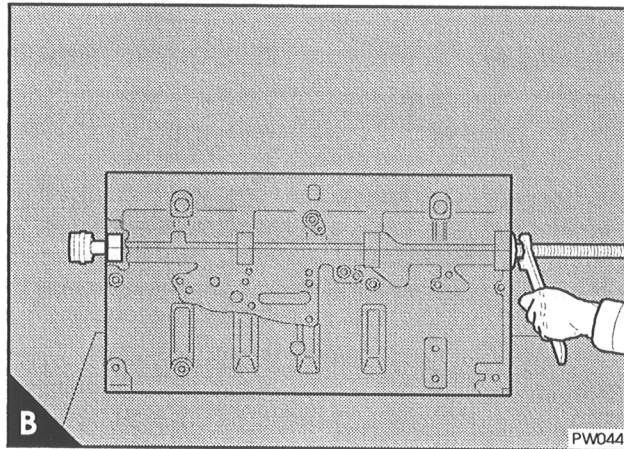
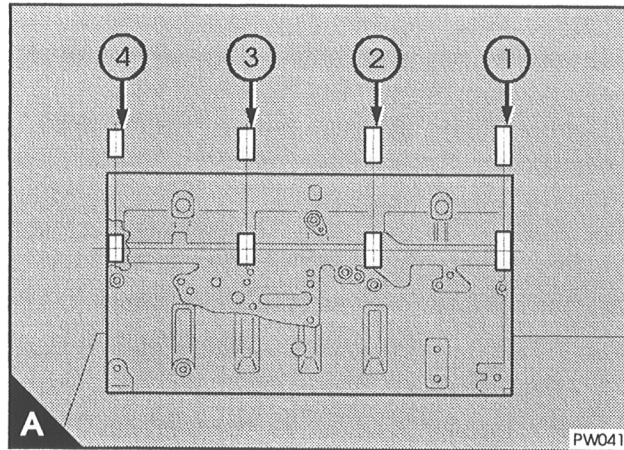
5 lubricate the bushes and the bush housings with clean engine lubricating oil.

6 Fit number 4 bush (A4); put it into position from the rear of the engine and then pull it toward the front of the engine.

7 Fit the other three bushes in the sequence: number 3 bush (A3), number 2 bush (A2) then the number 1 bush (A1). Put each bush into position from the front of the engine and then pull it toward the rear of the engine.

Caution: Ensure that the lubricating oil holes of each bush is on the same side, and is aligned with the lubricating oil holes in the crankcase.

8 Fit the camshaft, see [operation 15A-05](#).





Data and dimensions

Note: 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 the factory. The information applies to all engines, unless an engine type code is shown.

Camshaft

Diameter of all the journals.....	57,948/57,976 mm (2.2814/2.2825 in)
Clearance of all journals.....	0,051/0,178 mm (0.002/0.007 in)
Clearance service limit (maximum)	0,20 mm (0.008 in)
Cam lift:	
- Inlet.....	8,070 mm (0.3177 in)
- Exhaust	7,369 mm (0.2901 in)
Maximum permissible wear on cam lobes.....	0,51 mm (0.002 in)
End float	0,13/0,33 mm (0.005/0.013 in)
Thickness of thrust plate.....	6,96/7,01 mm (0.274/0.276 in)

Camshaft bushes

Inside diameter of all the camshaft bushes (fitted)	58,026/58,115 mm (2.2845/2.2880 in)
Number 1:	
- Outside diameter	63,6651/63,6270 mm (2.5065/2.5050 in)
- Width	25,4 mm (1.00 in)
- Parent bore diameter.....	63,5508/63,5127 mm (2.5020/2.5005 in)
Number 2:	
- Outside diameter	63,1571/63,1190 mm (2.4865/2.4850 in)
- Width	18,0/17,5 mm (0.71/0.69 in)
- Parent bore diameter.....	63,0428/63,0047 mm (2.4820/2.4805 in)
Number 3:	
- Outside diameter	62,6491/62,6110 mm (2.4665/2.4650 in)
- Width	18,0/17,5 mm (0.71/0.69 in)
- Parent bore diameter.....	62,5348/62,4967 mm (2.4620/2.4605 in)
Number 4:	
- Outside diameter	62,1411/62,1030 mm (2.4465/2.4450 in)
- Width	18,8/16,8 mm (0.71/0.69 in)
- Parent bore diameter.....	62,0268/61,9887 mm (2.4420/2.4405 in)

Timing gears

Backlash:

- Lower idler gear.....	0,356 mm (0.014 in)
- Compressor gear.....	0,508 mm (0.020 in)
- Upper idler gear.....	0,483 mm (0.019 in)
- Fuel injection pump gear	0,483 mm (0.019 in)
- Camshaft gear.....	0,457 mm (0.018 in)



Cylinder block assembly **16A**

General description 16A.02

Cylinder block

16A-01 To dismantle and to assemble 16A.03
16A-02 To inspect 16A.03

Cylinder liner

16A-03 To remove and to fit 16A.04
16A-04 To inspect 16A.06

Data and dimensions 16A.07



16A CYLINDER BLOCK ASSEMBLY

Cylinder block assembly

General description

The cylinder block is made of cast iron and provides support for the wet cylinder liners which are also made of cast iron.

Four bushes are fitted to the cylinder block for the camshaft journals.



Cylinder block

To dismantle and to assemble 16A-01

To dismantle

- 1 Drain the cooling system
- 2 Drain the lubricating oil.
- 3 Remove the engine from the vehicle or machine.
- 4 Remove the starter motor, see [operation 23B-01](#).
- 5 Remove all auxiliary equipment, see [section 24](#).
- 6 Remove the flywheel and the flywheel housing, see [section 22](#).
- 7 Remove the cylinder head, see [operation 12A-05](#).
- 8 Remove the timing case cover, see [operation 15A-01](#).
- 9 Remove the timing case backplate, see [operation 15A-04](#).
- 10 Remove the lubricating oil sump [19A-08](#).
- 11 Remove the pistons and connecting rods, see [operation 13A-03](#).
- 12 Remove the crankshaft, see [operation 14A-05](#).

To assemble

- 1 Clean thoroughly the cylinder block. Ensure that all the oil passages are clean and free of debris.
- 2 Fit the crankshaft and the rear oil seal assembly, see [section 14](#).
- 3 Fit the pistons and connecting rod assemblies, see [operation 13A-03](#).
- 4 Fit the lubricating oil sump [19A-08](#).
- 5 Fit the flywheel housing and the flywheel, see [section 22](#).
- 6 Fit the timing case and the timing gears, see [section 15](#).
- 7 Fit the cylinder head, see [operation 12A-05](#).
- 8 Fit the starter motor, see [operation 23B-01](#).
- 9 Fit all the auxiliaries removed earlier, see [section 24](#).
- 10 Install the engine into the vehicle or machine.
- 11 Fill the cooling system to the correct level with a coolant of the correct specification, see section 5 of the User's Handbook.
- 12 Fill the lubricating oil system to the correct level with an approved lubricating oil.

To inspect 16A-02

- 1 Clean the passages for the coolant and for the engine lubricating oil.
- 2 Check the cylinder block for cracks and for other damage.

3 The top face of the cylinder block must not be machined as this will affect the protrusion of the liner flange and the piston height.

4 Check the camshaft bushes for wear, see [operation 15A-07](#).



16A CYLINDER BLOCK ASSEMBLY

Cylinder liner

To remove and to fit

16A-03

Special tools:

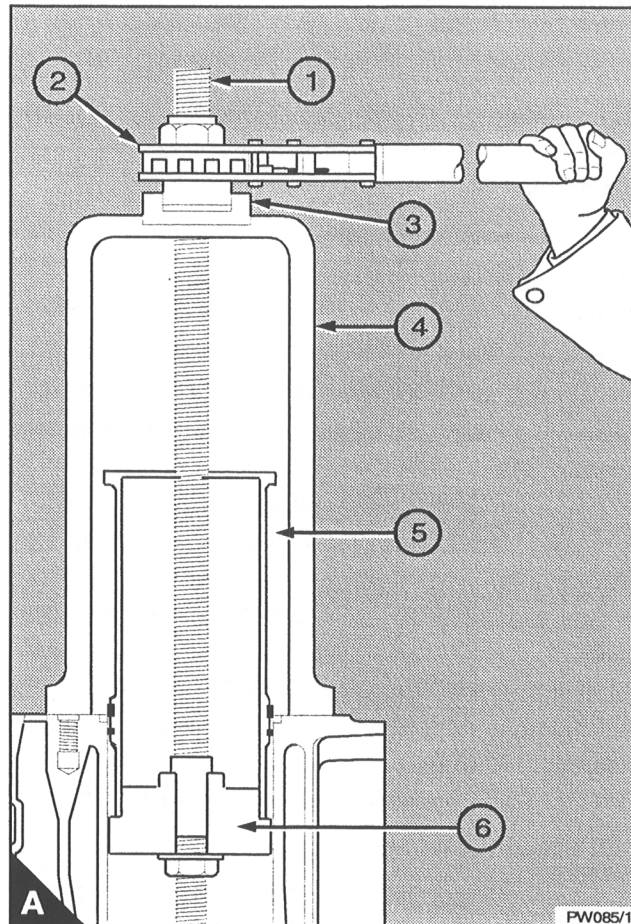
Cylinder liner retainer kit PD.234

Cylinder liner removal adaptor PD.231

Cylinder liner remover/replacer PD.150-B

To remove

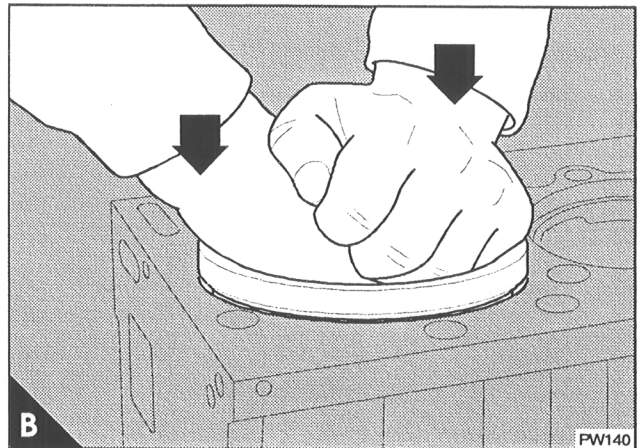
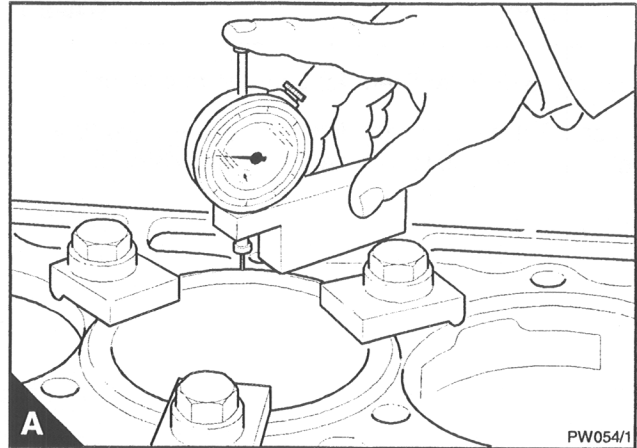
- 1 Drain the cooling system
- 2 Drain the lubricating oil.
- 3 Remove the lubricating oil sump, see [operation 19A-08](#).
- 4 Remove the cylinder head, see [operation 12A-05](#).
- 5 Remove the pistons and connecting rods, see [operation 13A-03](#).
- 6 Rotate the crankshaft to allow access to the cylinder liner and to protect the crank pin.
- 7 Put the tool (A4) on the top face of the cylinder block and over the centre of the cylinder liner (A5). Ensure that the base of the tool is not on top of the flange of the next cylinder liner.
- 8 Put the bearing (A3) in the top of the tool with the face of the bearing to the bottom of the recess.
- 9 Fit the threaded rod (A1) through the bearing and the top of the tool until the handle (A2) is in the recess in the top of the bearing. In this position adjust the threaded rod until the end is below the bottom of the cylinder liner.
- 10 Fit the adaptor PD. 231 (A6) onto the threaded rod and against the bottom of the cylinder liner.
- 11 Ensure that the two lugs on the top of the adaptor engage with the flats on the threaded rod.
- 12 Fit the washer and nut and tighten the nut onto the adaptor.
- 13 Lubricate the ratchet of the handle and the threaded rod with shell spirax or an equivalent oil. Operate the handle to pull the cylinder liner out of the top of the cylinder block.



**To fit**

If the original cylinder liner is to be fitted it must be rotated 90° from its original position to put the worn area away from the thrust face.

- 1 Clean thoroughly the parent bore and the cylinder liner. It is important that the recess for the flange of the cylinder liner is clean, and that the flange of the cylinder liner is also clean.
- 2 Fit new seals to the cylinder liner. Ensure that the seals are fitted correctly in their grooves.
- 3 Lightly lubricate the parent bore, the cylinder liner and the new seals with clean engine lubricating oil.
- 4 Engage the cylinder liner in the parent bore. Ensure that the cylinder liner is vertical and push the liner fully into the cylinder block by hand (B). Ensure that there is no distortion of the liner seals.
- 5 Fit the retainer kit PD.234, (A) for the cylinder liner. Tighten the three setscrews gradually and evenly to 55 Nm (40 lbf ft) 5,53 kgf m. Further tighten the three setscrews gradually and evenly to 110 Nm (80 lbf ft) 11,06 kgf m.
- 6 Measure the cylinder liner protrusion (A) to ensure that the liner is fitted correctly. Take one measurement between each of the three clamps of the retainer kit. Set the dial test indicator to zero on the top face of the cylinder block before each measurement. The correct protrusion of the cylinder liner is 0,05/0,13 mm (0.002/0.006 in).
- 7 Remove the retainer kit PD.234.
- 8 Fit the pistons and connecting rods, see [operation 13A-03](#).
- 9 Fit the cylinder head, see [operation 12A-05](#).
- 10 Fit the lubricating oil sump, see [operation 19A-08](#).
- 11 Fill the cooling system to the correct level.
- 12 Fill the lubricating oil system to the correct level with an approved oil.





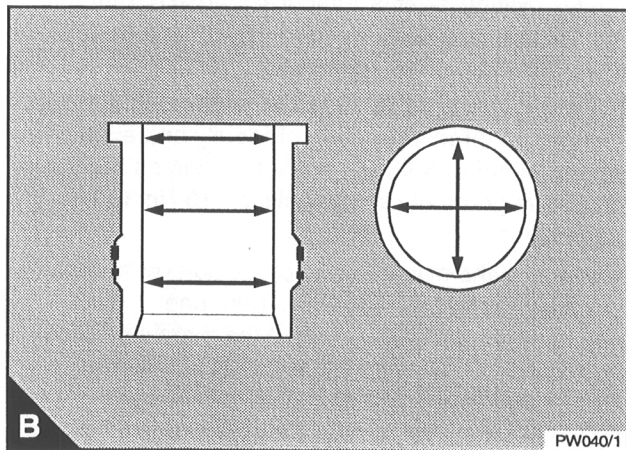
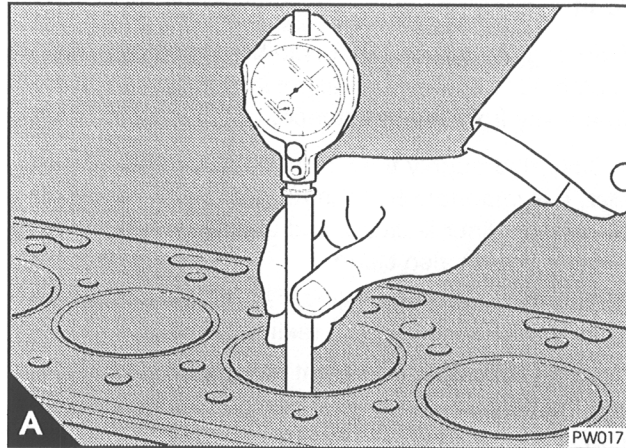
16A CYLINDER BLOCK ASSEMBLY

To inspect

16A-04

Check the cylinder liners for damage and wear.

To check the wear of the liner see (A) and (B) and compare the results with data and dimensions.





Data and dimensions

Note: 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 the factory. The information applies to all engines, unless an engine type code is shown.

Cylinder block

Face flatness	0,08 mm (0.003 in)
Diameter of parent bore for cylinder liner	104,20/104,23 mm (4.103/4.104 in)
Depth of recess for flange of cylinder liner	3,81/3,91 mm (0.150/0.154 in)
Diameter of recess for flange of cylinder liner	107,82/107,95 mm (4.245/4.250 in)
Diameter of parent bore for main bearing.....	96,500 +/- 0,0127 mm (3.8491 +/- 0.0005 in)
Internal diameter of piston cooling jet.....	1,22/1,24 mm (0.048/0.049 in)
Diameters of the parent bores for the camshaft bushes:	
- Number 1.....	63,551/63,513 mm (2.5020/2.5005 in)
- Number 2.....	63,043/63,005 mm (2.4820/2.4805 in)
- Number 3.....	62,535/62,497 mm (2.4620/2.4605 in)
- Number 4.....	62,141/62,103 mm (2.4465/2.4450 in)

Tappets

diameters:

- Tappet body	28,435/28,448 mm (1.1195/1.1200 in)
- Parent bore.....	28,512/28,550 mm (1.1225/1.1240 in)

Cylinder liners

Type.....	Wet, push fit, flanged
Inside diameter WD, WE,WF and WG engines.....	109,233/109,258 mm (4.3005/4.3015 in)
Inside diameter WH and WJ engines	116,573/116,599 mm (4.5895/4.5905 in)
Maximum permissible wear of liner bore	0,10 mm (0.004 in)
Thickness of flange.....	8,94/8,97 mm (0.352/0.353 in)
Flange protrusion above the top face of the cylinder block	0,050/0,127 mm (0.002/0.005 in)



Engine timing

17A

General description	17A.02
17A-01 To set number one cylinder to TDC on the compression stroke	17A.03
17A-02 To check the valve timing (with a feeler gauge)	17A.04
17A-03 To check the valve timing (with a dial test indicator),	17A.05
17A-04 To check and set the timing of the fuel injection pump	17A.06
17A-05 To find the setting for timing the fuel injection pump	17A.07
Static timing chart	17A.08
Data and dimensions	17A.09



Engine timing

General description

The marked teeth of the crankshaft gear, the camshaft gear and the two idler gears will be in mesh when number 1 piston is at TDC on the compression stroke. The marked teeth of the idler gear may not necessarily be in mesh, in this position, because of the different speeds at which the gears rotate.

With all of the marks aligned, the crankshaft will require 37 revolutions for all of the marks to align again.

There are no timing marks on the fuel pump gear, the centre hole in the group of three holes in the gear face must be at the 10 o'clock position approximately for correct timing of the fuel injection pump.



To set number one cylinder to
TDC on the compression stroke **17A-01**

- 1 Loosen the setscrews which retain the atomisers.
- 2 Remove the rocker cover, see operation 12A-01.
- 3 Slowly rotate the crankshaft clockwise, from the front, until the timing mark on the pulley/damper assembly aligns with the pointer on the timing case (17A.06/A1).
- 4 Check that the push rods of number 1 cylinder are free to rotate. Number 1 piston is now at TDC on the compression stroke.

Note: If the push rods are not free to rotate, this indicates that number 1 cylinder is on the exhaust stroke. Rotate the crankshaft one turn and align the timing marks.



17A ENGINE TIMING

To check the valve timing
(with a feeler gauge)

17A-02

- 1 Set the piston of number 1 cylinder to TDC on the compression stroke, see operation 17A-01.
 - 1 Loosen the setscrews which retain the atomisers.
 - 2 Set the piston of number 1 cylinder to TDC on the compression stroke, see operation 17A-01.
 - 3 Set the valve tip clearance of number one inlet valve to 0,74 mm (0.029 in).
 - 4 Rotate the crankshaft clockwise, from the front, until number one exhaust valve is just opening.
 - 5 Put a 0,10 mm (0.004 in) feeler gauge between the valve stem and the rocker lever of number one inlet valve.
 - 6 Slowly rotate the crankshaft clockwise, from the front, until the feeler gauge is tight. This is the point where the inlet valve of number one cylinder will begin to open. The timing mark on the pulley/ damper assembly should be at $24.5^{\circ} \pm 3.5^{\circ}$. If the valve timing is correct set the valve tip clearance of number one inlet valve to 0,64 mm (0.025 in).
 - 7 Fit the rocker cover, see operation 12A-01.
 - 8 Tighten the setscrews which retain the atomisers to 26 Nm (19 lb ft) 2,6 kgf m
 - 9 If the reading is incorrect remove the timing case cover, see operation 15A-01, and check the timing marks on the timing gears.
- Note:** Adjustment of the timing by one tooth on the timing gears = 11° or 30 mm (1.2 in) on the circumference of the pulley/damper assembly.



To check the valve timing
(with a dial test indicator),

17A-03

- 1 Set the piston of number 1 cylinder to TDC on the compression stroke, see operation 17A-01.
- 2 Loosen the setscrews which retain the atomisers.
- 3 Set the valve tip clearance of number one inlet valve to 0,74 mm (0.029 in).
- 4 Set a dial test indicator to zero against the valve rotator of number one inlet valve.
- 5 Slowly rotate the crankshaft clockwise, from the front, one full turn. The reading on the dial indicator should be 3,93/5,59 mm (0.155/0.220 in). If the reading is correct, set the valve tip clearance of number one inlet valve to 0,64 mm (0.025 in).
- 6 Remove the dial test indicator.
- 7 Fit the rocker cover, see operation 12A-01.
- 8 Tighten the setscrews which retain the atomisers to 26 Nm (19 lb ft). 2,6 kgf m.
- 9 If the reading is incorrect, remove the timing case cover, see operation 15A-01 and check the timing marks on the timing gears.

Note: Adjustment of the timing by one tooth on the timing gears = 11° or 30 mm (1.2 in) on the circumference of the pulley/damper assembly.



17A ENGINE TIMING

To check and set the timing
of the fuel injection pump

17A-04

Special tools:

Timing pin, with plunger PD.226

1 Remove the access cover (A2) to the drive gear of the fuel injection pump.

2 Rotate the crankshaft clockwise from the front, until number one piston is on the compression stroke and the correct timing mark (A1) for the engine is aligned on the pulley/ damper assembly (A7).

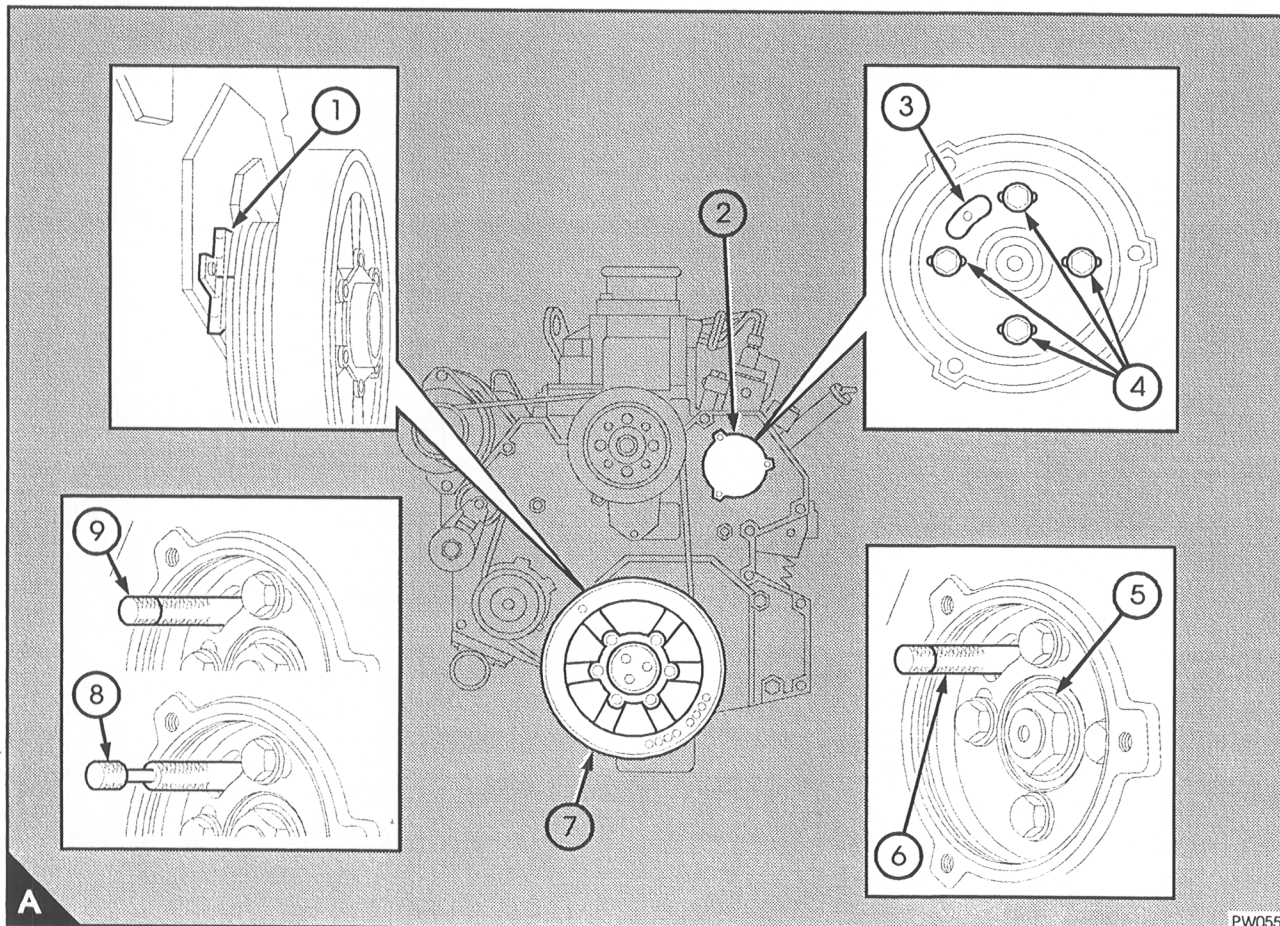
Note: See the static timing chart in this chapter for the correct timing mark.

3 Visually check the position of the fuel injection pump gear through the access hole. The centre hole (A3) in the group of three holes in the gear face should be at the 10 o'clock position, approximately.

4 Insert the timing pin PD.226 (A6) through the centre hole in the group of three holes in the gear face. Fit and tighten the timing pin into the drive flange of the fuel injection pump.

5 The timing of the fuel injection pump is:

- correct, if the plunger of the timing pin enters the hole in the pump timing plate, see (A9).
- incorrect If the plunger does not enter the timing plate, see (A8).





6 To adjust the timing, loosen the four setscrews (17A.06/A4) of the pump gear. Use a socket spanner on the hub nut (17A.06/A5) of the fuel injection pump to carefully rotate the pump until the plunger enters the hole in the pump timing plate.

7 Tighten the pump gear setscrews to 51Nm (38 lbf ft) 5,3 kgf m.

8 Remove the timing pin.

Caution: *Do not rotate the crankshaft while the timing pin is fitted, because the pin and the timing plate will be damaged.*

9 Rotate the crankshaft counter-clockwise, from the front, approximately 40° to eliminate the effect of backlash.

10 Rotate the crankshaft clockwise until the timing mark for the engine is aligned on the pulley/ damper assembly.

11 Fit the timing pin again and check that the plunger enters the timing plate. If it does, then the timing is correct.

12 Remove the timing pin.

13 Fit a new 'O' ring to the access cover and put the access cover in position on the crankcase cover.

14 Fit and tighten the access cover setscrews to 7,5 Nm (5.5 lbf ft) 0,76 kgf m.



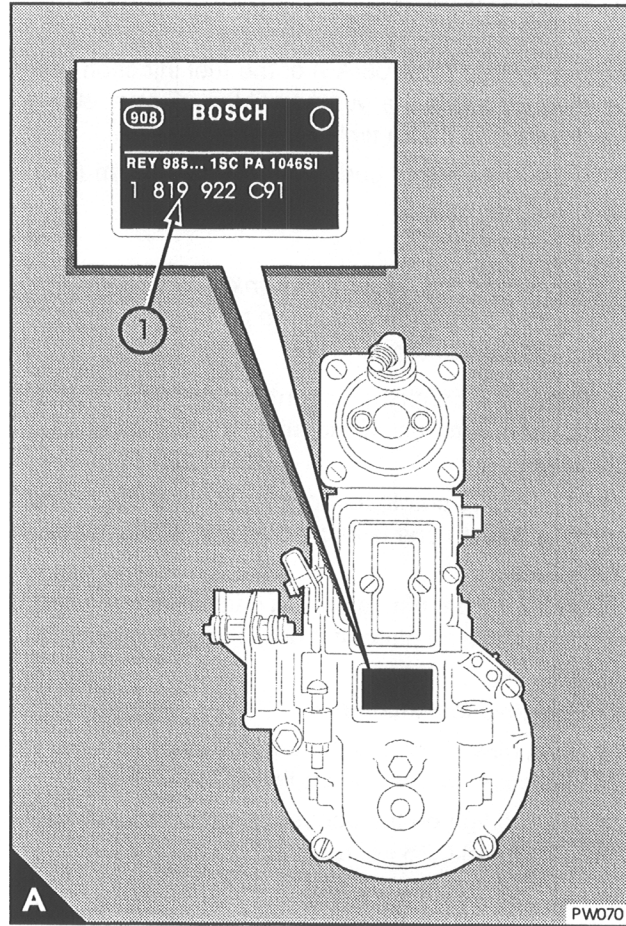
17A ENGINE TIMING

To find the setting for timing
the fuel injection pump

17A-05

- 1 Record the part number (A1) of the pump
- 2 Find that part number in the static timing chart on page 17A.09
- 3 Use the static timing BTDC setting shown next to the part number.

example: Pump part number 1 819 922 C91 (A1) has a timing setting of 12° BTDC.





Static timing chart

Pump part number	Static timing BTDC	Pump part number	Static timing BTDC	Pump part number	Static timing BTDC
1817 593 C91	17 ⁰	1820 271 C91 L	17 ⁰	1823 837 C91 A	12 ⁰
1817 694 C91	15 ⁰	1820 271 C91 M	17 ⁰	1823 837 C91 B	12 ⁰
1818 694 C91 A	15 ⁰	1820 271 C91 N	17 ⁰	1823 837 C91 C	17 ⁰
1819 913 C91	15 ⁰	1820 271 C91 P	17 ⁰	1823 837 C91 D	17 ⁰
1819 914 C91	15 ⁰	1820 271 C91 Q	17 ⁰	1823 837 C91 E	17 ⁰
1819 915 C91	10 ⁰	1820 888 C91	15 ⁰	1823 837 C91 F	17 ⁰
1819 916 C91	11 ⁰	1820 904 C91	12 ⁰	1823 837 C91 G	17 ⁰
1819 917 C91	13 ⁰	1821 048 C91	15 ⁰	1823 837 C91 H	17 ⁰
1819 918 C91	13 ⁰	1821 049 C91 A	15 ⁰	1823 837 C91 J	12 ⁰
1819 919 C91	13 ⁰	1821 049 C91 B	15 ⁰		
1819 920 C91	13 ⁰	1821 049 C91 C	15 ⁰		
1819 921 C91	12 ⁰	1821 958 C91	12 ⁰		
1819 922 C91	12 ⁰	1822 011 C91	17 ⁰		
1819 923 C91	12 ⁰	1822 012 C91	17 ⁰		
1819 924 C91	15 ⁰	1822 012 C91 A	17 ⁰		
1820 266 C91	12 ⁰	1822 140 C91	17 ⁰		
1820 267 C91	12 ⁰	1822 169 C91	15 ⁰		
1820 268 C91	20 ⁰	1822 370 C91	20 ⁰		
1820 268 C91	20 ⁰	1823 105 C91	12 ⁰		
1820 269 C91	17 ⁰	1823 105 C91 A	12 ⁰		
1820 269 C91 A	17 ⁰	1823 109 C91	13 ⁰		
1820 269 C91 B	20 ⁰	1823 109 C91 A	13 ⁰		
1820 269 C91 C	20 ⁰	18230135 C91	13 ⁰		
1820 269 C91 D	20 ⁰	18230135 C91 A	13 ⁰		
1820 271 C91	15 ⁰	18230136 C91	13 ⁰		
1820 271 C91 A	15 ⁰	18230136 C91 A	13 ⁰		
1820 271 C91 B	15 ⁰	18230137 C91	13 ⁰		
1820 271 C91 C	15 ⁰	18230137 C91 A	13 ⁰		
1820 271 C91 D	17 ⁰	18230138 C91 A	13 ⁰		
1820 271 C91 E	17 ⁰	1823 309 C91	20 ⁰		
1820 271 C91 F	12 ⁰	1823 309 C91 A	20 ⁰		
1820 271 C91 G	12 ⁰	1823 369 C91	24 ⁰		
1820 271 C91 H	12 ⁰	1823 369 C91 A	24 ⁰		
1820 271 C91 J	12 ⁰	1823 388 C91	12 ⁰		
1820 271 C91 K	12 ⁰	1823 837 C91	12 ⁰		



17A ENGINE TIMING

Data and dimensions

Note: 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 the factory. The information applies to all engines, unless an engine type code is shown.

Fuel injection pump

Type Bosch P3000 or Bosch P7100, in-line
Number 1 outlet The outlet nearest to the front of the engine
Direction of pump rotation Clockwise from the drive end of the pump



Turbocharger **18A**

General description 18A.02

Turbocharger

18A-01	To remove and to fit	18A.03
18A-02	To dismantle and to assemble	18A.05
18A-03	To inspect	18A.07
18A-04	To clean the impeller and compressor casing	18A.08
18A-05	To remove and to fit the actuator assembly of the waste-gate unit	18A.08
18A-06	To check and to adjust the actuator assembly of the waste-gate unit	18A.10

Turbocharger faults 18A.12

Data and dimensions 18A.14



Turbocharger

General description

Warning! *Turbochargers operate at high speed and at high temperatures. Keep fingers, tools and other objects away from the inlet and outlet ports of the turbocharger and avoid contact with hot surfaces.*

A turbocharger, is fitted between the exhaust and induction manifolds. The turbocharger is driven by exhaust gases and supplies air to the engine at more than atmospheric pressure. The turbocharger is lubricated by oil from the oil filter head. The oil passes through the bearing housing of the turbocharger and returns to the lubricating oil sump.

Some turbochargers are fitted with a waste-gate unit. This unit, which is controlled by boost pressure, allows some of the exhaust gases to by-pass the turbine rotor at higher engine speeds. With this arrangement, the turbocharger can be designed to be more effective at lower engine speeds.

Always use the manufacturers instructions and specialist assistance to fit the service kit for the turbocharger.

Caution: *Do not use a caustic solution to clean the components of the turbocharger because the turbocharger will be damaged.*



Turbocharger

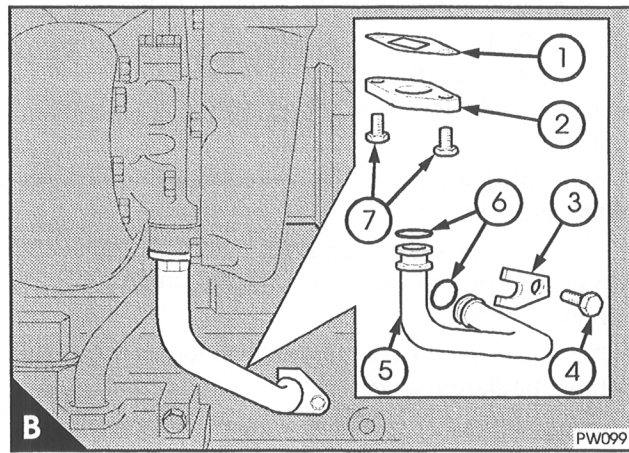
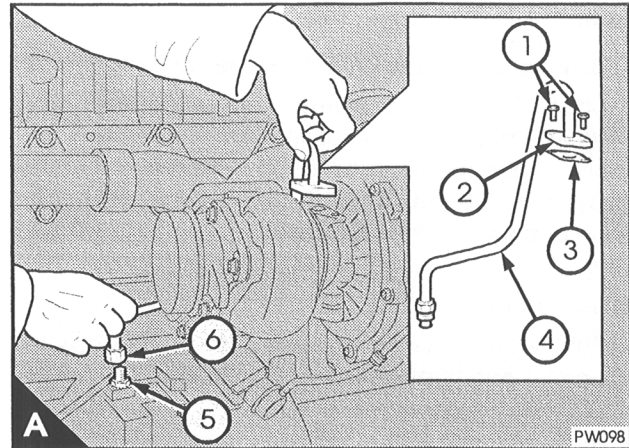
To remove and to fit

18A-01

To remove

Warning! Turbochargers operate at high speed and at high temperatures. Keep fingers, tools and other objects away from the inlet and outlet ports of the turbocharger and avoid contact with hot surfaces.

- 1 Thoroughly clean the turbocharger.
- 2 Remove the air cleaner hose at the compressor inlet.
- 3 Remove the hose from the compressor outlet.
- 4 Release the setscrews (A1) from the flange (A2) of the oil supply pipe (A4) at the top of the bearing housing.
- 5 Release the union nut/connection (A6) at the other end of the pipe on the oil filter head. Use a spanner to hold the union (A5) on the filter head when the union nut is released.
- 6 Remove the pipe and discard the flange joint (A3).
- 7 Remove the setscrews (B7) from the flange (B2) of the oil drain pipe (B5) at the bottom of the bearing housing.
- 8 Remove the setscrew (B4) and the clamp (B3), at the other end of the pipe.
- 9 Remove the oil drain pipe and discard its two 'O' rings (B6) and flange joint (B1).
- 10 Hold the turbocharger and release the setscrews at the turbocharger to exhaust manifold flange. Remove the turbocharger and discard the gasket.
- 11 Cover the openings in the manifolds and the pipes to ensure that debris will not enter.





18A TURBOCHARGER

To fit

1 Remove the covers from the pipes and manifolds.
2 Check that the turbocharger inlet and outlet are clean and free from restriction. Check that the turbocharger shaft rotates freely. Also check that the openings in the manifolds and the exhaust pipe are clean and free from restriction.

3 Fit a new gasket to the exhaust manifold to turbocharger flange.

4 Put the turbocharger in position and hold it. Fit the setscrews and tighten them to 68 Nm (50 lbf ft) 6,9 kgf m.

5 Put a suitable container under the turbocharger to contain the oil from the oil drain outlet of the turbocharger.

6 Pour 140 cm³ (0.25 pints) of clean engine lubricating oil into the oil supply port of the bearing housing.

7 Fit a new joint (A3) to the oil supply port on the top of the turbocharger.

8 Clean the threads of the union connection (A5 and A6) and apply a thread sealant to the union connection (A5).

9 Put the oil supply pipe (A4) in position, fit but do not tighten the flange setscrews (A1).

10 Use a spanner to hold the union connection (A5) on the oil filter head while the union nut (A6) on the pipe is tightened.

11 Tighten the flange setscrews (A1).

12 Fit the air cleaner hose to the compressor inlet.

13 Fit the compressor outlet hose.

14 Operate the stop control or, where fitted, disconnect the electrical stop control. Operate the starter motor until there is a flow of lubricating oil from the oil drain pipe of the turbocharger.

15 Connect the electrical stop control, if it was disconnected earlier.

16 Fit a new joint (B1), the flange (B2) and two new 'O' rings (B6) onto the oil drain pipe (B5).

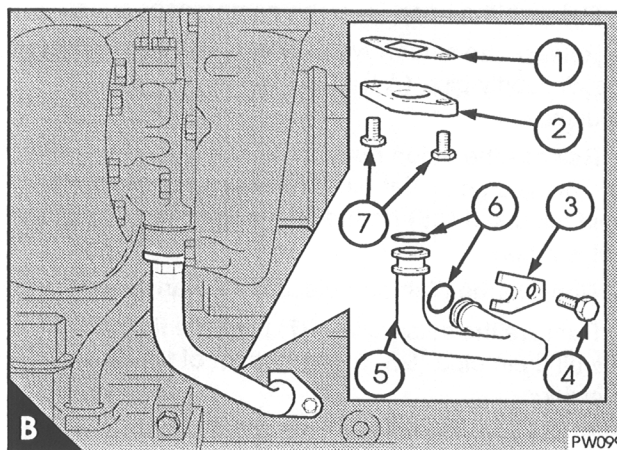
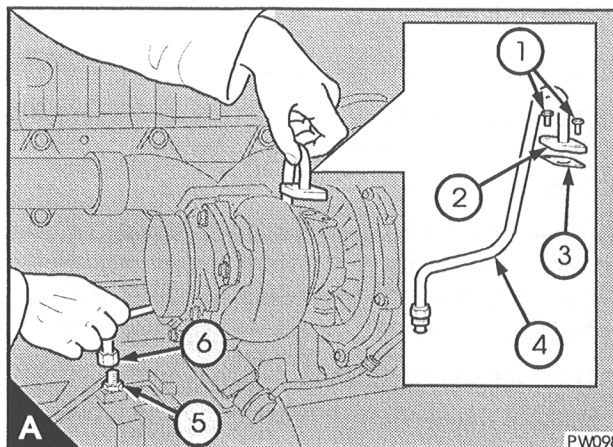
17 Install the oil drain pipe into its port in the crankcase. Put and hold the flanged end of the oil drain pipe against the oil drain port, at the bottom of the turbocharger.

18 Fit but do not tighten the two flange setscrews (B7).

19 Put the pipe clamp (B3) in position and hold it. Fit but do not tighten the setscrew (B4).

20 Tighten the three setscrews evenly and gradually.

21 Remove the container and dispose of the lubricating oil in a safe place in accordance with local regulations.





To dismantle and to assemble

18A-02

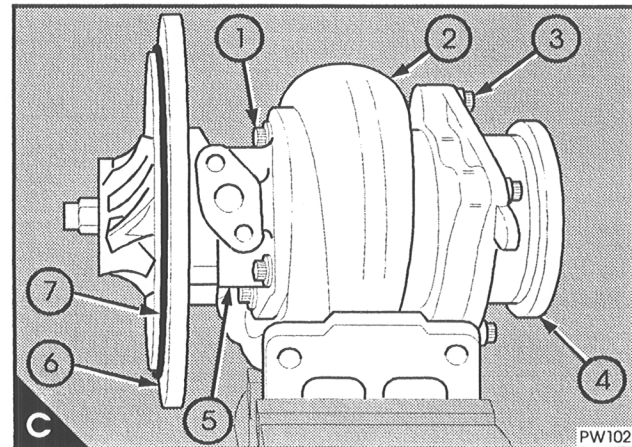
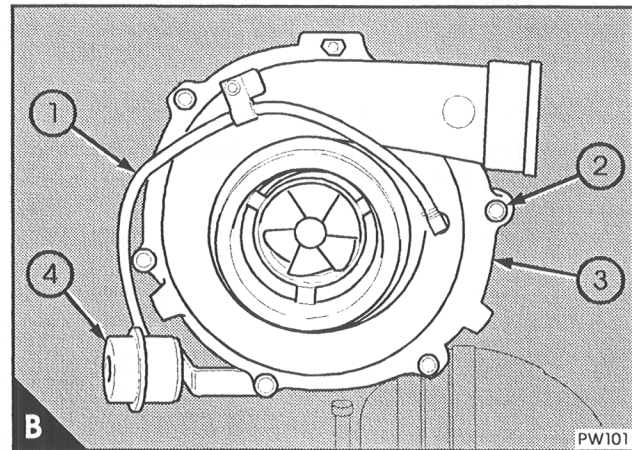
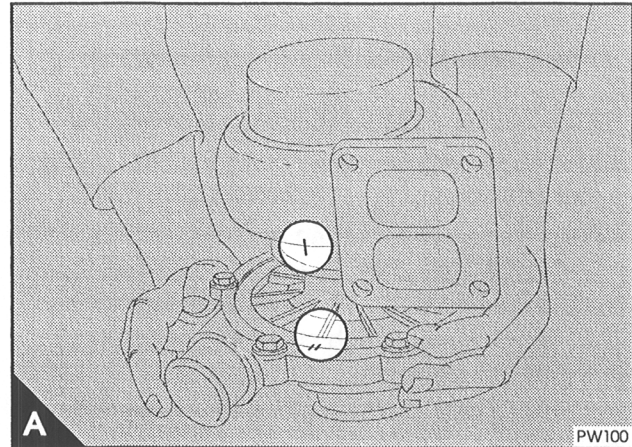
To dismantle

Note: The components of the rotating assembly and the components of the bearing housing, except the backplate 'O' ring, have been withdrawn as service items. If there is a failure of these components, or if they are excessively worn, the complete bearing housing and rotating assembly must be renewed as a unit.

- 1 Remove the turbocharger from the engine, see [operation 18A-01](#).
- 2 Make reference marks (A) on the compressor casing, on the backplate and on the turbine housing to ensure correct assembly later.
- 3 Hold the turbocharger in a vice which is fitted with soft jaws to protect the turbocharger.
- 4 Remove the boost sensor pipe (B1) at the waste-gate actuator (B4). Remove the waste-gate actuator and bracket assembly, see [operation 18A-05](#).
- 5 Remove the six setscrews (B2) which hold the compressor casing (B3) to the backplate (C6), remove the three lock plates.
- 6 Remove carefully the compressor casing from the turbocharger. If the casing is tight, lightly hit it with a soft faced hammer.
- 7 Remove the compressor housing seal (C7).

Caution: To change the angle of the compressor inlet, the casing must be removed completely and then fitted again. Do not turn the casing while it is fitted to the turbocharger because the compressor housing seal will be damaged.

- 8 Remove the six setscrews (C3) which hold the waste-gate housing (C4) to the turbine casing (C2) and remove the waste-gate housing.
- 9 Remove the four setscrews (C1) which hold the bearing housing assembly (C5) to the turbine casing, remove the bearing housing assembly.





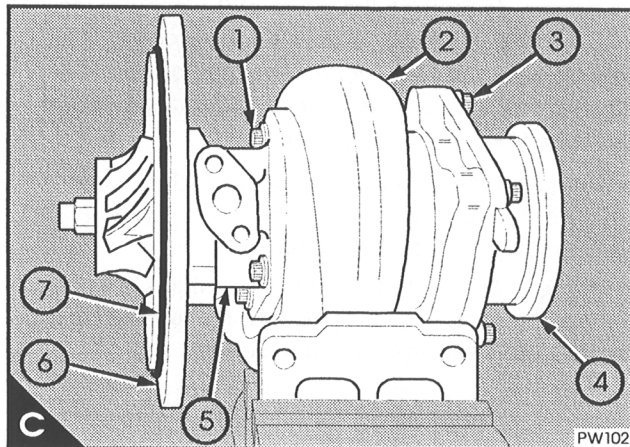
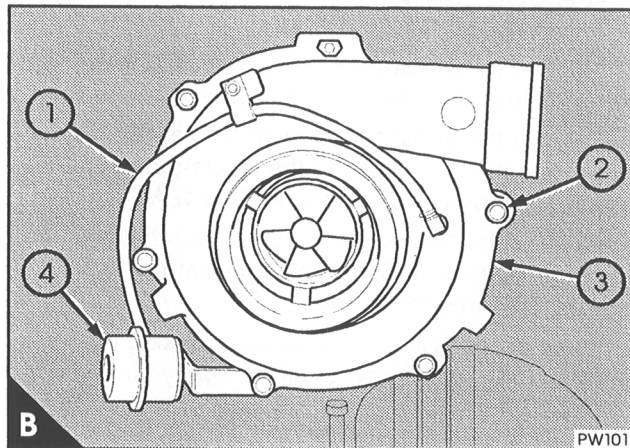
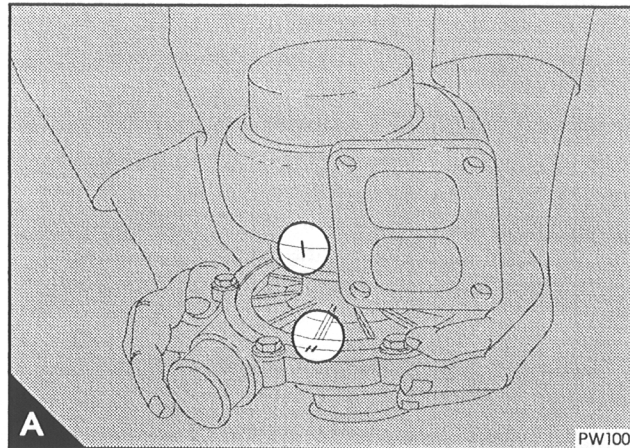
18A TURBOCHARGER

To assemble

- 1 Fit the waste-gate housing (C4) to the turbine housing (C2), fit and tighten the six setscrews (C3).
- 2 Fit the bearing housing assembly (C5) to the turbine housing (C2) and align the marks (A). Tighten the four setscrews (C1) to 13 Nm (9.6 lbf ft) 1,3 kgf m.
- 3 Fit the compressor housing seal (C7).
- 4 Fit the compressor housing to the backplate (C6) and align the marks (A). Fit the three lockplates and the six setscrews (B2), tighten the setscrews to 23 Nm (17 lbf ft) 2,35 kgf m.

Caution: To change the angle of the compressor inlet, the casing must be removed completely and then fitted again. Do not turn the casing while it is fitted to the turbocharger because the compressor seal will be damaged.

- 5 Check that the turbine rotates freely.
- 6 Fit the waste-gate actuator and bracket assembly, see operation 18A-05.



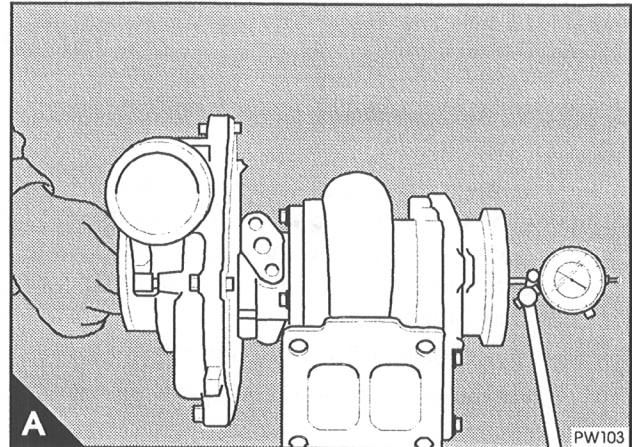


To inspect

18A-03

Caution: Do not straighten the blades of the impeller or the turbine. If they are bent or damaged, the turbocharger must be renewed.

- 1 Remove the turbocharger, see [operation 18A-01](#).
- 2 Visually inspect the turbocharger for damage and leaks.
- 3 Ensure that the turbine shaft turns freely.
- 4 Check the actuator rod movement, see [operation 18A-06](#).
- 5 Put a dial gauge (A) on the turbocharger (A) to measure the end-float of the turbine shaft. Ensure that the tip of the gauge is in contact with the end of the turbine shaft. Push the shaft fully in one direction and set the gauge to zero. Push the shaft fully in the other direction and note the reading on the gauge. The correct end-float tolerance is 0,02-0,10 mm (0.001-0.004 in). If the end-float is out of tolerance the turbocharger must be renewed.



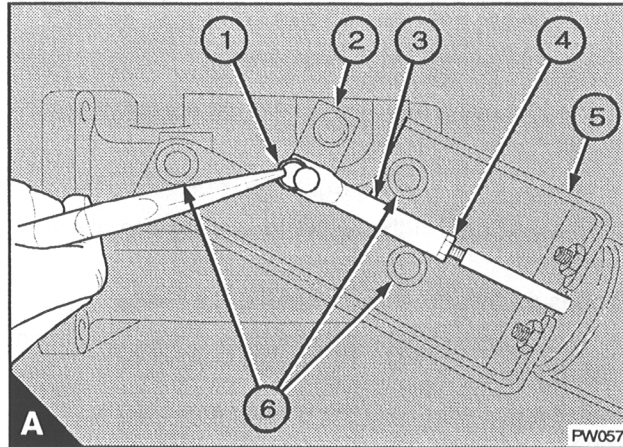


18A TURBOCHARGER

To clean the impeller and compressor casing

18A-04

- 1 Remove the compressor casing, see [operation 18A-02](#).
- 2 Put the compressor casing in a suitable container that contains a non-caustic solution. Allow the dirt to become soft and then clean the casing with a hard brush and/or a soft scraper. Dry the casing with clean, compressed air at low pressure.
- 3 Clean the impeller with a soft brush.
- 4 Fit the compressor casing, see [operation 18A-02](#).



To remove and to fit the actuator assembly of the waste-gate unit

18A-05

To remove

Caution: Do not operate the actuator rod by hand, because the calibration of the actuator will be affected. This may cause damage to the engine.

- 1 Disconnect the boost sensor pipe at the actuator.
- 2 Remove the clip (A1) which retains the actuator rod (A3).
- 3 Release the three setscrews (A6) which retain the waste-gate actuator and bracket assembly (A5) to the turbocharger.
- 4 Remove the actuator and bracket assembly as a unit, and at the same time, lift the end of the actuator rod off the arm of the waste-gate valve (A2).



To fit

Cautions:

- Do not apply an air pressure of more than 207 kPa (30 lbf/in²) 2,1 kgf/cm² to the actuator. Higher pressures may damage the actuator.
- Do not operate the actuator rod by hand, because the calibration of the actuator will be affected. This may cause damage to the engine.

1 Fit the actuator and bracket assembly (A5) to the turbocharger and tighten the three setscrews (A6).

Note: Do not put the end of the actuator rod (A3) onto the arm (A2) of the waste-gate valve.

2 Connect the actuator (B3), to an air supply which has a regulator (B5) and an accurate gauge (B4).

3 Operate the arm (B1) of the waste-gate valve by hand to check that the valve is free to move.

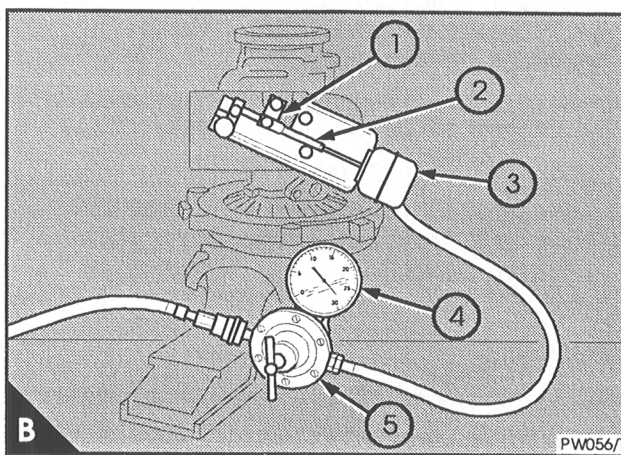
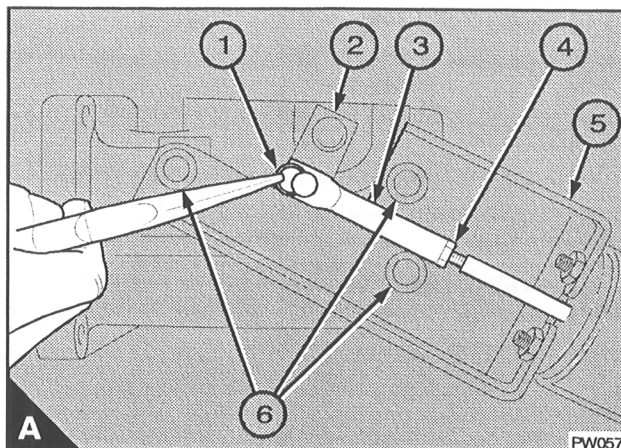
4 Push the arm of the waste-gate valve as far as possible toward the actuator and hold the arm in this position. Slowly apply air pressure to the actuator until the end of the actuator rod (B2) will fit easily onto the arm of the waste-gate valve.

5 If the end of the actuator rod will not fit easily onto the arm of the waste-gate valve, the rod of the actuator assembly must be adjusted, see [operation 18A-06](#).

6 Fit the clip (A1).

7 Release the air pressure.

8 Check the operation of the waste-gate unit, see [operation 18A-06](#).





18A TURBOCHARGER

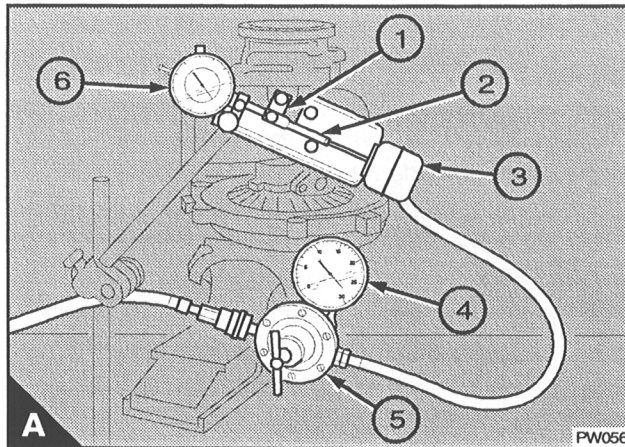
To check and to adjust the actuator assembly of the waste-gate unit **18A-06**

Notes:

- If the waste-gate valve does not operate at the correct pressure, it can affect the engine performance.
- If the valve opens at a low pressure, this can cause black exhaust smoke and loss of power at lower engine speeds.

Cautions:

- *A high pressure setting can cause high cylinder pressures which can cause failure of the cylinder head gasket and can cause damage to the bearings and pistons.*
- *Do not apply an air pressure of more than 207 kPa (30 lbf/in²) 2,1 kgf/cm² to the actuator. Higher pressures may damage the actuator.*
- *Do not operate the actuator rod (A3) by hand, because the calibration of the actuator will be affected, and this may cause damage to the engine.*



To check

- 1 Disconnect the boost sensor pipe at the actuator.
- 2 Connect the actuator to an air supply which has a pressure regulator (A5) and is fitted with an accurate gauge (A4).
- 3 Fasten a dial gauge (A6) to the turbocharger with its plunger in contact with the end of the actuator rod (A2), to measure the axial movement of the rod.
- 4 Slowly apply air pressure and check that the rod moves 0,381 mm (0.015 in) at 197 kPa (28.5 lbf in²) 2,0 kgf cm². Ensure that the pointer returns to zero when the pressure is released.
- 5 Repeat paragraph 4 of the operation several times, to ensure that an accurate reading is obtained
 - If the axial movement of the rod is correct, no adjustment is necessary. Remove the air supply and remove the dial gauge.
 - If the axial movement of the rod is wrong, adjustment is necessary, see page 18A.11. Remove the dial gauge.



To adjust

1 Check the operation of the actuator assembly, see [page 18A.10](#).

2 With the air pressure still applied, release the locknut (A4) on the actuator rod. Remove the clip (A1) and lift the actuator rod (A3) from the arm (A2) of the waste-gate valve.

- If the air pressure was too low, turn the end of the actuator rod to reduce its overall length.
- If the air pressure was too high, turn the end of the actuator rod to increase its overall length.

Note: Turn the end of the actuator rod in half turn increments.

Caution: Use only the end of the threaded rod to make adjustments. To pull or push the actuator rod could change the calibration of the actuator. The result could be damage to the engine because of too much boost.

3 Put the actuator rod in position on the arm of the waste-gate.

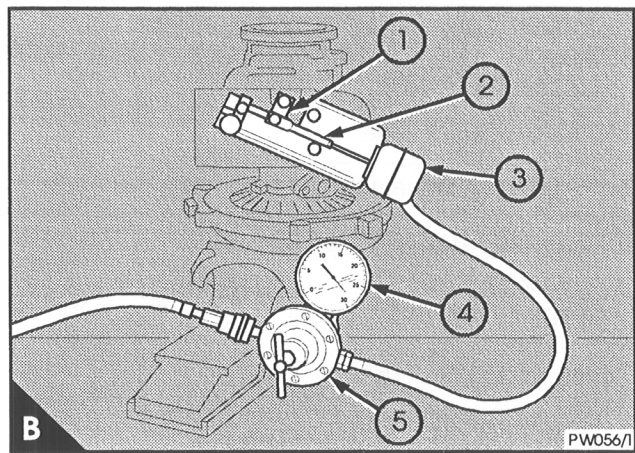
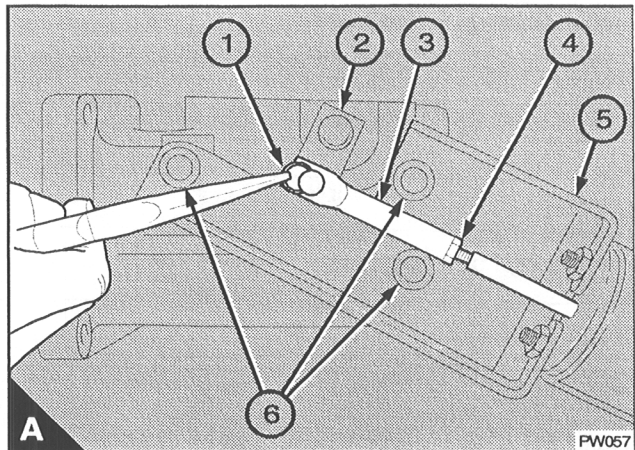
4 Check the operation of the actuator assembly, see [page 18A.10](#).

5 Repeat the adjustment procedure until the axial movement of the actuator rod is correct.

6 Fit the clip (A1).

7 Tighten the locknut (A4).

8 Release the air pressure.





18A TURBOCHARGER

Turbocharger faults

The chart below is given to assist in the correct diagnosis of turbocharger faults.

Problems	Possible causes, code numbers
Not enough power	1, 4, 5, 6, 7, 8, 9, 10, 11, 18, 20, 21, 22, 25, 26, 27, 28, 34, 35, 36
Black smoke	1, 4, 5, 6, 7, 8, 9, 10, 11, 18, 20, 21, 22, 25, 26, 27, 28, 34, 35, 36
Blue smoke	1, 2, 4, 6, 8, 9, 17, 19, 20, 21, 22, 30, 31, 32, 34
High consumption of lubricating oil	2, 8, 15, 17, 19, 20, 28, 29, 31, 32, 34
Too much lubricating oil at the turbine end	2, 7, 8, 17, 19, 20, 22, 28, 30, 31, 32
Too much lubricating oil at the compressor end	1, 2, 4, 5, 6, 8, 19, 20, 21, 28, 31, 32
Not enough lubrication	8, 12, 14, 15, 16, 23, 24, 29, 32, 33, 37, 38
Lubricating oil in the exhaust manifold	2, 7, 17, 18, 19, 20, 22, 28, 31, 32
Inside of the induction manifold wet	1, 2, 3, 4, 5, 6, 8, 10, 11, 17, 18, 19, 20, 21, 28, 32, 34, 39, 40
Damaged compressor impellor	3, 4, 6, 8, 12, 15, 16, 20, 21, 23, 24, 29, 32, 33, 37, 38
Damaged turbine rotor	7, 8, 12, 13, 14, 15, 16, 18, 20, 22, 23, 24, 25, 27, 29, 32, 33, 37, 38
Rotating assembly does not turn freely	3, 6, 7, 8, 12, 13, 14, 15, 16, 18, 20, 22, 23, 24, 29, 32, 33, 37, 38
Worn: bearings, bearing bores or journals	6, 7, 8, 12, 13, 14, 15, 16, 23, 24, 29, 33, 37, 38
Noise from the turbocharger	1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 20, 21, 22, 23, 24, 29, 32, 33, 34, 37, 38,
Sludge or carbon deposit in the bearing housing	2, 11, 13, 14, 15, 17, 18, 24, 29, 33, 37, 38

**Faults codes**

- 1 Element of the air filter dirty
- 2 Restricted crankcase breather
- 3 Element of the air filter missing, leaking or not sealing correctly. Loose connection to turbocharger.
- 4 Internal distortion or restriction in pipe from air filter to turbocharger.
- 5 Damaged/restricted crossover pipe, turbocharger to induction manifold.
- 6 Restriction between air filter and turbocharger.
- 7 Restriction in exhaust system.
- 8 Turbocharger loose or clamps/setscrews loose.
- 9 Induction manifold cracked or loose, flanges distorted.
- 10 Exhaust manifold cracked or loose, flanges distorted.
- 11 Restricted exhaust system.
- 12 Delay of lubricating oil to turbocharger at engine start.
- 13 Insufficient lubrication.
- 14 Dirty lubricating oil.
- 15 Incorrect lubricating oil.
- 16 Restricted lubricating oil supply pipe.
- 17 Restricted lubricating oil drain pipe.
- 18 Turbine housing damaged or restricted.
- 19 Leakage from turbocharger seals.
- 20 Worn turbocharger bearings.
- 21 Excessive dirt in compressor housing.
- 22 Excessive carbon behind turbine rotor.
- 23 Engine speed raised too rapidly at initial start.
- 24 Insufficient engine idle period.
- 25 Faulty fuel injection pump.
- 26 Worn or damaged atomisers.
- 27 Valves burned.
- 28 Worn piston rings.
- 29 Lubricating oil leakage from supply pipe.
- 30 Excessive preservation fluid (on initial engine start).
- 31 Excessive engine idle period.
- 32 Restriction in turbocharger bearing housing.
- 33 Restriction in lubricating oil filter.
- 34 Wet type air cleaner: Restricted, dirty element, viscosity of oil to low/high.
- 35 Wastegate actuator faulty or damaged.
- 36 Wastegate valve not free.
- 37 Engine stopped too soon from high load.
- 38 Insufficient lubricating oil.
- 39 Fuel leakage from fuelled starting aid.
- 40 Crack in backplate of compressor.



18A TURBOCHARGER

Data and dimensions

Note: 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 the factory. The information applies to all engines, unless an engine type code is shown.

Turbocharger

Shaft end-float.....	0,025/0,100 mm (0.001/0.004 in)
Shaft clearance.....	0,08/0,15 mm (0.003/0.006 in)
Waste-gate actuator movement.....	0,38 mm at 196 kPa (0.015 in at 28.5 lbf/in ²)



Lubrication system

19A

General description 19A.04

Filter canister

19A-01 To renew the canister of the lubricating oil filter 19A.06

Filter head and oil cooler assembly

19A-02 To remove and to fit 19A.07

19A-03 To inspect 19A.08

Oil temperature / pressure control valve

19A-04 To remove and to fit 19A.09

19A-05 To test 19A.09

Pressure regulating valve

19A-06 To remove and to fit 19A.10

19A-07 To inspect 19A.10

Sump

19A-08 To remove and to fit 19A.11

Oil strainer and suction pipe

19A-09 To remove and to fit 19A.14

Lubricating oil pump

19A-10 To remove and to fit 19A.15

19A-11 To inspect 19A.18

Front oil seal

19A-12 To renew 19A.19

Continued



19A LUBRICATION SYSTEM

Pressure relief valve

19A-13	To remove and to fit	19A.20
19A-14	To inspect	19A.20

Breather system

19A-15	To clean	19A.21
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Data and dimensions	19A.22
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Lubrication system

General description

Lubricating oil from the sump passes through a strainer and a pipe into a channel in the timing case. The lubricating oil passes through the channel to the inlet of the oil pump.

The lubricating oil passes from the oil pump, under pressure, through a channel in the timing case. The oil either passes through a relief valve which is fitted in the timing case or passes into an oil pressure rail. The relief valve opens at 551 kPa (80 lbf/in²) 5,6 kgf/cm² and returns the oil to the sump.

A temperature / pressure control valve in the oil filter head controls the flow of oil from the pressure rail. If the oil is hot, the valve will open and the oil passes through the oil cooler to the oil filter head and then into the filter. If the oil is cold, the valve closes and the oil passes directly to the oil filter.

Clean lubricating oil passes from the filter to a regulator valve which operates at 345 kPa (50 lbf/in²) 3,51 kgf/cm². If a restriction occurs in the filter element, a by-pass valve fitted in the filter housing opens. Oil which by-passes the filter passes directly to the regulator valve. The regulator valve either by-passes oil to the sump or allows oil to pass to the main pressure rail and then through ports in the cylinder block to the crankshaft main journals.

Lubricating oil from the main pressure rail also passes to jets in the crankcase which spray oil on the underside of the pistons to cool them.

There are ports in the crankcase through which oil passes to the camshaft journals.

Lubricating oil passes through holes drilled in the crankshaft journals to the crank pins to lubricate the big end bearings.

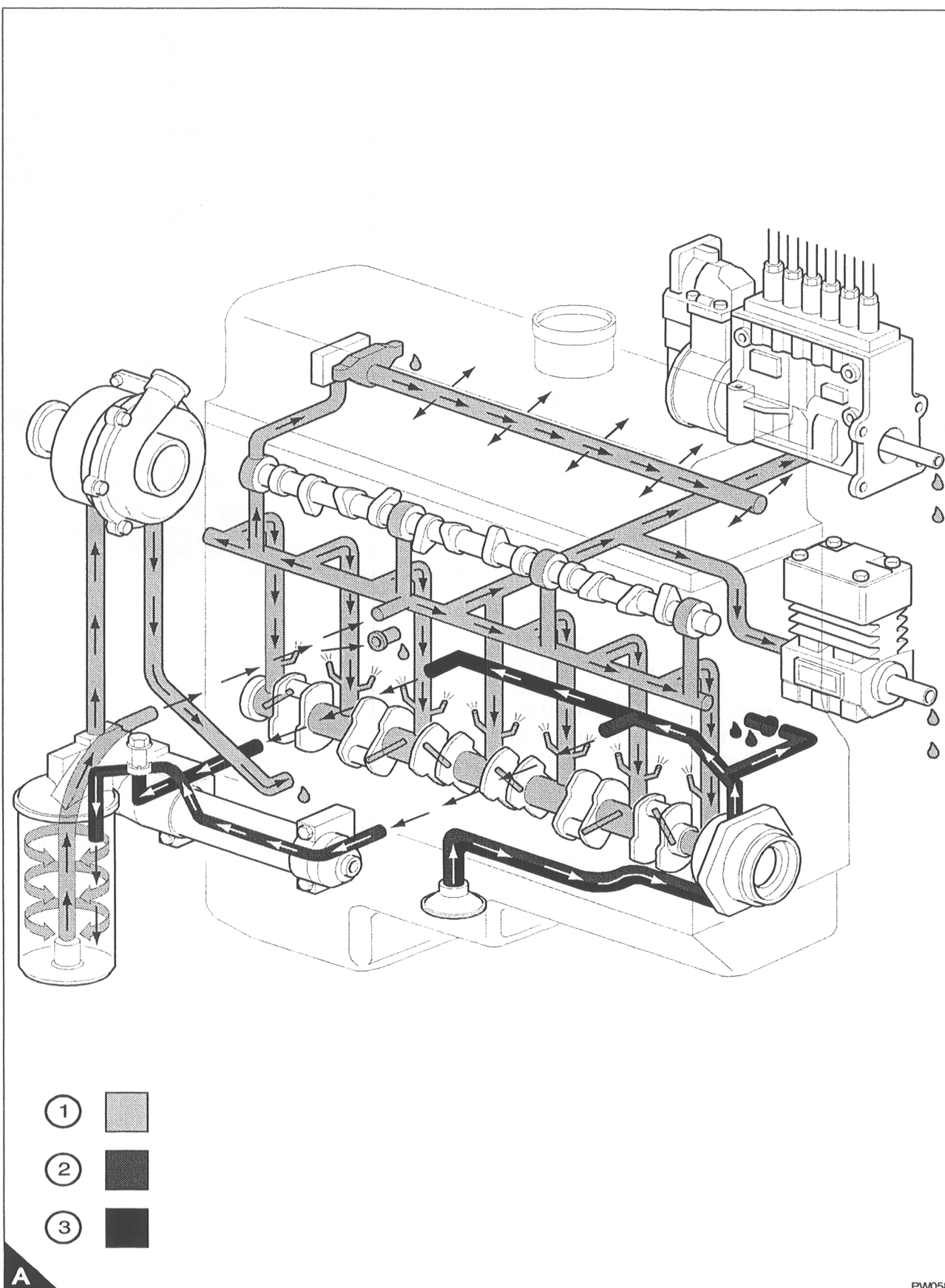
Lubricating oil from the rear journal of the crankshaft passes to the rear of the rocker shaft. The oil passes along the hollow rocker shaft to lubricate the rockers.

The turbocharger receives clean oil from the oil filter head, through a pipe. The oil passes through the bearing housing of the turbocharger and returns through a pipe to the crankcase, and then to the sump.

The fuel injection pump and the compressor, if fitted, receive oil from the common union connection fitted to the cylinder block. Lubricating oil from the main pressure rail passes through a drilled hole to the union, the oil then passes to the fuel injection pump and to the compressor. Lubricating oil from the fuel injection pump and the compressor returns to the sump.



1 Filtered oil 2 Hot oil 3 Cold oil



PW058



19A LUBRICATION SYSTEM

Filter canister

To renew the canister
of the lubricating oil filter

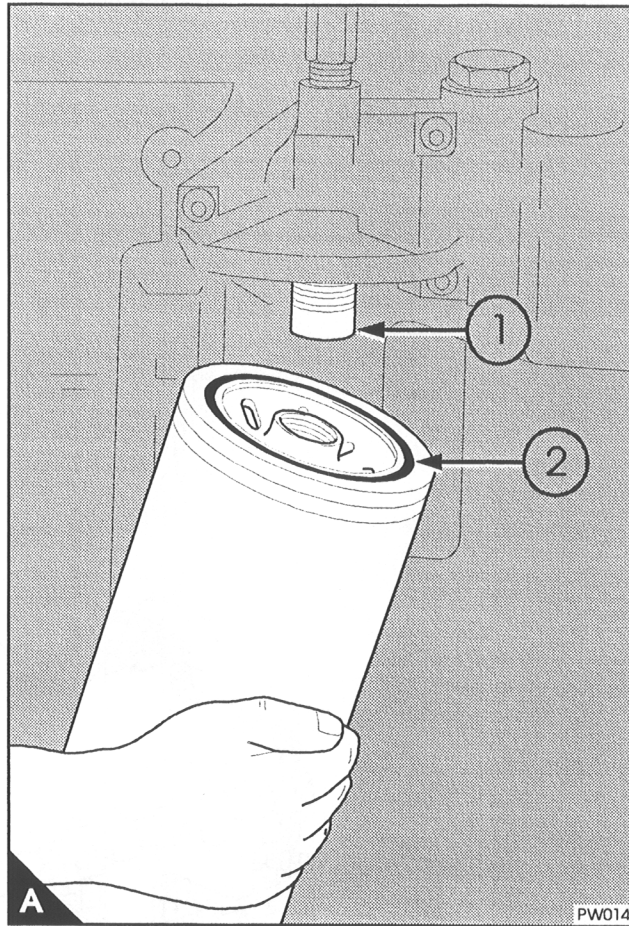
19A-01

Warning! Discard the used canister and lubricating oil in a safe place and in accordance with local regulations.

Caution: Ensure that the application is on a level surface to ensure an accurate reading on the dipstick.

- 1 Operate the engine before the oil filter is removed. This ensures that oil is in the bearing housing of the turbocharger.
- 2 Put a tray under the filter to retain lubricating oil.
- 3 Clean thoroughly the outside surfaces of the filter assembly.
- 4 Use a strap wrench or similar tool to loosen the filter canister. Remove and discard the canister. Ensure that the adaptor (A1) is secure in the filter head.
- 5 Clean inside the filter head.
- 6 Lubricate the seal (A2) on top of the canister with clean engine lubricating oil.
- 7 Fit the new canister and tighten it by hand until the seal contacts the filter head. Tighten the canister a further 1/2 to 3/4 of a turn by hand only. Do not use a strap wrench.
- 8 Ensure that there is lubricating oil in the sump.
- 9 Ensure that the engine will not start and operate the starter motor until oil pressure is obtained. To ensure that the engine will not start, either put the manual stop control in the "stop" position or disconnect the electrical stop control of the fuel injection pump. Oil pressure is indicated when the warning light is extinguished or by a reading on the gauge.
- 10 Start the engine and check for leakage from the filter.
- 11 Stop the engine. After 15 minutes check the oil level on the dipstick and, if necessary, put more lubricating oil into the sump.

Caution: Do not fill the sump past the "FULL" mark on the dipstick.





Filter head and oil cooler assembly

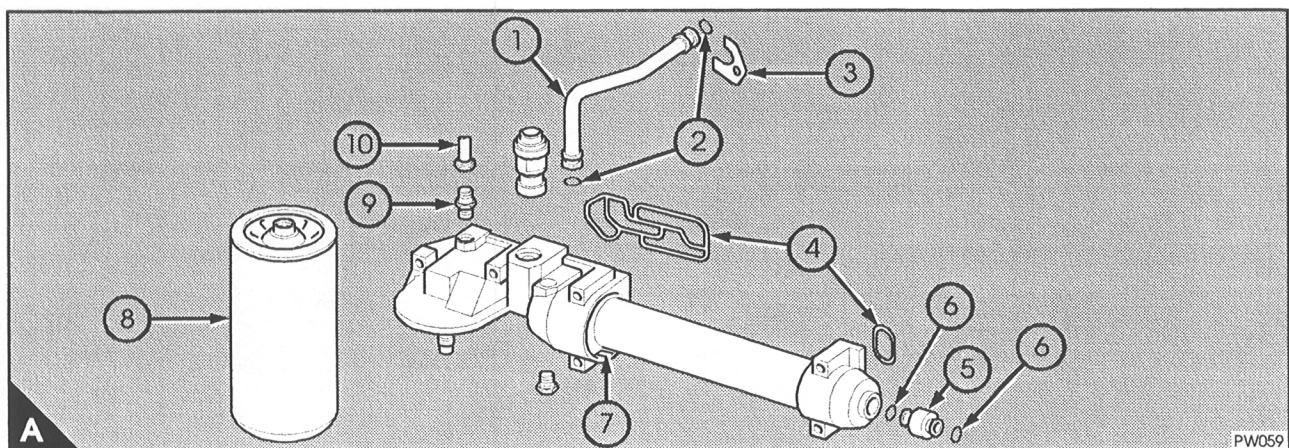
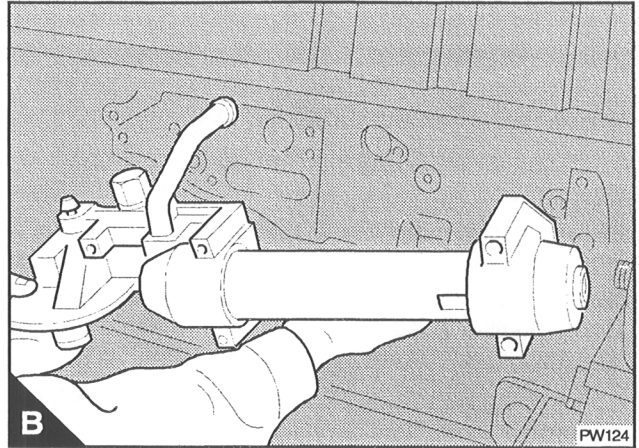
Note: The casting for the oil filter head includes the rear end-casing for the oil cooler and houses the oil temperature / pressure control valve. The filter head and the oil cooler are an assembly.

To remove and to fit

19A-02

To remove

- 1 Drain the lubricating system.
- 2 Drain the cooling system.
- 3 Remove the lubricating oil canister (A8), see operation 19A-01.
- 4 Disconnect the oil supply pipe (A10) for the turbocharger.
- 5 Remove the setscrew from the clamp (A3) to the cylinder block for the coolant inlet pipe (A1).
- 6 Release the setscrews and remove the filter head and oil cooler assembly (B7) from the cylinder block.
- 7 Discard the joints (A4) from the filter head and discard the 'O' rings (A2) from the coolant inlet pipe.
- 8 Remove the coolant outlet pipe and discard the 'O' rings (A6) from the coolant outlet pipe (A5).

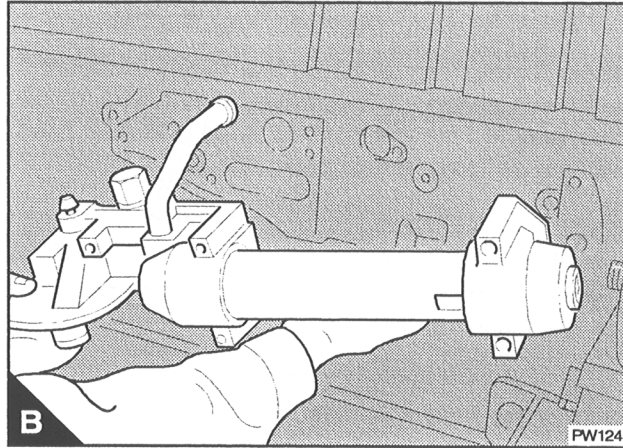




19A LUBRICATION SYSTEM

To fit

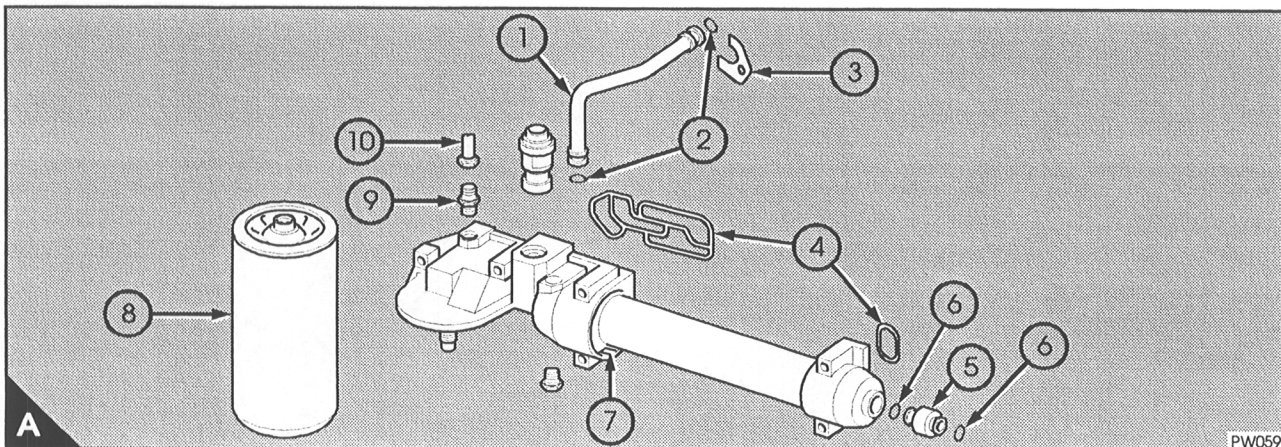
- 1 Clean the filter head and oil cooler assembly (A7), the joint face on the cylinder block, the coolant inlet pipe (A1) and coolant outlet pipe (A5).
- 2 Fit new joints (A4) to the filter head and fit new 'O' rings (A2 and A6) to the coolant inlet and outlet pipes.
- 3 Put the filter head and oil cooler assembly (B) in position on the cylinder block. Ensure that the coolant inlet pipe is correctly engaged in the cylinder block and in the filter head. Fit and tighten the setscrews for the filter head/oil cooler assembly.
- 4 Fit and tighten the setscrew for the clamp (A3) of the coolant inlet pipe.
- 5 Clean the thread of the union connection (A9) for the turbocharger pipe (A10) in the filter head and apply a thread sealant. Use a separate spanner to hold the union connection on the the oil filter head while the union nut on the pipe is tightened.
- 6 Fit a new oil filter canister (A8), see [operation 19A-01](#).
- 7 Fill the cooling system to the correct level.
- 8 Fill the sump to the correct level with lubricating oil of an approved grade.



To inspect

19A-03

- 1 Visually inspect the filter head and oil cooler assembly for damage and for signs of leakage of coolant or lubricating oil. If there is a leakage from the oil cooler it must be renewed.
- 2 Inspect the joint and seal faces for damage.
- 3 Remove the oil temperature/ pressure control valve and inspect it for damage.
- 4 Fit the valve and tighten it to 13,5 Nm (10 lbf ft) 1,3 kgf m.



Note: The oil temperature control valve is fitted into the top of the filter head/ oil cooler assembly.

To remove and to fit **19A-04**

To remove

- 1 Drain the lubricating oil.
- 2 Remove the oil temperature control valve and discard the "O" ring.

To fit

- 1** Fit a new "O" ring to the valve.
- 2** Fit the oil temperature/ pressure control valve and tighten to 13,5 Nm (10 lbf ft) 1,3 kgf m.
- 3** Fill the lubricating oil system to the correct level with an approved oil.

To test **19A-05**

- 1 Hang the valve in a suitable container filled with lubricating oil.
- 2 Heat the oil gradually. Use a thermometer to check the temperature at which the valve starts to open and at which it is fully open. The correct temperatures are given in data and dimensions.



19A LUBRICATION SYSTEM

Pressure regulating valve

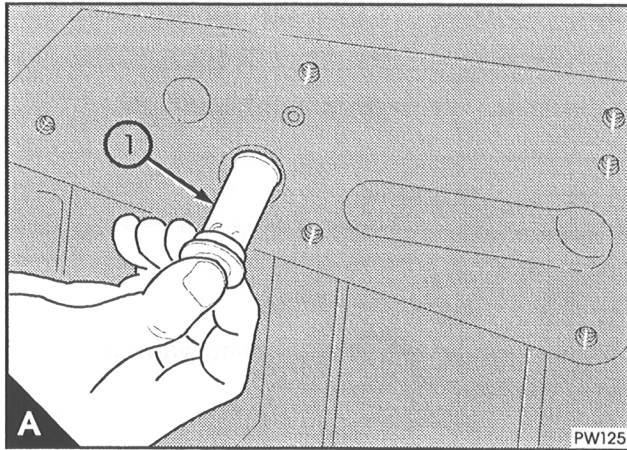
Note: The pressure regulating valve (A1) operates at 345 kpa (50 lbf/in²) and is fitted into the crankcase, behind the oil filter head.

To remove and to fit

19A-06

To remove

- 1 Remove the filter head and oil cooler assembly, see [operation 19A-02](#).
- 2 Push the pressure regulating valve open and insert a piece of copper wire into the valve. Use the copper wire to pull the valve from the crankcase.



To fit

- 1 Clean the filter head and cooler assembly, the joint face on the cylinder block and the coolant inlet and outlet pipes.
- 2 Fit the pressure regulating valve into position in the crankcase.
- 3 Fit the filter head and oil cooler assembly, see [operation 19A-02](#).

To inspect

19A-07

- 1 Visually inspect the valve assembly for damage.
- 2 Remove the circlip and the valve spring from the valve body.
- 3 Measure the free length of the valve springs and compare it with data and dimensions.
- 4 Measure the spring under a load of 107 N (24.1 lbf) and compare it with data and dimensions.

Caution: If the pressure regulating valve is damaged or the spring measurements are incorrect then the pressure regulating valve must be renewed.



Sump

Note: There are two arrangements to retain and seal the sump.

- Arrangement one (A): a sump with a joint and two metal strips to reduce the load applied by the setscrews. Fitted at the factory since engine serial number 875523.
- Arrangement two (B): a sump sealed with Hylosil instead of a joint. Fitted at the factory to engines with a serial number of 875522 or less.

Caution: Do not fit the joint from arrangement one to the sump of arrangement two. The ribbed flange of the sump could cause a failure of the joint and result in a leakage of engine lubricating oil.

To remove and to fit

19A-08

Consumable products:

POWERPART Silicon rubber sealant

Arrangement one

To remove

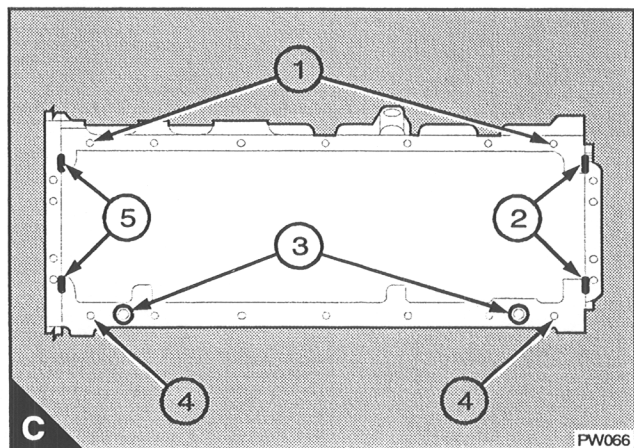
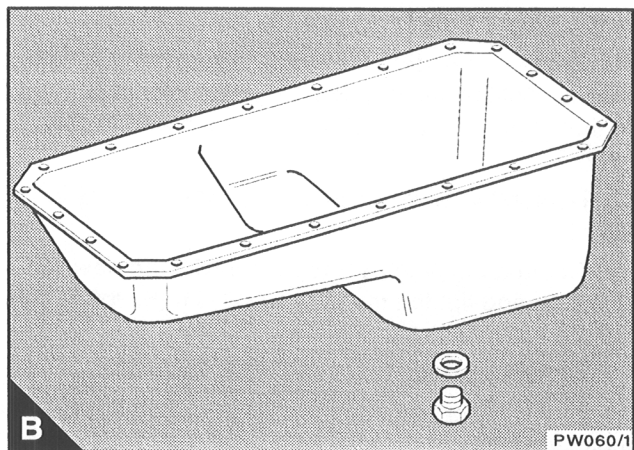
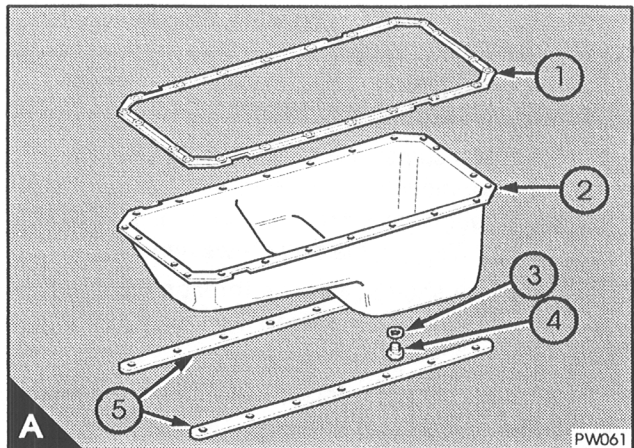
- 1 Operate the engine until it is warm.
- 2 Stop the engine.
- 3 Remove the sump drain plug (A4) and discard its "O" ring (A3). Drain the lubricating oil from the sump.
- 4 Remove the dipstick and dipstick tube.
- 5 Provide a support for the sump (A2).
- 6 Remove the 22 setscrews which fasten the sump to the cylinder block, and remove the metal strips.
- 7 Lower the sump (A5).
- 8 Remove the joint (A1).

To fit

- 1 Clean the flange face of cylinder block.
- 2 Install the four guide dowels, that have been manufactured locally, into the four corners (C1 and C4) of the cylinder block face.
- 3 Apply beads of POWERPART Silicon rubber sealant 6 mm (0.25 in) wide, as shown in (C), to:
 - the timing case (C5)
 - the rear oil seal housing (C2)
 - around the cup-plugs (C3).

Caution: Do not apply the sealant more than five minutes before the sump is to be fitted to the engine.

Continued





19A LUBRICATION SYSTEM

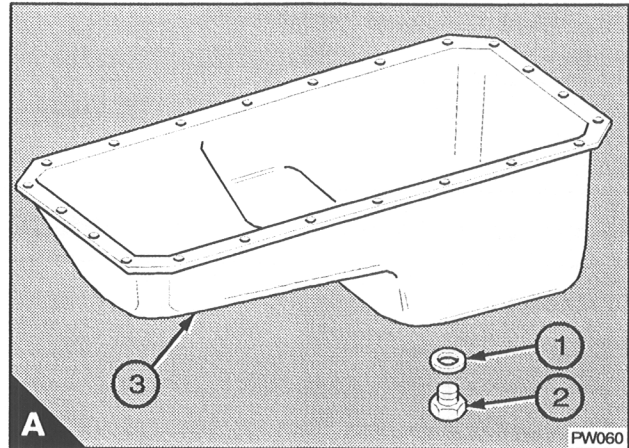
- 4** Put the joint (A1) onto the sump, with the bead of sealant toward the cylinder block.
- 5** Put the sump and the joint in position over the guide dowels, support the sump.
- 6** Put the metal strips (A5) in position against the sump. Fit 10 of the long setscrews through the metal strips and through the sump to secure them to the cylinder block. Tighten the setscrews finger tight.
- 7** Fit four of the short setscrews through the sump and into the timing case. Tighten the setscrews finger tight.
- 8** Fit the other four short setscrews through the sump and into the rear oil seal housing. Tighten the setscrews finger tight.
- 9** Remove the guide dowels.
- 10** Fit the remainder of the long setscrews through the metal strips and through the sump to secure them to the cylinder block. Tighten the setscrews finger tight.
- 11** Tighten the 22 setscrews to 23 Nm (17 lbf ft) 2,35 kgf m.
- 12** Fit the drain plug (A4) together with the new "O" ring (A3) and tighten the plug to 68 Nm (50 lbf ft) 7,0 kgf m.
- 13** Fit the dipstick tube, and fit the dipstick.
- 14** Fill the sump to the correct level with an approved lubricating oil.

**Arrangement two****To remove**

- 1 Operate the engine until it is warm.
- 2 Stop the engine.
- 3 Remove the sump drain plug (B2) and its "O" ring (B1) and drain the oil. Where necessary, remove the dipstick and the dipstick tube.
- 4 Provide a support for the sump (B3) and remove the setscrews which fasten the sump to the cylinder block.
- 5 Lower the sump.
- 6 Remove the Hylosil.

To fit

- 1 Wash the sump with an approved cleaning fluid, ensure that all the cleaning fluid is removed.
 - 2 Clean the flange face of the sump and the face of the cylinder block.
 - 3 Apply Hylosil to the flange face of the sump.
- Caution:** Do not apply Hylosil more than five minutes before the sump is to be fitted to the engine.
- 4 Fit the sump.
 - 5 Ensure correct location of the sump with a setscrew on each side. Fit the remainder of the setscrews and then tighten them to 18 Nm (13 lbf ft) 1,8 kgf m.
 - 6 Fit the drain plug (B2) together with a new "O" ring (B1) and tighten the plug to 68 Nm (50 lbf ft) 7,0 kgf m.
 - 7 Fit the dipstick tube and the dipstick, if removed earlier.
 - 8 Fill the sump to the correct level with an approved lubricating oil





19A LUBRICATION SYSTEM

Oil strainer and suction pipe

The oil strainer is an integral part of the suction pipe. No regular service is necessary, but wash the strainer when it is removed.

To remove and to fit

19A-09

To remove

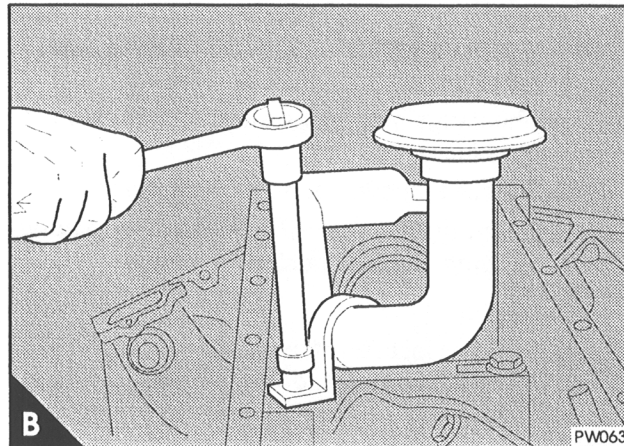
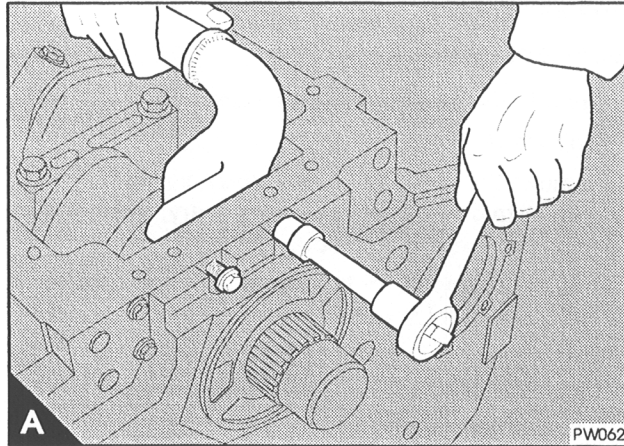
- 1 Drain the lubricating oil.
- 2 Remove the sump, see [operation 19A-08](#).
- 3 Release the setscrews from the flange (A) of the suction pipe.
- 4 Release the setscrew from the support bracket (B) of the suction pipe.
- 5 Remove the setscrews and remove the suction pipe and strainer assembly.
- 6 Remove the joint.

To fit

- 1 Clean the flange face of the suction pipe and the joint face of the crankcase.
- 2 Put the oil strainer and suction pipe, and its joint in position.
- 3 Fit and tighten the flange setscrews finger-tight.
- 4 Fit and tighten the setscrew for the support bracket finger-tight.
- 5 Tighten evenly and gradually all three setscrews to 19 Nm (13 lbf ft) 1,8 kgf m.

Caution: The setscrews of the suction pipe must be tightened evenly and gradually to prevent damage that can be caused by stress.

- 6 Fit the sump, see [operation 19A-08](#).
- 7 Fill the lubricating oil system to the correct level with an approved oil.





Lubricating oil pump

To remove and to fit

19A-10

Special tools:

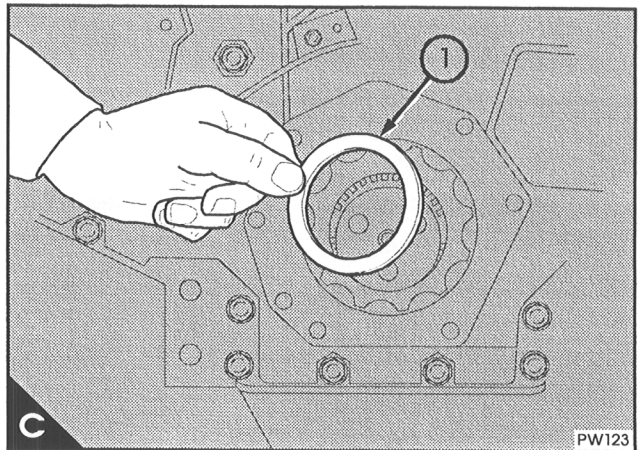
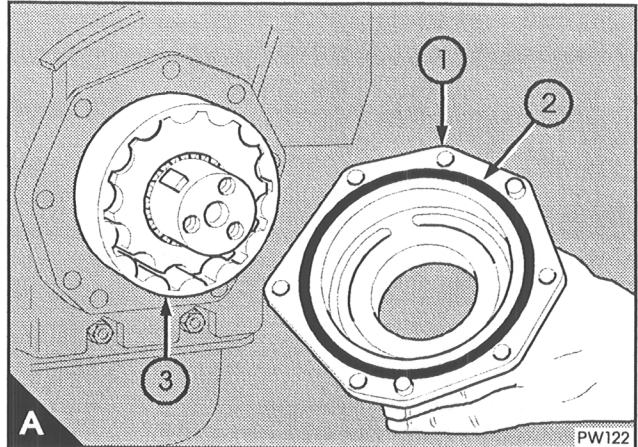
Front oil seal installer PD.170

Front oil seal installer adaptor PD.227

To remove

- 1 Drain the lubricating oil.
 - 2 Remove the crankshaft pulley and damper assembly, see [operation 14A-01](#).
 - 3 Remove and discard the front oil seal, see [operation 19A-12](#).
 - 4 Remove the six setscrews of the oil pump.
- Note:** There are short setscrews at the 2 o'clock and the 3 o'clock positions.
- 5 Remove the oil pump body (A1) and discard the 'O' ring (A2).
 - 6 Remove the outer rotor (A3).
 - 7 Remove the drive key (B1).
 - 8 Remove the oil deflector (C1).

Continued





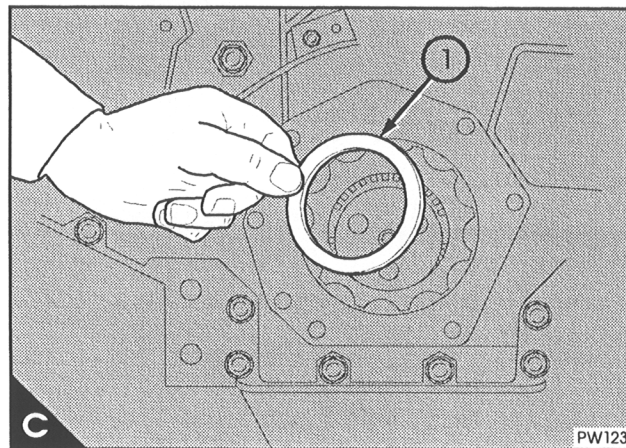
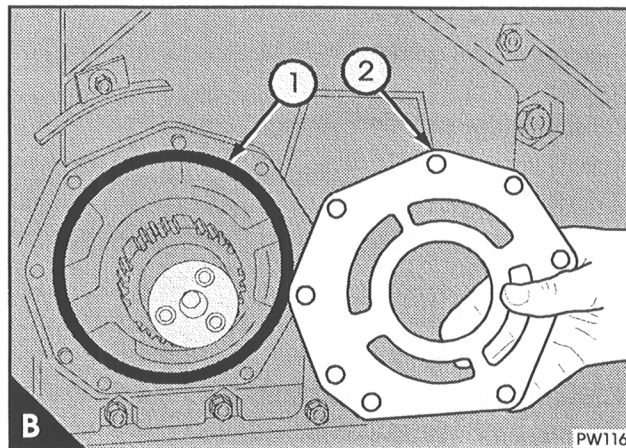
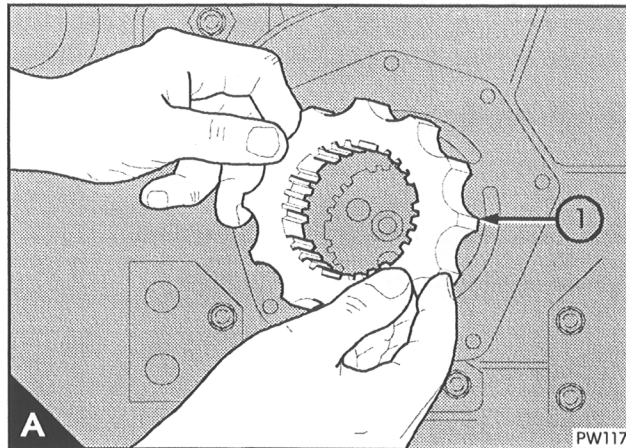
19A LUBRICATION SYSTEM

- 9 Remove the inner rotor (A1).
- 10 Remove the backplate (B2).
- 11 Remove and discard the 'O' ring (B1).

To fit

- 1 Clean the components of the lubricating oil pump and clean the face of the timing case cover.
- 2 Fit a new oil seal into the oil pump body, see [operation 19A-12](#).
- 3 Fit a new 'O' ring (B1) for the backplate into position in the timing case cover.
- 4 Lightly lubricate the backplate (B2) with clean engine lubricating oil. Put the backplate into position on the timing case cover.
- 5 Lightly lubricate the inner rotor (A1) with clean engine lubricating oil. Fit the inner rotor.
- 6 Lightly lubricate the oil deflector (C1) with clean engine lubricating oil. Fit the oil deflector into position on the crankshaft nose.

Note: Fit the oil deflector with the concave side to the inner rotor.





7 Carefully hammer the drive key (A1) into its recess in the crankshaft nose (A2).

8 Lightly lubricate the outer rotor (B3) with clean engine lubricating oil. Fit the outer rotor into the pump body (B2).

9 Fit a new 'O' ring (C1) into its recess in the pump body.

10 Lubricate the main lip of the front oil seal with clean engine lubricating oil. The lubrication of the seal is necessary to prevent damage to the seal when the engine is first started.

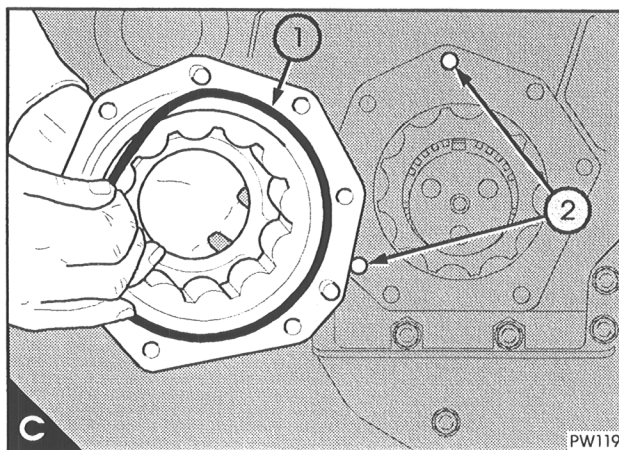
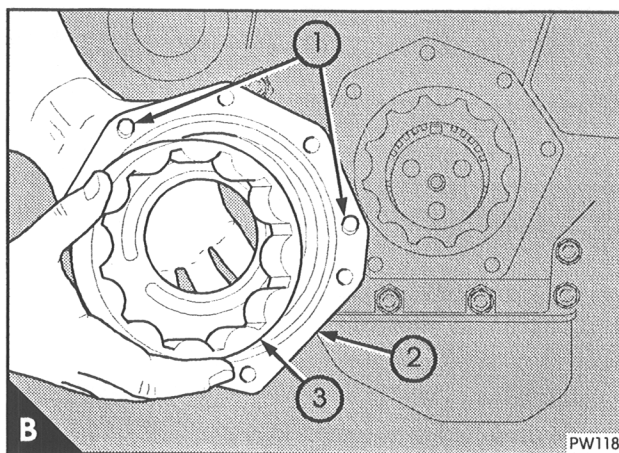
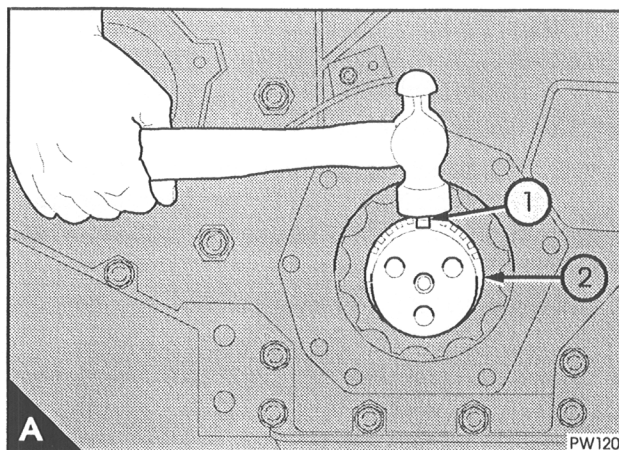
11 Fit the pump body, ensure that the outer rotor is in mesh with the inner rotor. Ensure that the dowel pins (B1) in the oil pump body engage with the holes (C2) in the timing case cover.

12 Fit and tighten the setscrews.

Caution: Fit a short setscrew at the 2 o'clock and the 3 o'clock positions.

13 Fit the pulley and damper assembly, see [operation 14A-01](#).

14 Fill the lubricating system to the correct level with an approved lubricating oil.



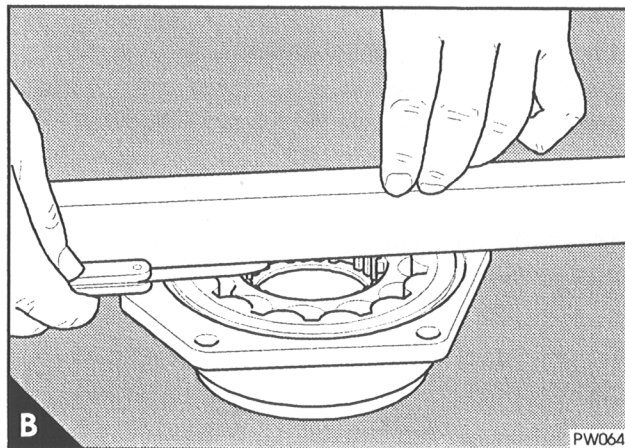
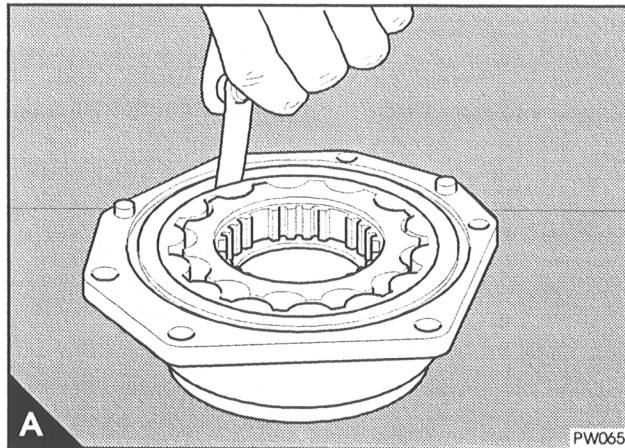


19A LUBRICATION SYSTEM

To inspect

19A-11

- 1 Remove the lubricating oil pump, [operation 19A-10](#).
- 2 Clean all the components of the oil pump.
- 3 Visually inspect the components for damage and wear. If either the inner rotor or the outer rotor are damaged or worn they must both be renewed as a unit.
- 4 Put the outer rotor and the inner rotor into the pump body.
- 5 Check the outer rotor to body clearance (A), see data and dimensions.
- 6 Check the inner rotor end-float (B), see data and dimensions.
- 7 Fit the lubricating oil pump, see [operation 19A-10](#)





Front oil seal

The front oil seal is fitted into the front of the oil pump housing.

To renew **19A-12**

Special tools:

Crank front oil seal replacer PD 170.

Front oil seal installer adaptor PD 227.

-
- 1** Remove the pulley and damper assembly, see [operation 14A-01](#).
 - 2** Remove the oil seal with a suitable lever behind the main lip of the oil seal. Do not damage the edge of the oil pump housing or the crankshaft nose.
 - 3** Remove the lubricating oil pump, see [operation 19A-10](#).
 - 4** Use tools PD.170 and PD.227 and press a new oil seal into the oil pump housing until it is level with the front of the housing.
 - 5** Fit the lubricating oil pump to the engine, see [operation 19A-10](#).
 - 6** Fit the pulley and damper assembly, see [operation 14A-01](#).
 - 7** Fill the lubricating system to the correct level with an approved lubricating oil.



19A LUBRICATION SYSTEM

Pressure relief valve

The pressure relief valve (15A.02/A2) operates at 552 kPa (80 lbf/in²) and is fitted into the crankcase, inside the timing case.

To remove and to fit **19A-13**

To remove

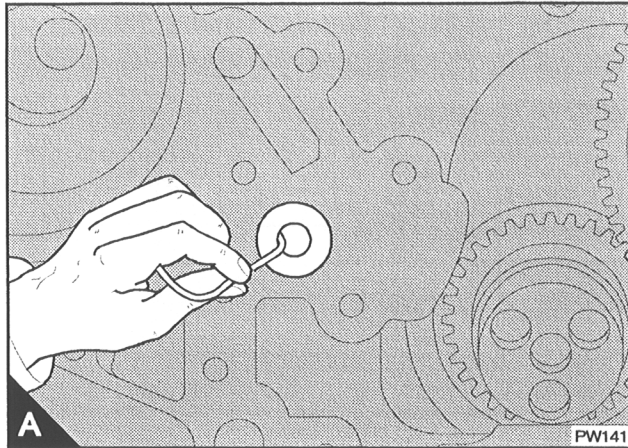
- 1 Remove the timing case cover, see operation 15A-01.
- 2 Push the pressure relief valve open and insert a piece of copper wire into the valve. Use the copper wire to pull the valve from the crankcase.

To fit

- 1 Clean the joint faces of the timing case cover.
- 2 Fit the pressure relief valve into position in the crankcase.
- 3 Fit the timing case cover, see operation 15A-01.

To inspect **19A-14**

- 1 Visually inspect the valve assembly for damage.
- 2 Remove the circlip and the valve spring from the valve body.
- 3 Measure the free length of the valve springs and compare it with data and dimensions.
- 4 Measure the spring under a load of 16,6 N (36.5 lbf) +/- 5% and compare it with data and dimensions. If the pressure relief valve is damaged or the spring measurements are incorrect, then the pressure relief valve must be renewed.





Breather system

All New Generation Peregrine and 1300 series engines have open breather systems. A breather element is fitted in a baffle assembly inside the rocker cover assembly. The breather element separates lubricating oil from the crankcase gases. The oil is kept inside the rocker cover and the crankcase gases pass through the breather element into an open breather pipe.

If the breather element is to be renewed, see operation 12A-01 for special instructions to remove and to fit the rocker cover.

To clean	19A-15
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Warning! Do not direct compressed air at your skin.

- 1 Remove the rocker cover, see operation 12A-01.
- 2 Remove the breather element from the baffle plate. Wash the breather element and the breather pipe with an approved cleaning fluid and dry it with low pressure air.
- 3 Clean the baffle plate and clean inside the rocker cover.



19A LUBRICATION SYSTEM

Data and dimensions

Note: 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 the factory. The information applies to all engines, unless an engine type code is shown.

Lubrication system

Pressure:

- at idle and normal engine temperature 104 kPa (15 lbf/in²)
- at maximum engine speed and normal engine temperature 345/497 kPa (50/72 lbf/in²)

Lubricating oil pump

- Type Differential rotor, the inner rotor fits into splines on the crankshaft nose.
- Radial clearance of outer rotor to body 0,662/0,470 mm (0.0245/0.0185 in)
- End float outer rotor to body 0,114/0,470 mm (0.0048/0.0020 in)
- End float of inner rotor to body 0,114/0,470 mm (0.0048/0.0020 in)

Oil pressure regulator valve

- Operating pressure 345 kPa (50 lbf/in²) 3,51 kgf/cm²
- Position In the crankcase between the oil cooler and the crankcase
- Valve spring:
- Diameter 15,24 mm (0,600 in)
 - Free length 65,76 mm (2.589 in)
 - Load 107 N (24.1 lbf) 11,0 kgf +/- 5%
 - Length under load 39,24 mm (1.545 in)

Oil pressure relief valve

- Operating pressure 552 kPa (80 lbf/in²) 5,6 kgf/cm²
- Position In the crankcase inside the timing case
- Valve spring:
- Diameter 15,24 mm (0,600 in)
 - Free length 59,9 mm (2.36 in)
 - Load 162 N (36.5 lbf) 16,6 kgf +/- 5%
 - Length under load 39,24 mm (1.545 in)

Oil filter

- Type Cannister
- By-pass valve Fitted inside the filter

Oil temperature/pressure control valve:

- Operating temperature range -54.4/148.9°C (-65/300°F)
- Valve closes at 104,4/115,6°C (235/240°F)
- Valve opens at 103,4/173,4 kPa (15/25 lbf/in²) 6,8/11,4 kgf/cm²
- at a temperature of 121,1°C (250°F)
- Valve movement from closed to open (minimum) 9,53 mm (0.375 in)



Fuel system

20A

General description 20A.02

Fuel filter

20A-01 To renew the fuel strainer and the canister of the fuel filter 20A.04
20A-02 To renew an atomiser 20A.05

Fuel lift pump

20A-03 To remove and to fit 20A.06
20A-04 To dismantle and assemble 20A.07

Fuel injection pump

20A-05 To remove and to fit 20A.08
20A-06 To set the adjustment of the speed control 20A.10
20A-07 To eliminate air from the fuel system 20A.11
To check and set the timing of the fuel injection pump refer to 17A.06
To find the setting for timing the fuel injection pump refer to 17A.07

Data and dimensions 20A.12



Fuel system

General description

Caution: *It is very important that dirt does not enter the fuel system. Before a connection is disconnected, clean thoroughly the area around the connection. After the component has been disconnected, fit a suitable cover to all open connections.*

All New Generation Peregrine and 1300 Series engines have Bosch in-line fuel injection pumps with a mechanical governor and a boost control device. The mechanical governor is fitted to control the engine speed. The boost control is a device which is affected by boost pressure (from the turbocharger) and reduces the maximum fuel delivery at lower engine speeds to match the reduced air supply to the cylinders.

An electrical stop solenoid is fitted to the fuel injection pump on some applications.

The atomisers are set at the factory, but they must be checked in accordance with the preventive maintenance schedules. Refer to the User's Handbook for the correct service intervals.

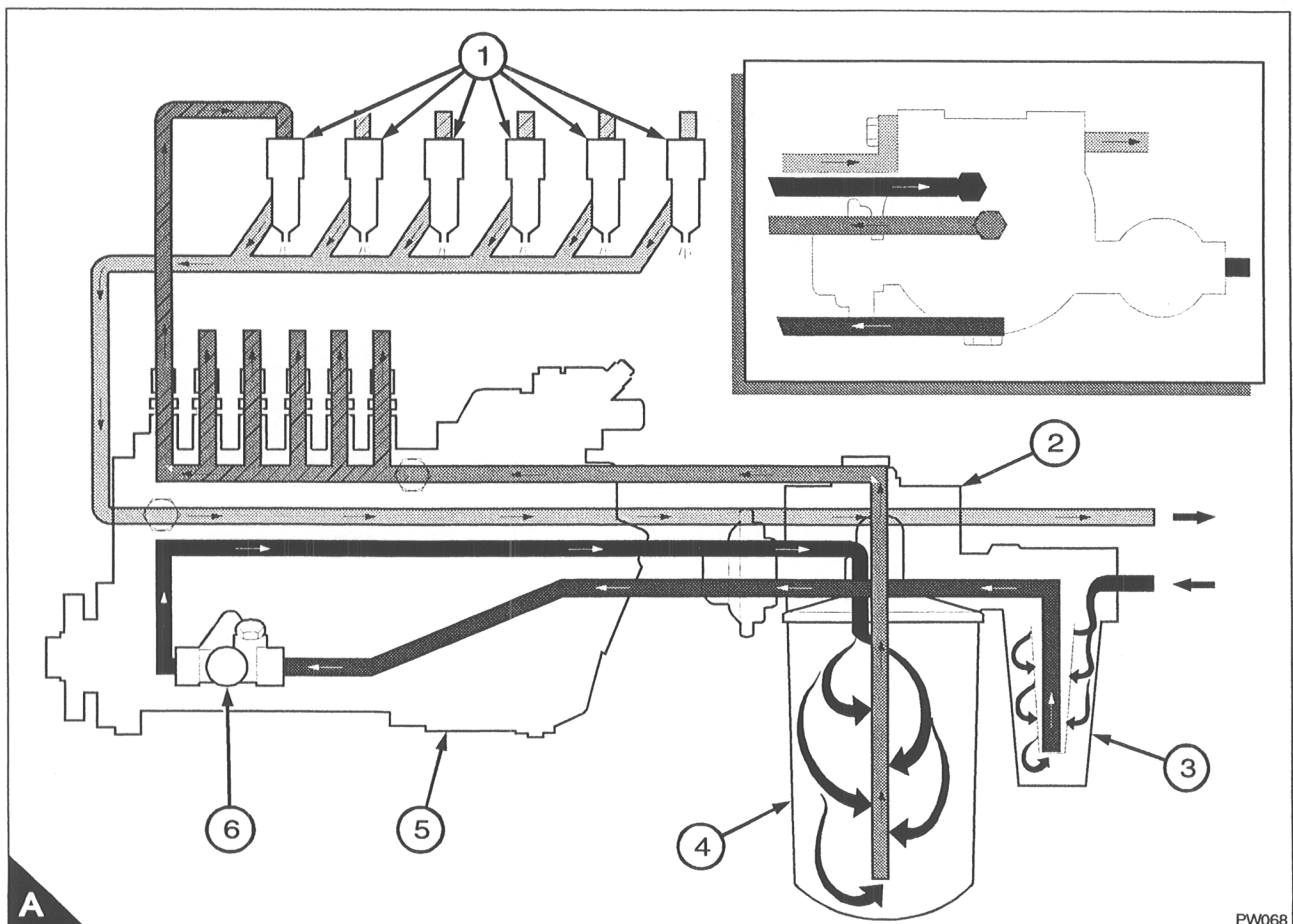
The fuel injection equipment must only be checked and adjusted by personnel who have had the correct training.

The fuel lift pump is of the plunger type and is mechanically driven. It is fitted to the left hand side of the fuel injection pump and is driven by an eccentric on the pump camshaft.

The casting for the fuel filter head includes the fuel strainer and the fuel priming pump. The fuel filter is of the removable canister type.



Fuel from the tank normally passes through a pre-filter and a pipe to the fuel strainer (A3). The fuel passes from the strainer, through a drilling in the filter head (A2), then through a pipe to the lift pump (A6). From the lift pump fuel passes, under pressure, through a pipe and through the filter head to the filter canister (A4). Clean fuel leaves the filter canister and returns to the filter head, then passes through a pipe to the fuel injection pump (A5). The fuel injection pump increases the pressure of the fuel before it passes through high pressure pipes at the correct time, to the atomisers (A1). Surplus fuel from the injectors returns to the filter head through the leak-off pipes, then to the fuel tank through a pipe.



PW068



20A FUEL SYSTEM

Fuel filter

Fuel pre-filter

This will normally be fitted between the fuel tank and the engine. Check the filter bowl for water at regular intervals and drain as necessary. Refer to the User's Handbook for the correct service intervals.

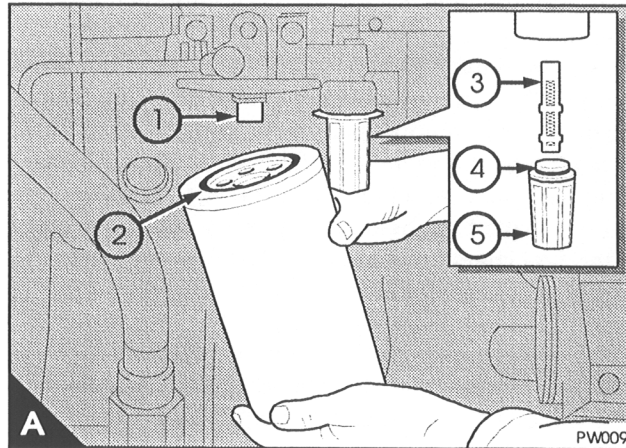
To renew the fuel strainer and the canister of the fuel filter

20A-01

Note: The fuel filter assembly has a fuel strainer to remove the larger particles from the fuel and a filter canister to remove the smaller particles. The fuel strainer and the filter canister should be renewed at the same time.

- 1 Thoroughly clean the outside surfaces of the fuel filter assembly.
 - 2 Use a strap wrench or similar tool to loosen the filter canister, and remove the canister.
 - 3 Use a 29 mm (1.1/8 in) socket spanner to remove the plastic cover (A5) from the fuel strainer. Remove the strainer (A3) and the 'O' ring (A4) from the the cover.
 - 4 Fit a new strainer and a new 'O' ring to the cover and fit the cover to the filter head.
- Caution:** Ensure that the open end of the new strainer is toward the filter head.
- 5 Ensure that the threaded adaptor (A1) is secure in the filter head and that the inside of the head is clean. Lubricate lightly the seal (A2) of the new canister with clean diesel fuel. Fit the new canister to the filter head and tighten the canister by hand until the seal contacts the filter head. Tighten the canister a further 1/2 turn by hand only. Do not use a strap wrench.
 - 6 Eliminate the air from the fuel filter, see [operation 20A-08](#).

Caution: It is important that only the genuine Perkins parts are used. The use of wrong parts could damage the fuel injection pump.





Atomiser fault

Warning! Ensure that the fuel does not spray onto your skin.

Note: An atomiser fault can cause an engine misfire.

In order to find which atomiser is defective, operate the engine at a fast idle speed. Loosen and tighten the union nut of the high-pressure fuel pipe at each atomiser. When the union nut of the defective atomiser is loosened, it has little or no effect on the engine speed.

To renew an atomiser

20A-02

- 1 Clean thoroughly the area around the atomiser to be removed.
- 2 Release the spring clips and remove the fuel leak-off pipe.
- 3 Remove the union nuts of the high-pressure pipe from the atomiser and from the fuel injection pump. Do not bend the pipe. If necessary, remove the pipe clamps.
- 4 Remove the setscrew (A5) of the atomiser clamp and remove the clamp (A4), the atomiser (A2) and its seat washer (A3). Remove the dust seal (A1) and fit a new dust seal onto the new atomiser.

Caution: Do not turn the atomiser from side to side during the removal of the atomiser as this action could loosen the atomiser sleeve in the cylinder head.

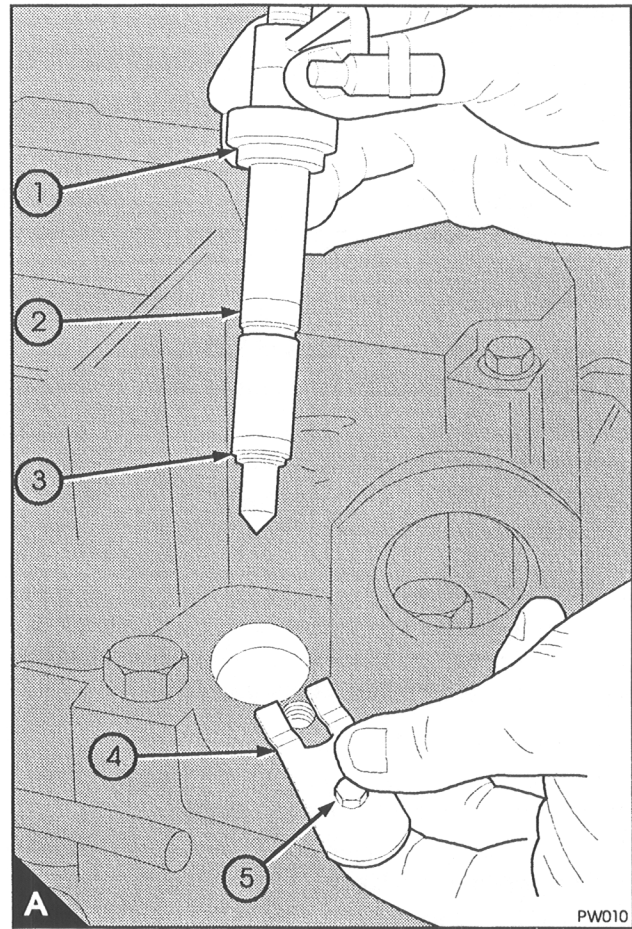
- 5 Put the new atomiser in position with its new dust seal and a new seat washer. Ensure that the fuel leak-off connection is not toward the engine. Fit the clamp and engage the clamp setscrew. Ensure that the atomiser is not tilted and tighten the setscrew to 26 Nm (19 lbf ft) 2,6 kgf m.

- 6 Fit the high-pressure fuel pipe and tighten the union nuts to 40 Nm (30 lbf ft) 4,0 kgf m. If necessary, fit the pipe clamps.

Caution: Do not tighten the nut of the high-pressure pipes more than the recommended torque tension. If there is leakage from the union nut, ensure that the pipe is correctly aligned with the atomiser inlet. If the leak continues, renew the pipe. Do not tighten the union nut more, as this can cause a restriction at the end of the pipe, this can affect the fuel delivery.

- 7 Push the leak off pipe onto the leak off connection and fit the spring clips.

- 8 Operate the engine and check for leakage of fuel and air.





20A FUEL SYSTEM

Fuel lift pump

Note: The fuel lift pump is fitted to the side of the fuel injection pump.

To remove and to fit

20A-03

To remove

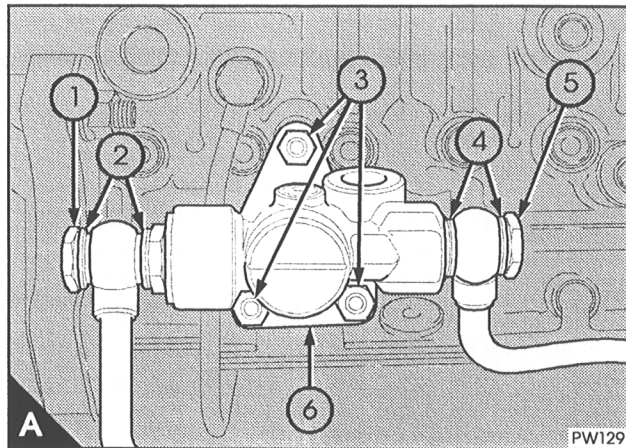
- 1 Remove the banjo bolts (A1 and A5) from the fuel lines and discard the washers (A2 and A4).
- 2 Release the nuts (A3) of the pump (A6) and remove the pump.
- 3 Remove and discard the joint.

To fit

- 1 Clean the joint face on the fuel lift pump and on the fuel injection pump.

Note: Ensure that the eccentric on the camshaft of the fuel injection pump is in the minimum lift position. If it is not, rotate the crankshaft until it is.

- 2 Fit a new joint to the lift pump.
- 3 Check that the push rod (B12) is in position and fit the lift pump to the fuel injection pump.
- 4 Fit and tighten the nuts (A3) gradually and evenly to 6 Nm (4 lbf ft) 0,6 kgf m.
- 5 Connect the fuel pipes to the fuel lift pump, fit new washers (A2 and A4) to the banjo bolts (A1 and A5).





To dismantle and assemble

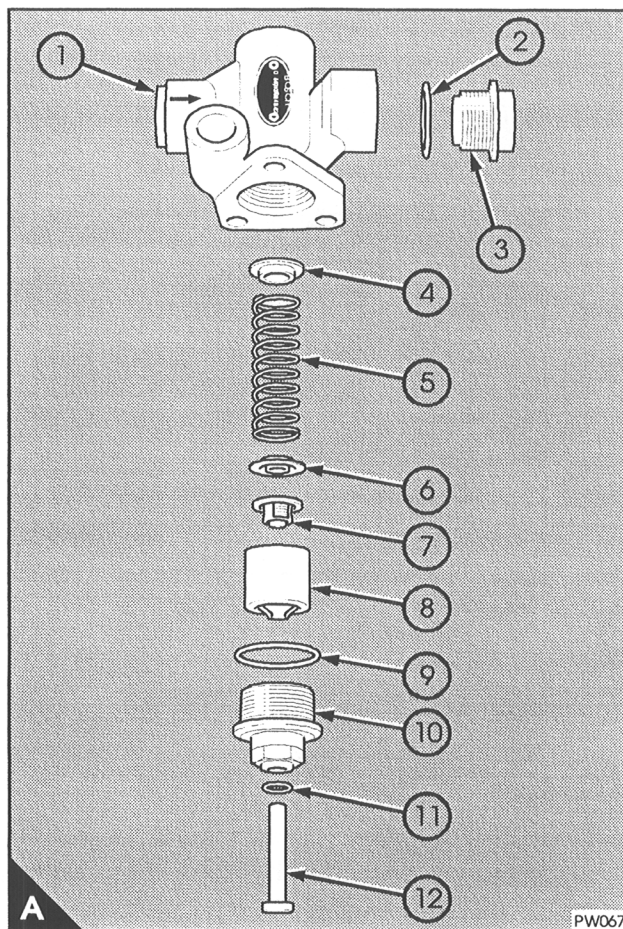
20A-04

To dismantle

- 1 Clean the outside surfaces of the fuel lift pump.
- 2 Remove the lift pump from the fuel injection pump, see [operation 20A-03](#).
- 3 Remove the push rod (A12).
- 4 Remove the end nut (A10).
- 5 Remove and discard the 'O' ring (A9) from the end nut.
- 6 Remove and discard the small 'O' ring (A11) from inside the end nut.
- 7 Remove the plunger (A8) the suction valve (A7) the spring seat washer (A6) the spring (A5) and the second spring seat washer (A4) from the pump body (A1).
- 8 Remove the delivery valve assembly (A3) from the body.
- 9 Remove and discard the 'O' ring (A2) from the delivery valve assembly.

To assemble

- 1 Thoroughly clean inside the body of the lift pump and ensure that the passages in the body are not restricted.
- 2 Carefully clean the valves in clean diesel fuel. Inspect each valve for damage to the valve spring and the valve plate. If there is damage, renew the valve.
- 3 Put a spring seat washer (A4) in position in the pump body (A1). Ensure that the flat face of the washer is toward the bottom of the body.
- 4 Put the spring (A5) on the spring seat washer and the other spring seat washer (A6) on the spring.
- 5 Put the suction valve (A7) in position on top of the valve seat washer. Ensure that the large diameter of the valve is toward the spring seat washer.
- 6 Put the plunger (A8) in position in the pump body over the valve and spring.
- 7 Renew the 'O' ring (A11) which fits inside the end nut (A10) and renew the 'O' ring (A9) on the outside of the end nut.
- 8 Support the pump body, put the end nut in position on the plunger. Compress the spring and engage the threads of the end nut with the threads in the pump body. Tighten the end nut to 42 Nm (31 lbf ft) 4,3 kgf m.
- 9 Put the push rod (A12) in position in the end nut.
- 10 Put a new 'O' ring (A2) on the delivery valve assembly (A3).
- 11 Fit the deliver valve assembly and tighten to 42 Nm (31 lbf ft) 4,3 kgf m.





20A FUEL SYSTEM

Fuel injection pump

Caution: Set the fuel injection pump to engine timing before the injection pump is removed from the engine.

Notes:

- To find, set and check the setting for timing the fuel injection pump, see [section 17A](#).
- The pump can be disconnected from its drive gear through an access cover in the timing case cover.
- There are no timing marks on the fuel pump gear. The centre hole in the group of three holes in the gear face must be at the 10 o'clock position, for correct timing of the pump.

To remove and to fit

20A-05

Special tools:

Timing pin PD.223.

Socket spanner for the union nuts PD.233.

To remove

1 Remove the access cover (A2) to the drive gear for the fuel injection pump, from the timing case cover.

2 Rotate the crankshaft clockwise, from the front of the engine, until the correct engine timing mark (A1) is aligned on the damper assembly (A6).

3 Visually check the position of the fuel injection pump gear through the access hole. The centre hole (A3) in the group of three holes in the gear face should be at the 10 o'clock position, approximately.

4 Insert the timing pin PD.223 (A5) through the centre hole in the group of three holes in the gear face. Fit and tighten the timing pin into the drive flange of the fuel injection pump until the pin enters the hole in the pump timing plate (A8).

5 Use tool PD.233 to remove the high-pressure pipes.

6 Remove the low pressure pipes, the lubricating oil pipe and the pipe for the boost control.

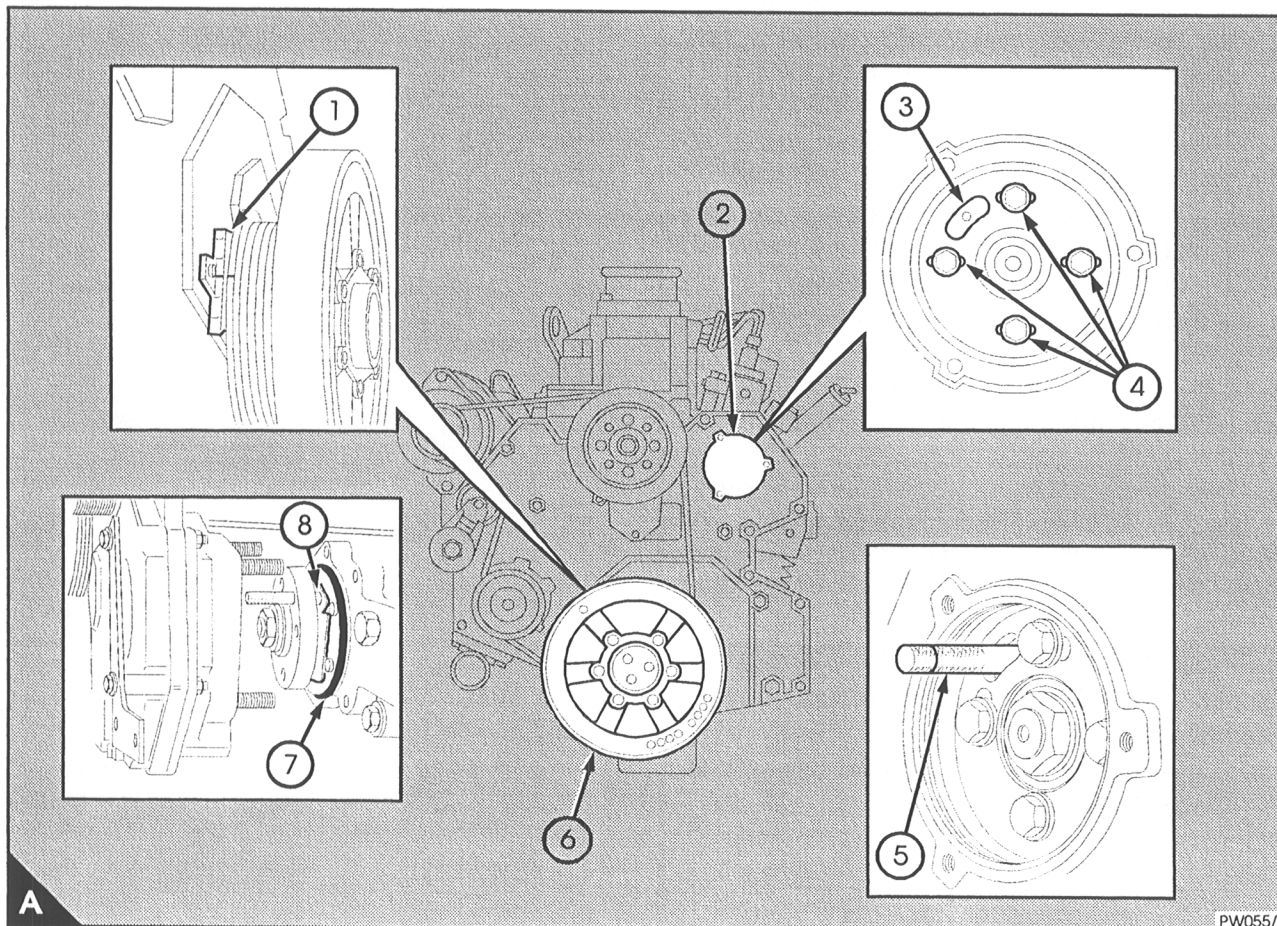
7 Disconnect the electrical cable for the stop control. If a manual stop control is fitted, disconnect the control cable.

8 Disconnect the engine speed control

9 Remove the return springs for the speed control.

10 Remove the setscrews (A4) of the drive gear.

Continued.





11 Remove the nuts which retain the fuel pump.

Caution: *Hold the fuel injection pump before the support bracket is removed. The pump will fall if it is not held.*

12 Loosen the setscrews which retain the pump support bracket to the cylinder block.

13 Loosen the nut and bolt of the bracket. Loosen the nut that retains the pump support bracket to the pump.

14 Remove the fasteners and remove the support bracket. Remove the fuel injection pump, remove and discard the 'O' ring (A7) from the pump flange.

Cautions:

- *If the crankshaft is rotated while the fuel injection pump is removed:*
- the engine will not be in the correct position to receive the fuel injection pump.
- the pump drive gear will damage the timing case. If the crankshaft must be rotated, the drive gear must be held away from the timing case.

To fit

1 Fit and tighten the timing pin PD.223 (A5) into the drive flange of the fuel injection pump until the pin enters the hole in the pump timing plate (A8).

2 Fit a new 'O' ring (A7) to the flange of the fuel injection pump.

3 Ensure that the centre hole (A3) in the group of three holes in the timing gear is at the 10 o'clock position. Fit and hold the pump onto its retaining studs. Ensure that the timing pin (A5) enters the centre hole (A3) in the group of three holes in the timing gear. Fit and tighten the nuts that retain the pump.

4 Lightly lubricate the threads and shoulders of the setscrews for the fuel injection pump gear with clean engine lubricating oil.

5 Align the drive gear to put the timing pin in the centre of its hole. Fit and tighten the setscrews (A4) to 51 Nm (38 lbf ft) 5,3 kgf m.

6 Put the support bracket in position and fit the fasteners finger-tight.

7 Tighten the setscrews which retain the bracket to the cylinder block to 115 Nm (85 lb ft) 11,9 kgf m. Tighten the nut which retains the bracket to the fuel injection pump to 115 Nm (85 lb ft) 11,9 kgf m. Tighten the nut and bolt of the bracket to 66 Nm (49 lb ft) 6,8 kgf m.

8 Remove the timing pin.

9 Lightly lubricate the threads and shoulders of the setscrews for the access cover with clean engine lubricating oil. Put a new 'O' ring onto the access cover (A2) and put the cover in position.

10 Fit and tighten the setscrews of the access cover to 7 Nm (5.5 lbf ft) 0,8 kgf m.

11 Use tool PD.233 to fit the high pressure pipes

12 Fit the low pressure pipes and the lubricating oil pipe.

13 Fit the pipe for the boost control to the valve cover and to the fuel injection pump, tighten the banjo bolt to 32 Nm (24 lbf ft) 4,5 kgf m.

14 Connect the stop control or the electrical cable.

15 Connect the engine speed control.

16 Fit the return springs for the speed control.

17 Eliminate air from the fuel system, see [operation 20A-08](#).

18 Set the adjustment of the speed control, see [operation 20A-07](#).



20A FUEL SYSTEM

To set the adjustment
of the speed control

20A-06

Idle speed.

- 1 Operate the engine until it reaches its normal temperature of operation and check the idle speed:
 - If the idle speed is too low; release the locknut (A2), turn the screw (A1) counter-clockwise until the correct speed is reached and, then tighten the locknut.
 - If the idle speed is too high; release the lucknut, turn the screw clockwise until the correct speed is reached, then tighten the locknut.

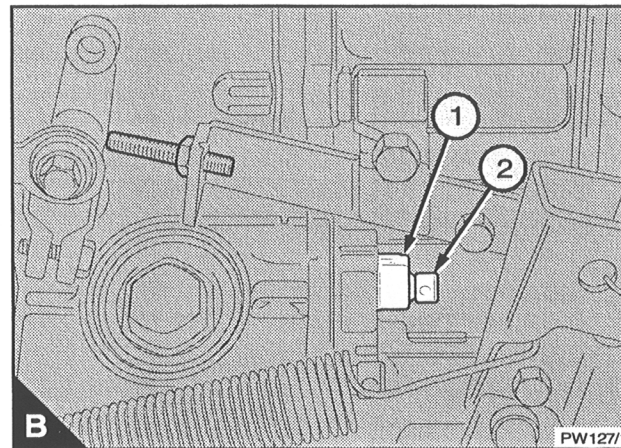
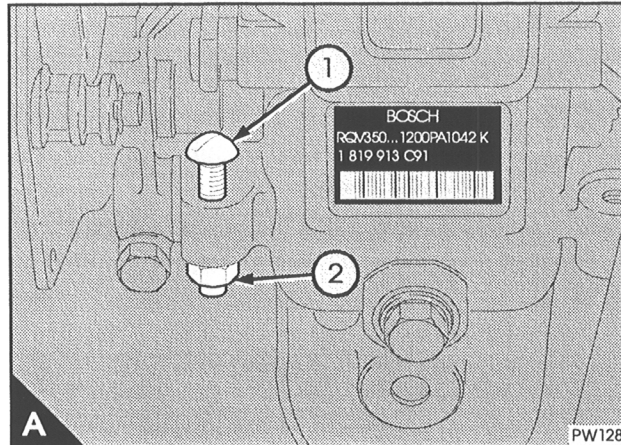
Note: The setting of the idle speed can change for different applications. The correct speed will normally be given in the manufacturer's handbook for the application. If it is not given, contact the Service Department of Perkins International Limited at Peterborough.

Caution: The person who fits the pump must ensure that the adjustment screw is suitably sealed against interference after it has been set initially. The adjustment screw on original fuel pumps is set and sealed by the manufacturer. The setting must not be changed as this could affect the engine warranty.

Maximum no load speed.

- 1 With the engine at its normal temperature of operation, check the maximum no load speed:
 - If the maximum no load speed is too low; release the lucknut (B1), turn the screw (B2) clockwise until the correct speed is reached, then tighten the locknut.
 - If the maximum no load speed speed is too high; release the lucknut, turn the screw, counter-clockwise until the correct speed is reached, then tighten the locknut and, seal the screw.

Note: The setting of the maximum no load speed can change for different applications. The correct speed will normally be given in the manufacturer's handbook for the application. If it is not given, contact the Service Department of Perkins International Limited at Peterborough.

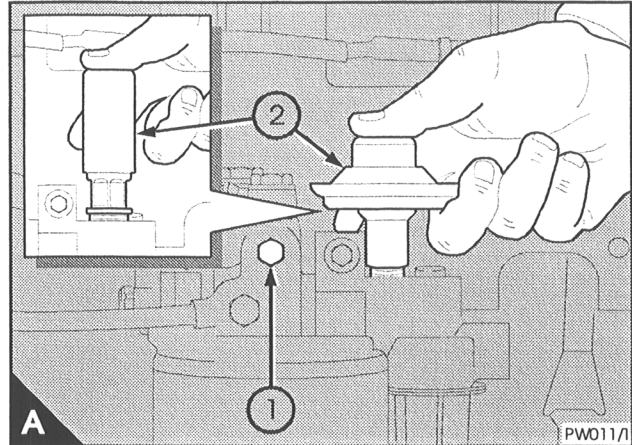




To eliminate air from the fuel system

20A-07

- 1 If air enters the fuel system, it must be eliminated before the engine can be started.
 - 2 Air can enter the system if:
 - The fuel tank is drained during normal operation.
 - The low-pressure fuel pipes are disconnected.
 - A part of the low-pressure fuel system leaks during engine operation.
 - 3 In order to eliminate air from the fuel system, proceed as follows:
 - 4 Loosen the vent plug on the top of the fuel filter head (A1).
 - 5 Operate the plunger of the fuel priming pump (A2) until fuel, free from air, comes from the filter vent point. Tighten the vent plug.
- Note:** The fuel priming pump is fitted either on the top or on the left hand side of the fuel filter head, and may be the plunger type or the diaphragm type.
- 6 Ensure that the manual stop control is in the "run" position. If an electrical stop control is used, turn the start key to the "ON" position.
 - 7 Operate the starter motor for intervals of 15 seconds until the engine starts. If the engine runs correctly for a short time and then stops or runs roughly, check for air in the fuel system. If there is air in the fuel system, there is probably a leakage in the low pressure system. Stop the engine and turn the start key to the "OFF" position. Rectify the leakage and repeat the procedure.





Data and dimensions

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 the factory. The information applies to all engines, unless an engine type code is shown.

Fuel injection pump

Type Bosch P3000 or Bosch P7100, in-line
Drive.....Forged steel gear
Number 1 outlet The outlet nearest to the front of the engine
Direction of pump rotation.....Clockwise from the drive end of the pump
Static timing See static timing chart on page 17A.08

Fuel filter

Type Canister and strainer

Atomisers

Type Multi hole
Opening pressure 24820/25855 kPa (3600/3750 lbs/in²)
Opening pressure service limit..... 20000 kPa (2900 lbs/in²)



Cooling system **21A**

General description 21A.02

21A-01 To renew the canister of the coolant filter/ inhibitor 21A.04

Thermostat

21A-02 To remove and to fit 21A.05

21A-03 To test 21A.05

Water pump

21A-04 To remove and to fit 21A.06

Fan

21A-05 To remove and to fit 21A.07

Fan drive

21A-06 To remove and to fit 21A.07

Fan drive belt

21A-07 To remove and to fit 21A.08

Data and dimensions 21A.09



21A COOLING SYSTEM

Cooling system

General description

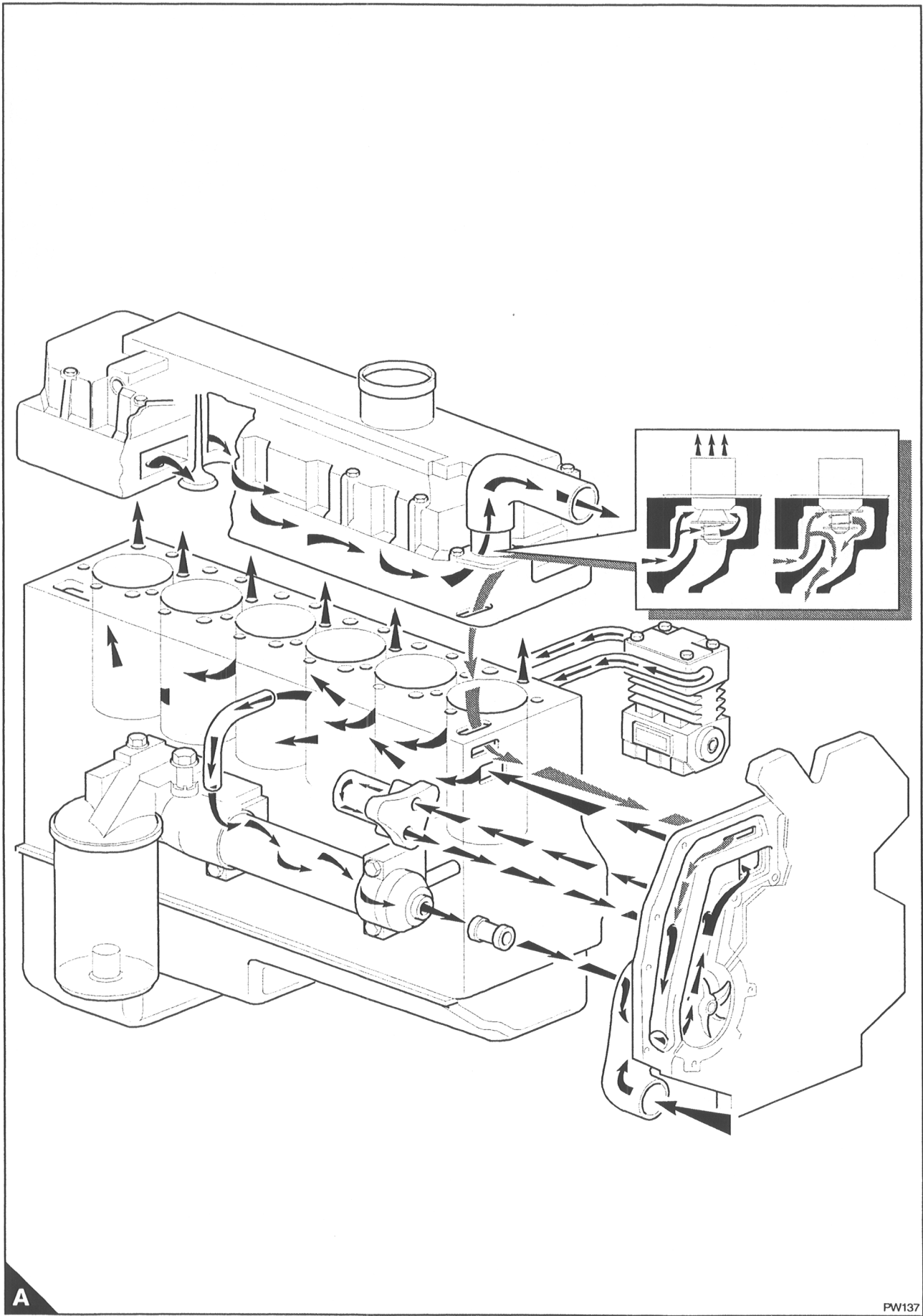
Coolant from the bottom of the radiator passes into a channel in the timing case to the centrifugal water pump, which is fitted on the front of the timing case. The pump is belt driven and assists the flow of the coolant through the system. The coolant passes through another channel in the timing case to a passage in the cylinder block. An equal amount of coolant passes to the bottom of each cylinder liner at an angle. This angle makes the coolant swirl around and up the cylinder liner to the cylinder head. This swirl assists in cooling the cylinders. The coolant leaves the cylinder head at the front and passes into the thermostat housing. If the thermostat is closed, the coolant goes directly through a by-pass to the inlet side of the water pump; if the thermostat is open, the by-pass is closed and the coolant passes to the top of the radiator.

From the cylinder block, coolant also passes through the oil cooler to the inlet side of the water pump.

From the cylinder block, coolant also passes through the air compressor, if one is fitted.

A coolant filter is fitted to the rear of the timing case. Ports in the coolant channels in the timing case allow 3% to 10% of the coolant to pass through the filter. Non-return valves control the direction of coolant flow from the outlet side side of the water pump, through the filter to the inlet side of the pump.

A tensioner pulley automatically maintains the correct tension of the drive belt.





21A COOLING SYSTEM

To renew the canister of the coolant filter/ inhibitor

21A-01

Warning! Do not remove the canister while the engine is still hot and under pressure because dangerous hot fluid can be discharged.

Caution: The canister contains a corrosion inhibitor which is circulated around the cooling system as the coolant passes through the canister. It is important that only the genuine correct Perkins canister is used.

1 When the engine has cooled, remove the radiator filler cap to release the system pressure.

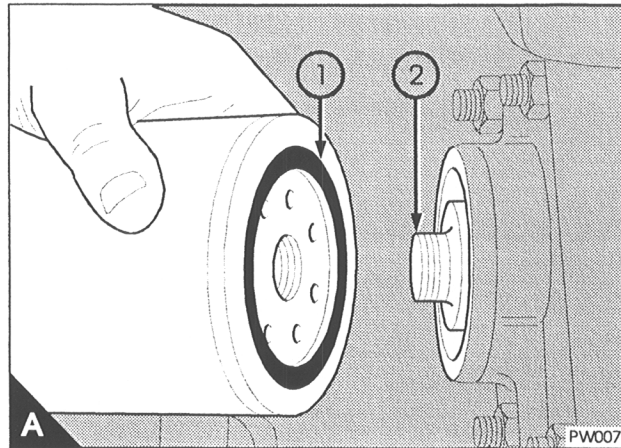
Note: When the system pressure is released, valves will close in the filter canister and in the housing for the canister. This will prevent the loss of coolant when the filter is removed.

2 Thoroughly clean the outside surfaces of the coolant filter assembly.

3 Use a strap wrench or similar tool to loosen the filter canister and remove the canister. Valves in the filter head will prevent the loss of coolant when the canister is removed.

4 Ensure that the threaded adaptor (A2) is secure in the filter head and that the inside of the head is clean.

5 Lubricate lightly the seal (A1) on top of the new canister with clean engine coolant. Fit the new canister to the filter head and tighten, by hand only. Do not overtighten the canister.





Thermostat

To remove and to fit

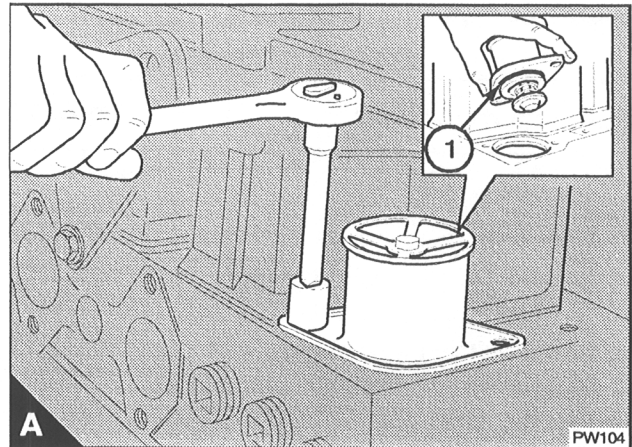
21A-02

To remove

- 1 Drain the cooling system so that the coolant level is below the thermostat position and disconnect the top hose from the water outlet connection.
- 2 Release the setscrews and remove the thermostat assembly (A). Discard the 'O' ring (A1).

To fit

- 1 Ensure that the joint faces of the thermostat assembly and the outlet are clean.
- 2 Fit a new 'O' ring to the thermostat assembly and put the thermostat assembly in position on the cylinder head. Fit and tighten the setscrews.
- 3 Connect the top hose and fill the cooling system.



To test

21A-03

- 1 Hang the thermostat in a suitable container filled with water.
- 2 Heat the water gradually. Use a thermometer to check the temperature at which the valve starts to open and at which it is fully open. The correct temperatures are given in data and dimensions.



21A COOLING SYSTEM

Water pump

To remove and to fit

21A-04

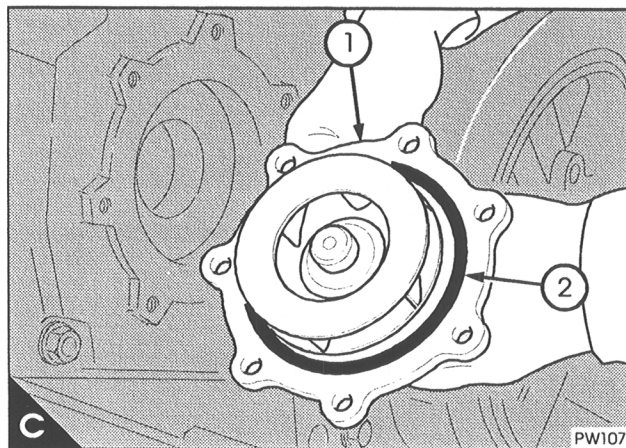
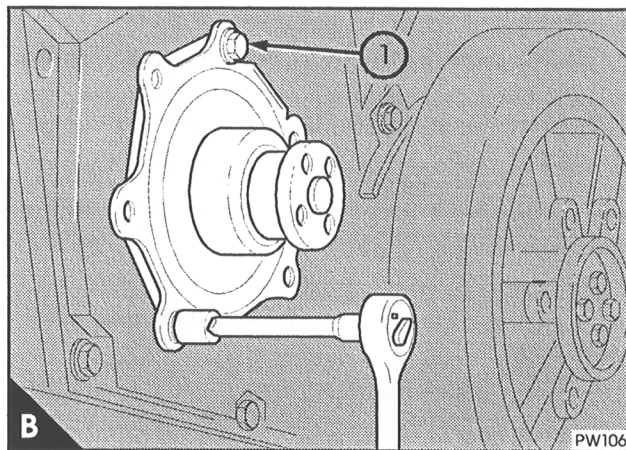
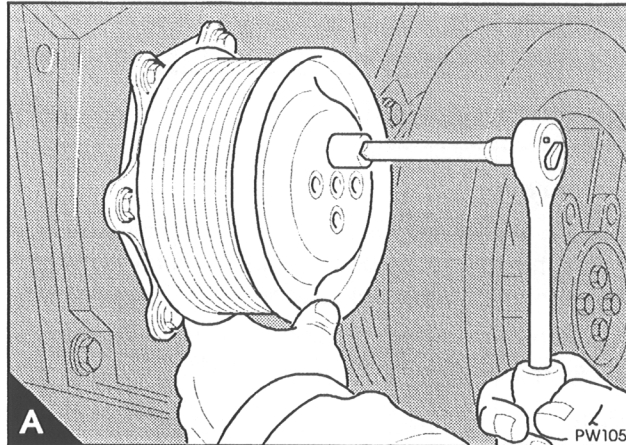
To remove

- 1 Drain the cooling system.
- 2 Remove the drive belt, see [operation 21A-07](#).
- 3 Remove the setscrews from the drive pulley, remove the drive pulley (A).
- 4 Remove the water pump fasteners (B1) and remove the water pump. Discard the 'O' ring (C2).

Note: The bolt at the 1 o'clock position (B1) passes through the timing case to a nut on the rear of the timing case.

to fit

- 1 Ensure that the joint faces are clean.
- 2 Fit a new 'O' ring (C2) to the water pump (C1) and put the water pump into position in the timing case. Fit the nut and bolt (B1) at the 1 o'clock position and tighten finger tight only. Fit the remaining setscrews and tighten finger tight only. Tighten all the fasteners evenly and gradually to 7 Nm (5.5 lbf ft) 0,8 kgf m.
- 3 Fit the drive pulley and tighten the setscrews to 7 Nm (5.5 lbf ft) 0,8 kgf m (A).
- 4 Fit the drive belt, see [operation 21A-07](#).
- 5 Fill the cooling system to the correct level.





Fan

To remove and to fit **21A-05**

To remove

- 1 Remove the fan drive belt, see operation 21A-07.
- 2 Release the setscrews and remove the fan.

To fit

- 1 Clean thoroughly the rear of the fan where it fits onto the fan spacer. Also ensure that all paint is removed from this area. Clean the front face of the fan spacer. Fit the fan and tighten the setscrews.
- 2 Fit the fan drive belt, see operation 21A-07.

Note: There is no need to check the tension of the belt as the tension is set automatically.

Fan drive

To remove and to fit **21A-06**

To remove

- 1 Remove the fan, see operation 21A-07.
- 2 Release the setscrews and remove the fan spacer. Remove the drive pulley, if one is fitted, remove the fan pulley.
- 3 Release the setscrews and remove the fan drive.
- 4 Visually inspect the fan drive assembly for damage and wear. If the fan drive is damaged or worn it must be renewed as a unit.

To fit

- 1 Put the fan drive in position, fit and tighten the setscrews to 17 Nm (13 lbf ft) 1,8 kfg m.
- 2 Put the fan pulley, the drive pulley and the fan spacer in position, fit and tighten the setscrews.
- 3 Fit the fan, see operation 21A-07.



21A COOLING SYSTEM

Fan drive belt

Note: There is no need to check the tension of the belt as the tension is set automatically.

To remove and to fit

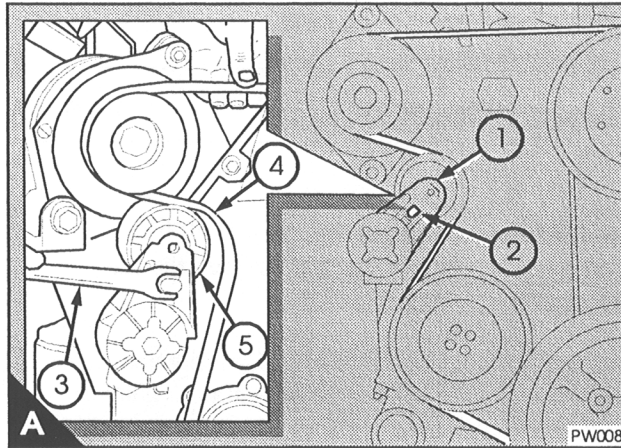
21A-07

To remove

1 Fit a square headed lever (A3) into the 12,7 mm (0.5 in) hole (A2) in the fan tensioner assembly (A1). Operate the lever to release the tension from the belt (A4) and remove the belt. The tensioner will return to its original position by spring pressure. Remove the lever.

To fit

1 With the lever in the fan tensioner, pull the tensioner outwards. Put the fan belt in position around all of the pulleys. Ensure that the tensioner pulley is on the outside of the belt. Allow the tensioner to return and tension the belt. Remove the lever.





Data and dimensions

Note: 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 the factory. The information applies to all engines, unless an engine type code is shown.

Water pump

type.....Belt driven, impeller

Coolant filter

type.....Canister
number 1

Thermostat

Starts to open82⁰/85⁰C (180⁰/185⁰F)
Fully open94⁰C (202⁰F)



Flywheel and housing **22A**

General description 22A.02

Flywheel

22A-01 To remove and to fit 22A.03

Ring gear

22A-02 To remove and to fit 22A.04

Flywheel housing

22A-03 To remove and to fit 22A.05

Data and dimensions 22A.06



22A FLYWHEEL AND HOUSING

Flywheel and housing

General description

The steel flywheel is fitted with a hardened ring.

The flywheel housing is made of cast iron.



Flywheel

Warning! The flywheel weighs 27 kg (59.5lbs). Use lift equipment or obtain assistance to lift the flywheel.

Caution: During removal of the flywheel and while it is fitted, be careful not to damage the rear oil seal.

To remove and to fit

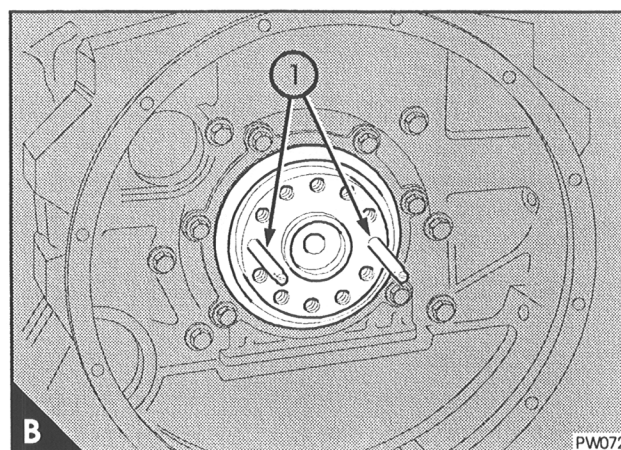
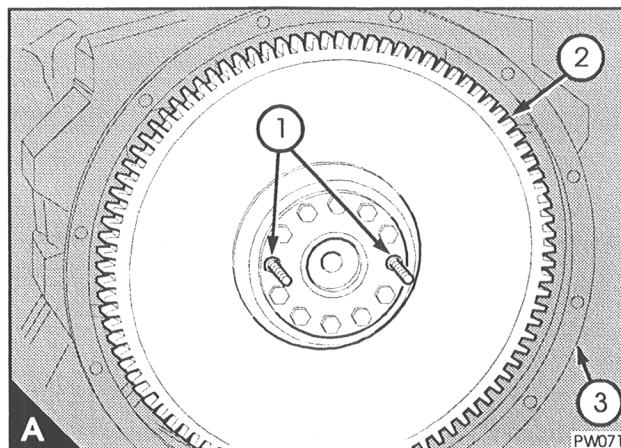
22A-01

To remove

- 1 Remove two opposite setscrews from the flywheel (A2) and fit temporarily two guide studs (A1) to ensure safety when the flywheel is removed and fitted.
- 2 Remove the remaining setscrews and slide the flywheel out of the flywheel housing (A3).

To fit

- 1 Ensure that the location faces of the crankshaft and the flywheel are clean and free from damage.
- 2 Fit the flywheel over the guide studs (B1) and slide the flywheel into position.
- 3 Fit two opposite setscrews and tighten to finger tight only. Remove the two guide dowels.
- 4 Fit the remaining setscrews and tighten all the setscrews to 136 Nm (100 lbf ft) 13,8 kgf m.





22A FLYWHEEL AND HOUSING

Ring gear

To remove and to fit	22A-02
----------------------	--------

To remove

Warning! *For this operation eye protection must be used.*

- 1 Before the ring gear is removed, check the position of the chamfer on the teeth.
- 2 To remove the ring gear use a hammer and a chisel to break the ring. Ensure that the flywheel is not damaged during this operation.

To fit

- 1 The ring gear is heated onto the flywheel. When a new gear is to be fitted, ensure that it is not heated to more than 278° C (500° F). Ensure that the ring gear is fully against the shoulder on the flywheel.



Flywheel housing

To remove and to fit

22A-03

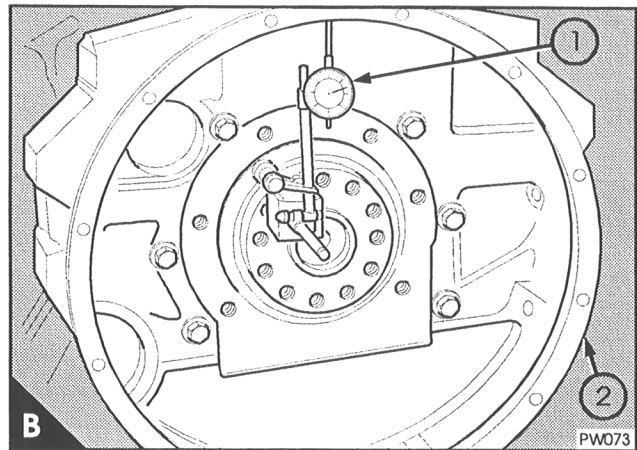
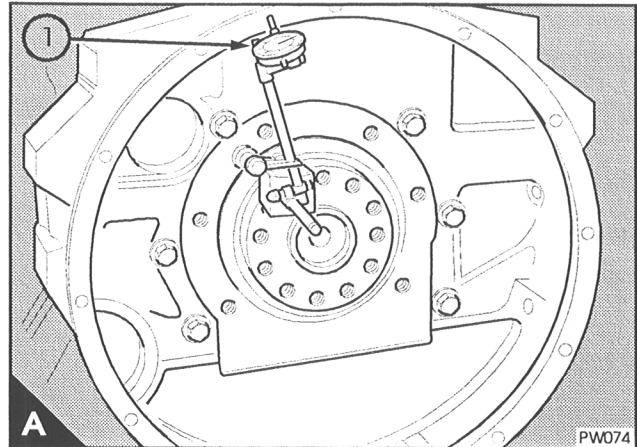
Warning! The flywheel housing weighs 33,5 kg (73.87lbs). Use lift equipment or obtain assistance to lift the flywheel housing.

To remove

- 1 Remove the starter motor, see [section 23](#)
- 2 Remove the flywheel, see [operation 22A-01](#).
- 3 Release the housing setscrews and remove the housing.
- 4 Remove and discard the camshaft 'O' ring, from the rear face of the crankcase.

To fit

- 1 Ensure that the rear face of the cylinder block and the faces of the housing are clean and free from damage.
- 2 Fit a new camshaft 'O' ring into its recess in the rear face of the crankcase.
- 3 Fit the housing (B2) and tighten lightly the setscrews.
- 4 Check the housing run-out (B) with a dial test indicator (B1) at the 3 o'clock, 6 o'clock, 9 o'clock and 12 o'clock positions. Ensure that the crankshaft is pushed fully toward the front of the engine for each measurement. The maximum tolerance is given in data and dimensions. If any adjustment is necessary, it must be made on the housing and the run-out checked again.
- 5 Tighten the setscrews to 108 Nm (80 lbf ft) 11 kgf m.
- 6 Check the housing alignment (A) with a dial test indicator (A1) at the 3 o'clock, 6 o'clock, 9 o'clock and 12 o'clock positions. The maximum tolerance is given in data and dimensions. Any necessary adjustment must be made on the housing and not on the cylinder block.
- 7 Fit the flywheel, see [operation 22A-01](#).





22A FLYWHEEL AND HOUSING

Data and dimensions

Note: 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 the factory. The information applies to all engines, unless an engine type code is shown.

Flywheel

Alignment0,013 mm (0.007 in) measured at a radius of 178 mm (7.0 in)
Run-out0,15 mm (0.008 in)
Mounting surface alignment.....0,05 mm (0.002 in)

Flywheel housing

Alignment SAE1 0,030 mm (0.012 in), SAE2 0,028 mm (0.011 in)
Run-out SAE1 0,030 mm (0.012 in), SAE2 0,028 mm (0.011 in)



Electrical equipment **23**

Alternators	23A
Starter motors	23B
Starting aid	23C
Stop control solenoid	23D



Alternators

23A

General description	23A.02
23A-01 To remove and to fit	23A.03
23A-02 To maintain	23A.03
23A-03 Fault diagnosis	23A.04
Data and dimensions	23A.06



Alternators

General description

The alternator is driven from the crankshaft pulley by a single belt. To remove and to fit the drive belt, see operation 21A-07. There is no need to check the tension of the belt as the tension is set automatically.

The Lucas CAV AC5RS 12 volt and 24 volt alternators have solid state regulators fitted at the rear. The regulators of both alternators are sealed and repair is not possible.

Precautions

To prevent damage to the diodes, the transistors and the resistors, the precautions given below must be followed:

Do not disconnect the battery while the engine is in operation. This will cause a voltage surge in the alternator charge system which will immediately cause damage to the diodes or to the transistors.

Do not disconnect an electrical wire before the engine is stopped and all electrical switches are in the "off" position.

Do not cause a short circuit by the connection of electrical wires to the wrong terminals. The correct electrical wire must be connected to the correct terminal. A short circuit or wrong connection which gives reverse polarity will immediately cause permanent damage to the diodes and to the transistors.

Do not connect a battery into the system until it has been checked for correct polarity and voltage.

Do not check for current flow with a spark contact as damage can be caused to the transistors.



To remove and to fit**23A-01**

To remove

- 1 Disconnect the electrical connection.
- 2 Remove the drive belt, see operation 21A-07.
- 3 Loosen the fasteners of the alternator and the fasteners of the alternator bracket. Remove the alternator. Make a note of the position of the washers and distance pieces to ensure that they are fitted correctly.

To fit

- 1 Put the alternator in position and assemble loosely the alternator bracket fasteners. Ensure that the washers and the distance pieces are fitted in their correct positions and that the alternator pulley is aligned to the crankshaft pulley. Tighten the fasteners.
- 2 Fit the drive belt, see operation 21A-07.
- 3 Connect the electrical connection.

To maintain**23A-02**

- 1 Ensure that the drive belt is not worn.
- 2 Keep the alternator clean. To clean the alternator, use a material which is damp with kerosene or a special fluid used for this purpose. Ensure that the fluid does not enter the cover of the alternator.
- 3 Ensure that air can pass easily over the casing to keep it cool.



23A ALTERNATORS

Fault diagnosis

23A-03

If the warning light is not lit or there is a reading on the ammeter, the operation of the alternator is correct. If the system is in correct operation, no open circuit, voltage or current output checks need to be done on the installation unless:

- The warning light does not show when the alternator is stationary and the switch is in the "on" position or it shows a light when the alternator is in operation.
- No charge current is shown on the ammeter.
- The battery is discharged.
- The battery is hotter than normal which is an indication of loss of voltage control.

If one or more of the above symptoms occur, the procedure indicated below should be applied.

- 1 Ensure that the battery is fully charged.
- 2 Connect a moving-coil voltmeter of good quality, with a range of 0-50 volts, across the positive and negative terminals of the alternator. If an ammeter is not fitted in the electrical circuit, fit a moving-coil ammeter of good quality, with a range of 0-100 ampere, in the wire between the alternator and the positive terminal of the battery.
- 3 Turn the warning light switch to the "on" position (main switch on instrument panel); the warning light should be illuminated.
- 4 Switch on a 10-15 ampere load, for example, lights, fans, etc.
- 5 Start the engine and operate it at a fast idle speed; either the warning light should be extinguished or the ammeter indicates a small change in the current in relationship to the engine speed.
- 6 Increase the engine speed for a moment to near maximum speed, when the charge current should be approximately equal to the rating for the alternator.
- 7 Operate the alternator at approximately half speed (engine speed approximately 1500 rev/min) and remove the electrical load. The voltage should go up to 14 volts for a 12 volt system or 28 volts for a 24 volt system and then remain constant. At the same time the current reading should show a reduction.

Any change in the above data can indicate a fault and the procedure that follows should be used before any components are disconnected.

Note: The regulator is a sealed unit and a repair is not possible. If there is a regulator fault, the regulator must be renewed.

If the warning light is not illuminated when the switch is in the "on" position:

- 1 Check the bulb.
- 2 If no fault: Check all the connections at the regulator, at the alternator and at the battery.



3 If no fault: Turn the switch to the "off" position.

Disconnect the wire from the "F" terminal on the alternator and connect a wire between the "F" terminal and the negative terminal on the alternator. Turn the switch to the "on" position.

If the warning light shows, the fault is in the regulator.

If the warning light does not show, the fault is in the alternator.

If the warning light continues to show and the ammeter shows no output when the alternator is in operation:

4 Check all the connections at the regulator, alternator and battery.

5 If no fault: Turn the switch to the "off" position.

Disconnect the wire from the "F" terminal on the alternator and connect a wire between the "F" terminal and the negative terminal on the alternator. Turn the switch to the "on" position and operate the engine at fast idle.

If there is no output, there is a fault in the alternator.

If there is an output, there is a fault in the regulator.

If the warning light continues to show when the alternator is in operation and the ammeter shows a reduced output with maximum output only at maximum engine speed, there is a fault in the alternator.

If the warning light does not show, but there is a reduced output from the alternator with maximum output only at maximum engine speed, there is a fault in the alternator

If there is an intermittent light from the warning light and the ammeter needle is not stationary when the battery is charged fully and no load is applied.

6 Check for a higher than normal resistance in the negative control wire of the regulator.

If the resistance is normal, there is a fault in the regulator.

If the battery charge is too high and the ammeter indicates high or maximum output at all times:

7 Check the positive control wire and its connection at the regulator.

If the wire and its connection are correct, there is a fault in the regulator.



23A ALTERNATORS

Data and dimensions

Note: 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 the factory. The information applies to all engines, unless an engine type code is shown.

The information which follows is general and can change with individual applications.

Alternators

Make and typeLucas AC5RS. Delco 21SI.

Ratings:

- Lucas 12V/55A or 24V/55A

- Delco..... 12V/70A or 12V/100A



Starter motors

23B

General description	23B.02
23B-01 To remove and to fit	23B.03
23B-02 To maintain	23B.03
23B-03 To test on the engine	23B.04
Data and dimensions	23B.05



23B STARTER MOTORS

Starter motors

General description

The Lucas S115 starter motor has a smooth cylinder surface with no protrusions. This is because the solenoid and the main switch assemblies are inside the drive end cover around (co-axially with) the armature shaft. The main feature of the co-axial starter is that only the pinion assembly moves axially to engage the engine flywheel. There is no axial movement of the whole armature as with the axial type motor. To ensure smooth engagement of the pinion, full load is not applied until the pinion is completely engaged with the flywheel.

The Lucas PE129 is a pre-engaged starter motor and is actuated by a solenoid. The solenoid is fitted to the starter motor outer casing. When the starter button or key is operated, the solenoid pulls a lever to engage the pinion in the starter ring, against spring pressure. As soon as the pinion is fully in mesh with the starter ring, the starter relay electrically connects the starter motor directly to the batteries. When the engine runs, the starter button or key is released, current to the solenoid is stopped and the solenoid is de-energised. Current to the starter motor from the batteries is stopped. Spring pressure on the lever disengages the pinion from the starter ring.



To remove and to fit**23B-01****To remove**

- 1 Disconnect the battery.
- 2 Disconnect the starter motor cables.
- 3 Release the fasteners and remove the starter motor and, if necessary, the distance piece.

To fit

- 1 If necessary, put the distance piece in position with its location lip to the flywheel housing. Fit the starter motor and tighten the fasteners.
- 2 Connect the starter motor cables.
- 3 Connect the battery.

9 If the commutator is dirty and has a colour other than its natural colour, lift the brushes and put a strip of fine carborundum paper or similar material around the commutator, with the rough surface to the inside. Turn the armature by hand until the surface has returned to its natural colour. Clean the commutator with a material which is damp with gasolene.

10 If a repair is necessary to the commutator or switch gear, etc. the starter must be removed for specialist repair.

To maintain**23B-02**

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

2 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 brush seat is not correct, put a piece of very fine carborundum paper or similar material tight around the commutator with the rough face to the outside.

3 With the brush in position, turn the armature by hand, in the normal direction of rotation, until the brush has the correct shape. If the brushes are so worn that the springs do not give enough pressure, they must be renewed.

4 Check the spring pressure with the hook of a spring balance under the spring lip. The correct tension is 8,34/11,00 N (30/40 ozf) 0,85/1,13 kgf.

5 The new brushes must be the exact same grade as the original brushes. To ensure that correct brushes are fitted, use only parts from the approved manufacturer.

6 To remove the brushes, remove the four setscrews that hold the brushes, one for each brush.

7 When the new brushes are assembled, connect carefully the field coil and connector wires, held by two of the setscrews. 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.

8 The commutator must be completely clean; dirt or oil must be removed by a piece of clean dry material (with no loose fibres) pressed against it, while the armature is turned by hand.



23B STARTER MOTORS

To test on the engine

23B-03

- 1 Ensure that the battery is fully charged.
- 2 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.
- 3 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.
- 4 Slow action of the starter can be caused by faulty connections.
- 5 Difficulty to engage smoothly between the starter and the flywheel can be caused, on some types of starter motor, by dirt on the helical grooves of the starter motor drive, which can prevent free pinion movement.
- 6 Clean the shaft thoroughly with gasolene, or a fluid made specially for the purpose, and apply a small quantity of Aero Shell 6B or its equal.



Data and dimensions

Note: 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 the factory. The information applies to all engines, unless an engine type code is shown.

The information which follows is general and can change with individual applications.

Starter motors

Make and typeLucas S115, Lucas PE129, Delco 37 MT or Delco 42 MT

Ratings:

- Lucas 12V/4.25kW or 24V/6kW

- Delco 12V or 24V



Starting aid **23C**

General description 23C.02



Starting aid

General description

An ether start system is used to start the engine at temperatures below -20°C (-4°F).

At temperatures below -20°C (-4°F) the system thermostat contacts are closed. When the starter motor solenoid is energised, the ether start solenoid is also energised. The ether start solenoid will remain energised during engine start and while the alternator is charging.

Note: See section 3 of the User's Handbook for, "How to start an engine with an ether start system".



Stop control solenoid

23D

General description	23D.02
23D-01 To remove and to fit	23D.02
23D-02 To inspect	23D.03
23D-03 To adjust	23D.04



23D STOP CONTROL SOLENOID

Stop control solenoid

General description

The stop control solenoid is electrically operated. The solenoid must be energised for the engine to run. If the solenoid is de-energised the fuel supply is stopped and the engine stops.

The solenoid has two coils, the pull coil and the hold coil.

The pull coil is energised by current from the starter relay, when the engine start circuit is activated. When the solenoid is energised it pulls the control lever of the fuel injection pump to the "RUN" position, against spring tension. The hold coil is energised by a reduced current from the ignition switch.

When the engine starts and the start circuit is disengaged, the pull coil is de-energised. The hold coil retains the fuel injection pump control lever at the "RUN" position.

If the ignition is turned to the "OFF" position, current to the hold coil is stopped and the coil is de-energised. Return springs pull the control lever of the fuel injection pump to the "STOP" position and the engine stops.

To remove and to fit

23D-01

To remove

- 1 Ensure that the engine start key is in the "OFF" position. Disconnect the electric connector from the stop control solenoid.
- 2 Disconnect the end of the solenoid rod from the control lever of the fuel injection pump.
- 3 Release the fasteners for the solenoid mounting and remove the solenoid.

To fit

- 1 Ensure that the mating faces of the solenoid and the fuel injection pump are clean.
- 2 Fit the solenoid to the fuel injection pump and tighten the fasteners.
- 3 Connect the end of the solenoid rod to the control lever of the fuel injection pump.
- 4 Energise the solenoid two or three times to check that it operates correctly.

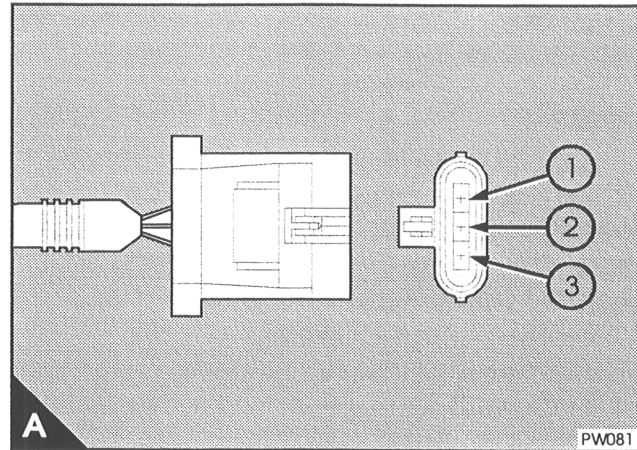
Caution: Do not energise the solenoid more than three times during one check, because the solenoid coils will overheat and be damaged.



To inspect

23D-02

- 1 Ensure that all the components of the solenoid are clean, visually inspect the components for damage and wear. If the solenoid is damaged or worn it must be renewed.
- 2 Ensure that the solenoid operates correctly when the start circuit is activated.
- 3 If the solenoid fails to energise when the start circuit is activated:
 - Check the circuit fuses.
 - Check the power supply to the solenoid.
 - Check the adjustment of the solenoid rod, see [operation 23D-03](#), and adjust if necessary.
 - Check the resistance between the terminal of the hold coil (A1) and the common terminal (A3).
 - Check the resistance between the terminal of the pull coil (A2) and the common terminal (A3).



Terminal	12 volt	24 volt
Hold to common	12.8 - 16.0 Ohms	46.7 - 57.1 Ohms
Pull to common	0.16 - 0.24 Ohms	0.55 - 0.68 Ohms



23D STOP CONTROL SOLENOID

To adjust

23D-03

- 1 Ensure that the engine start key is in the "OFF" position.
- 2 Loosen the locknut on the end of the solenoid rod.
- 3 Disconnect the the electric connector from the stop control solenoid.
- 4 Apply the correct system voltage (12 volts or 24 volts as necessary) to the "HOLD" and the "COMMON" terminals of the electrical connector.
- 5 Push the solenoid rod into the solenoid until the rod is held by the hold coil. Adjust the solenoid rod until the fuel injection pump control lever is fully to the run position.
- 6 Adjust the solenoid rod in the opposite direction two turns to set the correct gap inside the solenoid. Tighten the locknut. Connect the electrical connector.
- 7 Energise the solenoid two or three times to check that it operates correctly.

Caution: *Do not energise the solenoid more than three times during one check, because the solenoid coils will overheat and be damaged.*

Notes:

- An ether start system is used to start the engine at temperatures below -20°C (-4°F).
- At temperatures below -20°C (-4°F) the system thermostat contacts are closed. When the starter motor solenoid is energised, the ether start solenoid is also energised. The ether start solenoid will remain energised during engine start and while the alternator is charging.



Auxiliary equipment **24**

Compressors **24A**

Power steering pump **24B**



Compressors

24A

General description	24A.02
Operation	24A.02
24A-01 To remove and to fit	24A.03



Compressors

General description

The Bendix 2150, Bendix 550 and Bendix 750 direct drive compressors are fitted to the rear face of the timing case on the left side of the engine. The drive gear for the compressor is engaged with the lower idler gear in the timing case.

The cylinder head of the single cylinder compressor is cooled by coolant from the engine. The compressor is lubricated from the lubrication system of the engine. Oil passes through an external pipe from the engine pressure rail to the compressor crankcase. The oil passes to the main bearings and the big end bearings of the compressor and also to the rear bush for the drive shaft. Oil which drains from the compressor crankcase into the drive housing, lubricates the drive gears and the bearing. The oil returns to the engine sump through the timing case.

Operation

As the piston moves down the cylinder, air pressure above the piston is reduced. The reduction in air pressure opens the inlet valve and allows air to enter the cylinder above the piston. As the piston moves up the cylinder, air pressure under the valve and the action of the valve spring, closes the valve. The increase in air pressure under the delivery valve, opens the valve and air is discharged to the reservoir. Air pressure in the reservoir is controlled by an unloader valve which, at a certain pressure, holds the inlet valve of the compressor open until air pressure in the reservoir is reduced.



To remove and to fit**24A-01**

To remove

- 1 Drain the engine cooling system.
 - 2 Release the air pressure in the air system.
 - 3 Disconnect the air pipes from the compressor.
 - 4 Disconnect the coolant pipes of compressor from the cylinder block of the engine.
- Caution:** *The top coolant hose is permanently fitted to the compressor, it must be disconnected at the cylinder block end and removed from the engine as a part of the compressor.*
- 5 Remove the lubricating oil pipe from the compressor.
 - 6 If necessary, remove the power steering pump from the rear of the compressor, see [operation 24B-01](#).
 - 7 Support the compressor. loosen the two nuts and bolts which fasten the compressor to its support bracket. loosen the two setscrews which fasten the support bracket to the cylinder block.
 - 8 Remove the two setscrews that hold the compressor to the timing case.
 - 9 Remove the support bracket and its fasteners.
- Note:** Spacers are used between the compressor bracket and the compressor body.
- 10 Remove the compressor from the engine.

To fit

- 1 Fit the compressor to the timing case, ensure that the drive gear is in mesh with the lower idler gear. Tighten the setscrews to 62 Nm (46 lbf ft) 6,4 kgf m.
- 2 Fit the setscrews for the compressor bracket to the engine and tighten to 115 Nm (85 lbf ft) 11,7 kgf m.
- 3 Fit the setscrews for the compressor bracket to the compressor and tighten to 66 Nm (49 lbf ft) 6,7 kgf m.
- 4 Ensure that there is no restriction in the oil pipe between the engine and the compressor. Before the oil pipe is connected to the compressor, ensure that the engine stop solenoid is disconnected or that the engine stop control is in the 'stop' position. Operate the starter motor until a free flow of oil comes from the oil pipe. Connect the engine stop solenoid.
- 5 Connect the oil pipe, the compressor coolant pipes and the air pipes to the compressor.
- 6 Fill the engine cooling system.
- 7 Start the engine and check for leakage of oil, coolant and air from the compressor.



Power steering pump

24B

24B-01 To remove and to fit 24B.02



24B POWER STEERING PUMP

Power steering pump

To remove and to fit	24B-01
----------------------	--------

To remove

- 1 Disconnect the connections at the power steering pump and fit covers to the openings.
- 2 Release the setscrews and remove the pump.
Discard the 'O' ring.

To fit

- 1 Fit a new 'O' ring and lubricate it with clean engine lubricating oil.
- 2 Fit the drive shaft into the end of the compressor output flange and push the pump fully into position.
- 3 Fit and tighten the setscrews.
- 4 Remove the covers from the openings and connect the connections.



Special tools **25A**

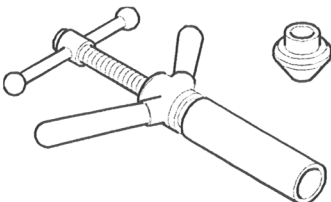
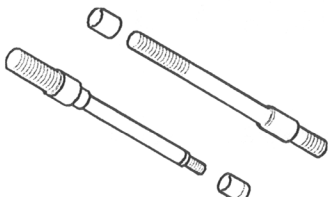
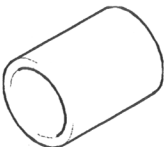
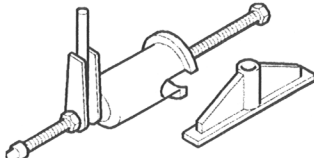
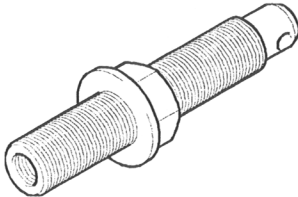
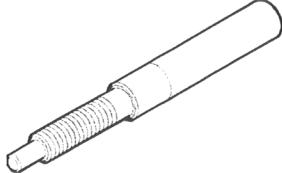
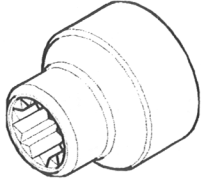
list of special tools 25A.02

These tools are available through your local Perkins Distributor.
If you cannot obtain the correct tool locally contact:
The Perkins Service Department, Peterborough, PE1 5NA, England, UK.
Tel 01733 67474, Fax 01733 582240, Telex 32501 PERKEN G

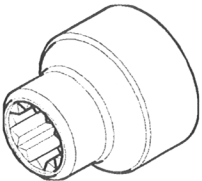
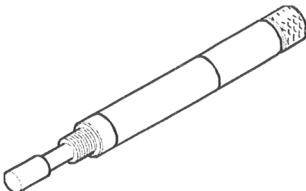
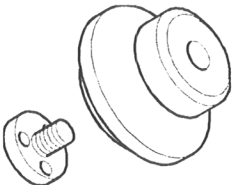
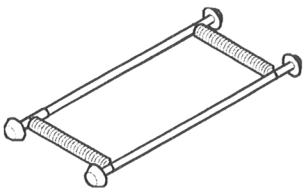
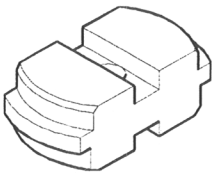
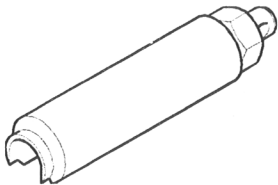
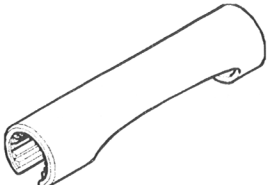
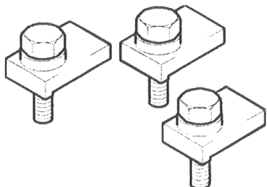


Special tools

list of special tools

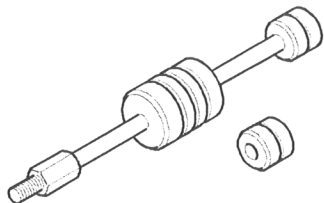
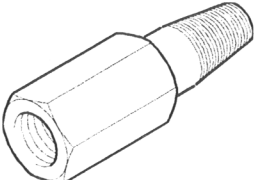
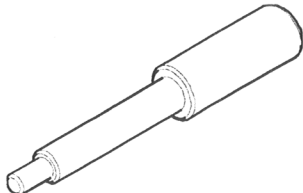
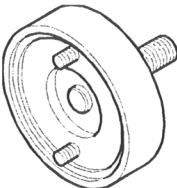
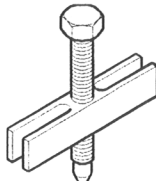
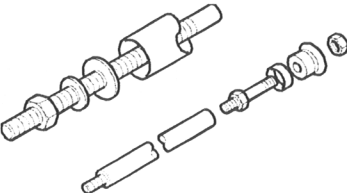
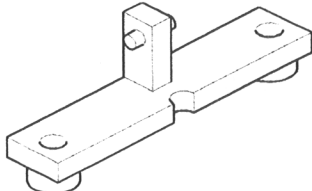
Tool number	Description	Illustration
PD.1D	Remover/ replacer for valves guides (main tool) Perkins part number 21825478	
PD.1D-11	Adaptor for replacer/ remover for valve guide Perkins part number 21825935	
PD.1D-1A	Adaptor for remover/ replacer for valve guide Perkins part number 21825479	
PD.150-B	Remover/ replacer for cylinder liner (main tool) Perkins part number 21825543	
PD.170	Replacer for crankshaft front oil seal Perkins part number 21825577	
PD.223	Timing pin, fixed type Perkins part number 21825949	
PD.224	Socket for upper idler gear Perkins part number 21825450	



Tool number	Description	Illustration
PD.225	Socket for lower idler gear Perkins part number 21825951	
PD.226	Timing pin, plunger type Perkins part number 21825952	
PD.227	Adaptor for installer for front oil seal Perkins part number 21825953	
PD.229 PD.230	0.090 inch gauge for piston groove Perkins part number 21825954 0.115 inch gauge for piston groove Perkins part number 21825955	
PD.231	Adaptor for liner remover Perkins part number 21825956	
PD.232	injector remover Perkins part number 21825957	
PD.233	Socket for H.P. pipe nuts Perkins part number 21825958	
PD.234	Holding kit for cylinder liner Perkins part number 21825959	



25A SPECIAL TOOLS

Tool number	Description	Illustration
PD.235	Remover kit for nozzle sleeve Perkins part number 21825960	
PD.235/1	Adaptor for injector sleeve puller Perkins part number 21825961	
PD.236	Installer for nozzle sleeve Perkins part number 21826012	
PD.237	Installer for rear oil seal Perkins part number 21825963	
PD.240	Puller for crankshaft pulley/ damper assembly Perkins part number 21825965	
ZTSE 2893A	Remover / replacer camshaft bush Perkins part number 21825995	
PD.41D	Gauge for valve height, for use with PD.208. Perkins part number 21825496	
PD.208.	Dial gauge for use with PD.41D. Perkins part number 21825617	