
Perkins 900 Series

Models CP and CR

WORKSHOP MANUAL

3 cylinder, naturally aspirated, and turbocharged diesel engines for agricultural and industrial use

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1

General information

Introduction

This Workshop Manual has been designed to provide assistance in the service and overhaul of Perkins 900 Series engines. For overhaul procedures the assumption is made that the engine is removed from the application.

The engine conforms with USA (EPA/CARB) stage 1 and EEC stage 1 emissions legislation for agricultural and industrial applications.

Read and remember the "Safety precautions" on page 4. They are given for your protection and must be used at all times.

Most of the general information which is included in the User's Handbook (Chapters 1 to 6) has not been repeated in this workshop manual and the two publications should be used together.

The details of some operations will be different according to the fuel injection pump that is fitted. The specific pump type used can be found by reference to the manufacturer's identification plate on the pump body. Generally, the type of pump fitted is as shown below.

- Delphi - DP200 Series
- Stanadyne - DB4

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 tools is given in Chapter 16, Special tools. Reference to the relevant special tools is also made at the beginning of each operation.

Original setscrews or studs used in holes that are open to the inside of the engine, have a sealant that is applied by the manufacturer. If the setscrew or stud is to be used again, the threads must be cleaned and a suitable sealant should be used on the threads. POWERPART recommended consumable products are listed on page 8. Reference to the relevant consumable products are made at the beginning of each operation.

Data and dimensions are included in Chapter 2, Specifications.

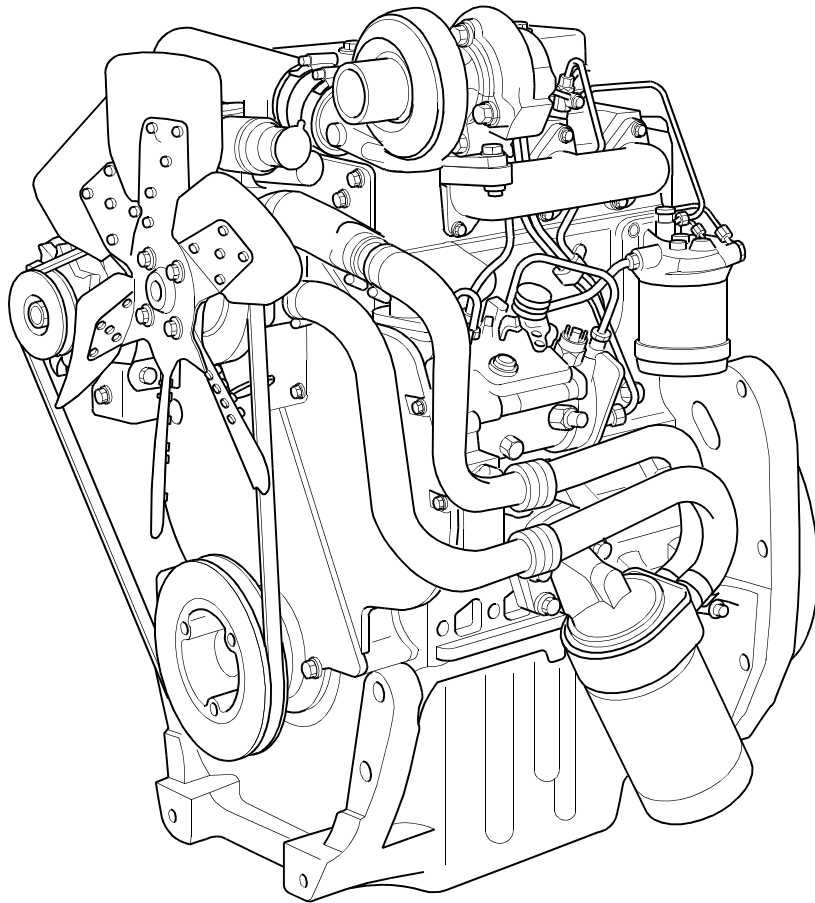
Danger is indicated in the text by two methods:

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

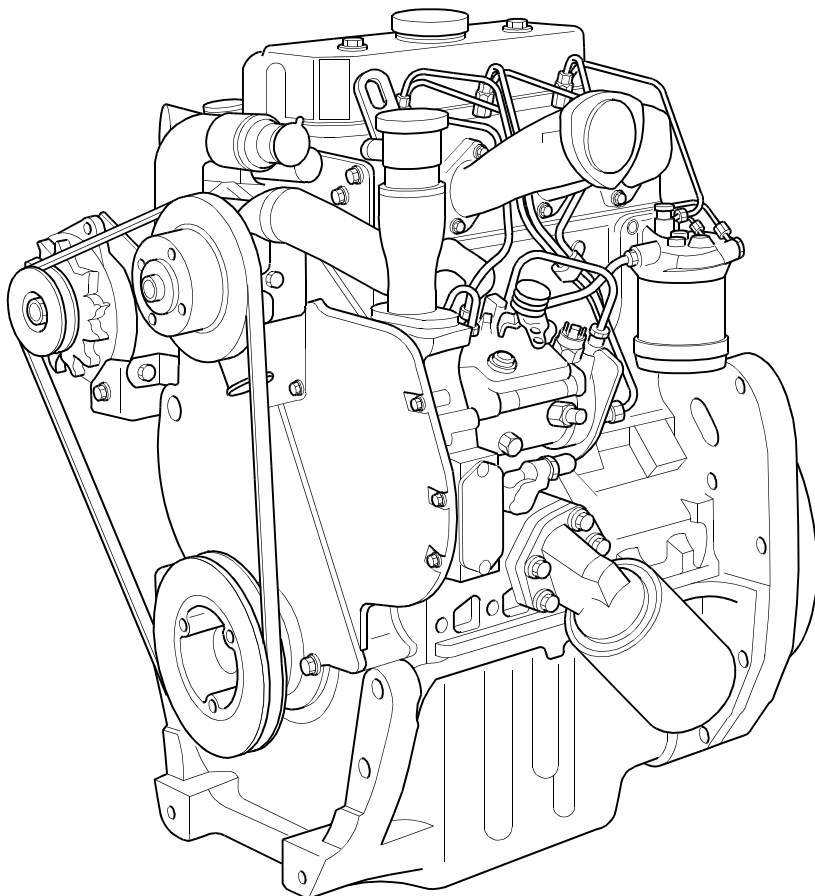
Caution: *This indicates that there is a possible danger to the engine.*

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

Engine views



C0004/1



C0002

Engine identification

The 900 Series is a 3 cylinder, water cooled, direct injection, diesel engine for industrial and agricultural applications. The complete engine family consists of both turbocharged and naturally aspirated models.

The engine number is stamped on a label (A2) fastened to the left side of the cylinder block.

The two letters at the beginning of the engine number are the code letters for the engine type.

Code letters	Engine type
CP	Three cylinder, naturally aspirated
CR	Three cylinder, turbocharged

An example of an engine number is:

CP12345U123456A

Further information about the engine number system can be found in the User's Handbook

If you need parts, service or information for your engine, you must give the complete engine number to your Perkins distributor. If there is a number in the area of the label marked TPL No, then this number must also be given to your Perkins distributor.

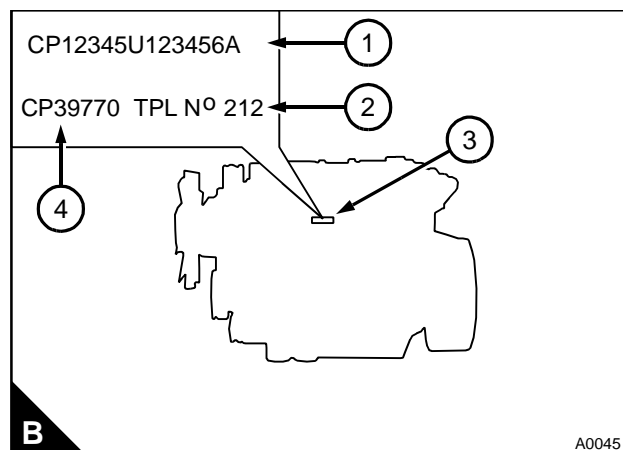
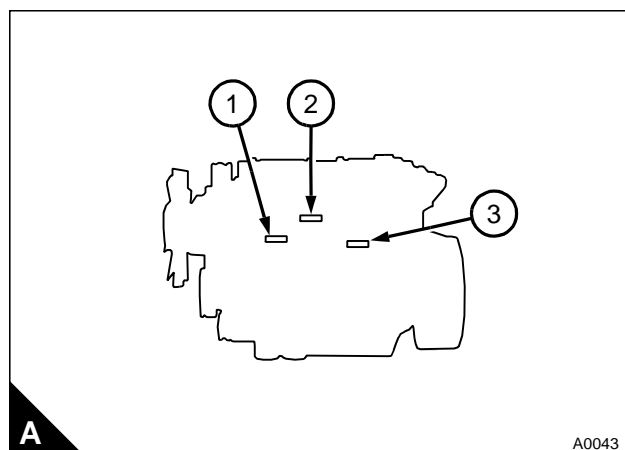
Other identification labels fitted to the engine include:

- An emissions legislation label (A3) fitted to the side of the cylinder block
- A label (A1), fitted to the fuel injection pump, with the fuel injection pump part number.

If a short engine has been fitted in service, two engine serial numbers and a TPL number are stamped on the engine serial number pad (B3).

Examples of the serial numbers are shown in (B).

If parts for the short engine are needed in service, use the serial number (B4). If parts that were moved from the original engine to the short engine are needed, use the serial number (B1) and the TPL number (B2).



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.

- Do not fill the engine with lubricating oil above the mark on the dipstick (see Operation 10-1/B1) or damage could occur to the engine.
- If the lubrication system has been drained, the rocker gear and the camshaft reservoir must be lubricated before the engine is started or damage could occur to the engine.
- 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.

Warning! *Keep away from moving parts during engine operation. Some moving parts cannot be seen clearly while the engine runs.*

- Do not operate the engine if a safety guard has been removed.
- Do not remove the filler cap of the cooling system while the engine is hot and while the coolant is under pressure, because dangerous hot coolant can be discharged.
- Do not use salt water or any other coolant which can cause corrosion in the closed circuit of the cooling system.
- 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, refer to "Viton seals" on page 7.
- Read and use the instructions relevant to lift equipment, refer to "Engine lift equipment" on page 6.

Continued

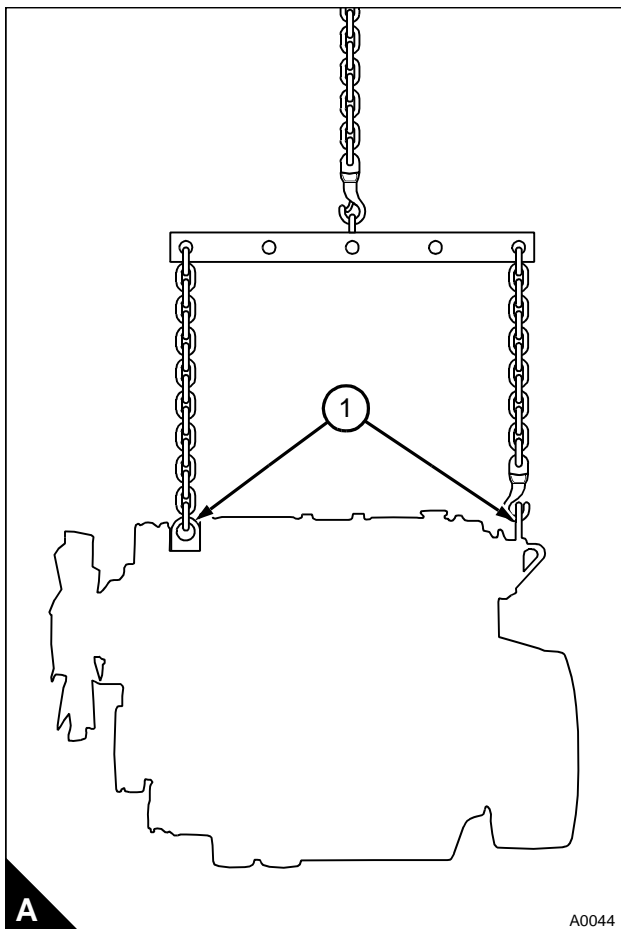
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- Always use a safety cage to protect the operator when a component is to be pressure tested in a container of water. Fit safety wires to secure the plugs which seal the hose connections of a component which is to be pressure tested.
 - Do not allow compressed air to contact your skin. If compressed air enters your skin, obtain medical help immediately
 - Turbochargers operate at high speeds and at high temperatures. Keep fingers, tools and items away from the inlet and outlet ports of the turbocharger and prevent contact with hot surfaces.
 - Do not clean an engine while it runs. If cold cleaning fluids are applied to a hot engine, certain components on the engine may be damaged.
 - Fit only genuine Perkins parts.

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 313 Kg (690 lbs) minimum capacity is used.

Before the engine is lifted:

- 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 that they are secure before the engine is lifted. The torque for the setscrews for the engine lift brackets is 44 Nm (33 lbf ft) 4,5 kgf m
- To prevent damage to the rocker cover, ensure that there is clearance between the hooks and the rocker cover.
- Use lift equipment or obtain assistance to lift heavy engine components such as the cylinder block, cylinder head, flywheel housing, crankshaft and flywheel.



Viton seals

Some seals used in engines and in components fitted to engines are made of Viton. Viton is used by many manufacturers and is a safe material under normal conditions of operation. If Viton is burned, a product of this burnt material is an acid which is extremely dangerous. Never allow this burnt material to come into contact with the skin or with the eyes. If it is necessary to come into contact with components which have been burnt, ensure that the precautions which follow are used:

Warnings!

- *Ensure that the components have cooled.*
- *Use Neoprene gloves and discard the gloves safely after use.*
- *Wash the area with calcium hydroxide solution and then with clean water.*
- *Disposal of components and gloves which are contaminated must be in accordance with local regulations.*

If there is contamination of the skin or eyes, wash the affected area with a continuous supply of clean water or with calcium hydroxide solution for 15-60 minutes. **Obtain immediate medical attention.**

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 and corrosion. Part number 21825166.

POWERPART Easy Flush

Cleans the cooling system. Part number 21825001.

POWERPART Gasket and flange sealant

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

POWERPART Gasket remover

An aerosol for the removal of sealants and adhesives. Part number 21820116.

POWERPART Griptite

To improve the grip of worn tools and fasteners. Part number 21820129.

POWERPART Hydraulic threadseal

To retain and seal pipe connections with fine threads. Especially suitable for hydraulic and pneumatic systems. Part number 21820121.

POWERPART Industrial grade super glue

Instant adhesive designed for metals, plastics and rubbers. Part number 21820125.

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.

POWERPART Metal repair putty

Designed for external repair of metal and plastic. Part number 21820126.

POWERPART Pipe sealant and sealant primer

To retain and seal pipe connections with coarse threads. Pressure systems can be used immediately. Part number 21820122.

POWERPART Radiator stop leak

For the repair of radiator leaks. Part number 21820127.

POWERPART Retainer (oil tolerant)

To retain components that have an interference fit, but is in contact with oil. Part number 21820603.

POWERPART Retainer (high strength)

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

POWERPART Safety cleaner

General cleaner in an aerosol container. Part number 21820128.

Continued

POWERPART Silicone adhesive

An RTV silicone adhesive for application where low pressure tests occur before the adhesive sets. Used for sealing flange where oil resistance is needed and movement of the joint occurs. Part number 21826038.

POWERPART Silicone RTV sealing and jointing compound

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

POWERPART Stud and bearing lock

To provide a heavy duty seal to components that have a light interference fit. Part number 21820119 or 21820120.

POWERPART Threadlock and nutlock

To retain small fasteners where easy removal is necessary. Part number 21820117 or 21820118.

POWERPART Universal jointing compound

Universal jointing compound which seals joints. Part number 1861117.

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Specifications

Data and dimensions

Note: This information is given as a guide for personnel engaged on engine overhauls. The dimensions that are shown are those that are mainly used in the factory. The information applies to all engines, unless an engine type code is shown.

Basic engine data

Cycle	Four stroke
Number of cylinders	3
Cylinder arrangement	In line
Firing order	1, 2, 3
Direction of rotation	Clockwise from the front
Induction system	Turbocharged / naturally aspirated
Cubic capacity	2,7 litres (164.76 in ³)
Compression ratio	17.25:1
Combustion system	Direct injection
Nominal bore	95,0 mm (3.74 in)
Stroke	127 mm (5.00 in)
Valve tip clearances (hot or cold):	
- Inlet	0,20 mm (0.008 in)
- Exhaust	0,45 mm (0.018 in)
Lubricating oil pressure ⁽¹⁾	207 kPa (30 lbf/ in ²) 2,1 kgf/cm ²
Typical dry installed engine weight	305 kg (672 lbs)

⁽¹⁾ Minimum at maximum engine speed and normal engine temperature.

Cylinder head assembly

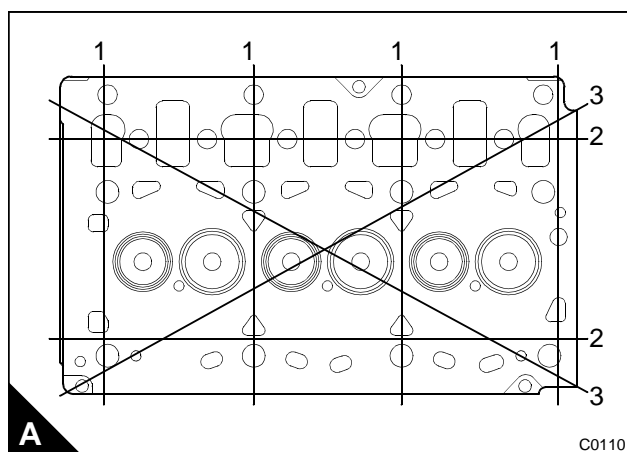
Cylinder head

Angle of valve seats:

Inlet	36° (108° included angle)
Exhaust	46° (88° included angle)
Diameter of parent bores for valve guides	12,000/12,027 mm (0.4724/0.4735 in)
Leak test pressure	200 kPa (29 lbf/in ²) 2,0 kgf/cm ²
Cylinder head thickness	87,6/88,4 mm (3.45/3.48 in)
Diameter of bore for tappets	14,000/14,027 mm (0.5512/0.5522 in)
Finish grade of head face for cylinder head gasket	1,1/3,20 micrometres

Maximum permissible cylinder head distortion

A1	0,08 mm (0.003 in)
A2	0,15 mm (0.006 in)
A3	0,15 mm (0.006 in)



Maximum protrusion of the atomiser nozzle

Code letter KB	1,6/2,13 mm (0.0629/0.0838 in)
Code letter KK	3,49/4,01 mm (0.1374/0.1579 in)
Code letter KL	3,49/4,01 mm (0.1374/0.1579 in)
Code letter KS	2,36/2,88 mm (0.0929/0.1134 in)
Code letter PF	3,45/4,01 mm (0.1358/0.1579 in)

Valve guides

Inside diameter	7,027/7,052 mm (0.2767/0.2776 in)
Outside diameter	12,034/12,047 mm (0.4738/0.4743 in)
Interference fit of guide in cylinder head	-0,007/-0,047 mm (-0.0003/-0.0019 in)
Length	51,0/51,5 mm (2.00/2.03 in)
Protrusion above face of spring seat	11,10/11,40 mm (0.437/0.449 in)

Valve springs

Fitted length	38,0 mm (1.50 in)
Load at fitted length	218,5/241,5 N (49.12/54.29 lbf) 22,3/24,6 kgf
Number of active coils	5.0

Tappets

Diameter of stem	13,925/13,968 mm (0.5482/0.5499 in)
Clearance of tappet in cylinder block...	0,075/0,102 mm (0.0030/0.0040 in)
Diameter of tappet bore in cylinder head.	14,027/14,000 mm (0.5522/ 0.5519)

Rocker shaft

Outside diameter	9,012/19,037 mm (0.7485/0.7495 in)
----------------------------	------------------------------------

Rocker levers

Bore diameter	19,070/19,101 mm (0.7508/0.7520 in)
Clearance fit on rocker shaft	0,033/0,089 mm (0.0012/0.0035 in)
Maximum permissible clearance	0,13 mm (0.005 in)

Inlet and exhaust valves**Inlet valves**

Diameter of valve stem	6,980/7,000 mm (0.2748/0.2756 in)
Clearance fit of valve in guide	0,027/0,072 mm (0.0011/0.0028 in)
Maximum permissible clearance in valve guide	0,15 mm (0.006 in)
Diameter of valve head	41,63/41,87 mm (1.639/1.648 in)
Angle of valve face	35°
Full length, engine types CP and CR	115,755/115,105 mm (4.557/4.532 in)

Depth of valve head below cylinder head face:

CP and CR engines.	1,60/1,90 mm (0.063/0.075 in)
Service limit	1,65 mm (0.065 in)
Seal arrangement ⁽¹⁾	Rubber seal fitted to valve guide

⁽¹⁾ Certain engines do not have a seal fitted to the valve guide for the inlet valve. Ensure that the full engine part number is used to order parts.

Exhaust valves

Diameter of valve stem	6,966/6,987 mm (0.2743/0.2751 in)
Clearance fit of valve in guide	0,040/0,086 mm (0.0016/0.0034 in)
Maximum permissible clearance in valve guide	0,14 mm (0.0055 in)
Diameter of valve head	37,88/38,12 mm (1.491/1.501 in)
Angle of valve face	45°
Full length, engine types CP and CR	115,845/115,195 mm (4.56/4.53 in)

Depth of valve head below cylinder head face:

CP and CR engines	1,11/1,39 mm (0.044/0.055 in)
-Service limit	1,64 mm (0.065 in)
Seal arrangement	Rubber seal fitted to valve guide

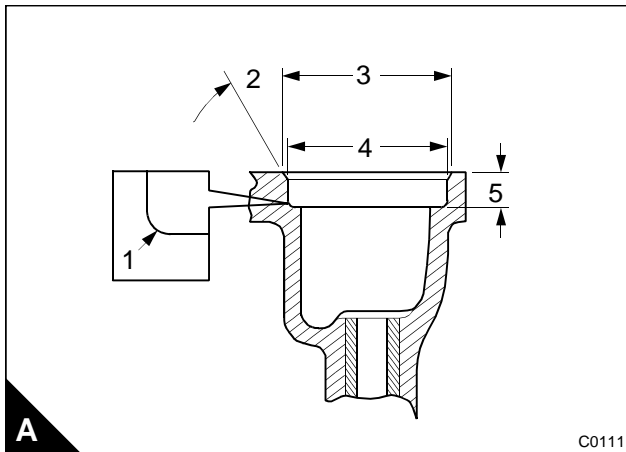
Dimensions of a recess for a valve seat insert

Exhaust valve

A1...	Radius 0,42 mm (0.017 in) maximum
A2...	45° chamfer
A3...	43,1/43,3 mm (1.67/1.70 in)
A4...	40,620/40,645 mm (1.5992/1.6002 in)
A5...	10,06/10,19 mm (0.396/0.401 in)

Inlet valve

A1...	Radius 0,42 mm (0.017 in) maximum
A2...	45° chamfer
A3...	44,3/44,5 mm (1.74/1.75 in)
A4...	41,907/41,932mm (1.6499/1.6509)
A5...	9,94/10,06 mm (0.3913/0.3961)

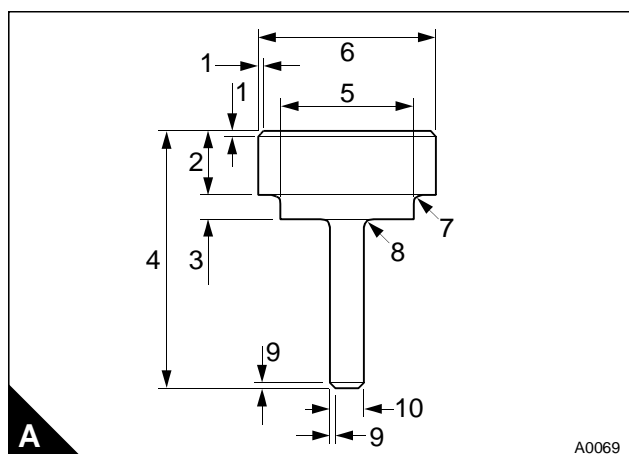


Valve seat insert tool**Inlet**

A1	...	1,59 mm (0.063 in)
A2	...	19,05 mm (0.750 in)
A3	...	7,92 mm (0.312 in)
A4	...	76,20 mm (3.00 in)
A5	...	36,10/36,15 mm (1.421/1.423 in)
A6	...	43,30/43,40 mm (1.705/1.709 in)
A7	...	0,79 mm (0.031 in)
A8	...	1,59 mm (0.063 in)
A9	...	1,59 mm (0.063 in)
A10	...	6,98/7,00 mm (0.275/0.276 in)

Exhaust

A1	...	1,59 mm (0.063 in)
A2	...	19,05 mm (0.750 in)
A3	...	7,92 mm (0.312 in)
A4	...	76,20 mm (3.00 in)
A5	...	32,30/32,40 mm (1.272/1.276 in)
A6	...	39,62/39,72 mm (1.560/1.564 in)
A7	...	0,79 mm (0.031 in)
A8	...	1,59 mm (0.063 in)
A9	...	1,59 mm (0.063 in)
A10	...	6,98/7,00 mm (0.275/0.276 in)



Piston and connecting rod assembly

Pistons and connecting rods

Type	Re-entrant bowl, off set gudgeon pin
Height grades	X and Y
Height of piston above top face of cylinder block	0,23/0,35 mm (0.009/0.014 in)
Diameter of bore for gudgeon pin	31,753/31,759 mm (1.2501/1.2504 in)
Width of groove for top ring (CP)	2,560/2,580 mm (0.1008/0.1016 in)
Width of groove for top ring CR	3,0mm (0.1181 in)
Width of groove for second ring	2,020/2,040 mm (0.0800/0.0803 in)
Width of groove for third ring	4,010/4,030 mm (0.1579/0.1587 in)

Piston rings

Top compression ring (CP)	Barrel face, molybdenum insert
Top compression ring (CR)	Wedge shaped, barrel face, molybdenum insert
Second compression ring	Taper face, cast iron, chamfer at inner bottom edge
Oil control ring	Coil spring loaded, chromium faced
Width of top ring (CP)	2,475/2,490 mm (0.0974/0.0980 in)
Width of top ring (CR)	3,0 mm (0.1181 in)
Width of second ring	1,975/1,990 mm (0.0778/0.0783 in)
Width of third ring	3,975/3,990 mm (0.1565/0.1571 in)
Clearance of top ring in groove	0,07/0,11 mm (0.003/0.004 in)
Clearance of second ring in groove	0,03/0,07 mm (0.001/0.003 in)
Clearance of third ring in groove	0,02/0,06 mm (0.001/0.002 in)
Maximum permissible clearance in top groove	0,20 mm (0.008 in)
Maximum permissible clearance in other grooves	0,10 mm (0.004 in)
Gap of top ring (CP)	0,25/0,48 mm (0.010/0.019 in)
Gap of top ring (CR)	0,25/0,51 mm (0.010/0.020 in)
Gap of second ring	0,40/0,73 mm (0.016/0.029 in)
Gap of third ring	0,30/0,68 mm (0.012/0.027 in)

Connecting rods

Type	"H" section
Diameter of parent bore for big end	60,833/60,846 mm (2.3950/2.3955 in)
Diameter of parent bore for small end	34,920/34,956 mm (1.3745/1.3762 in)
Big end width	39,375/39,434 mm (1.5502/1.5525 in)
Big end side clearance on crank pin	0,24/0,50 mm (0.009/0.020 in)
Length between centres	223,812/223,863 mm (8.8115/8.8135 in)

Continued

Gudgeon pins

Type. Fully floating
 Outside diameter 31,745/31,750 mm (1.2498/1.2500 in)
 Clearance fit in piston boss 0,003/0,014 mm (0.0001/0.0006 in)

Small end bushes

Type. Steel back, lead bronze face
 Outside diameter 35,014/35,052 mm (1.3785/1.3800 in)
 Inside diameter (reamed) ... 31,763/31,788 mm (1.2505/1.2515 in)
 Clearance fit on gudgeon pin... 0,013/0,043 mm (0.0005/0.0017 in)

Connecting rod bearings

Type. Steel back, aluminium tin face
 Inside diameter ... 57,188/57,214 mm (2.2515/2.2525 in)
 Clearance on big end .. 0,058/0,104 mm (0.0023/0.0041 in)
 Thickness at centre of bearings... 1,816/1,823 mm (0.0715/0.0718 in)
 Available undersize bearings... - 0,25 mm (0.010 in); - 0,51 mm (0.020 in); - 0,76 mm (0.030 in)

Crankshaft assembly

Crankshaft

Diameter of main journal	69,812/69,832 mm (2.7485/2.7493 in)
Width of second and third main journals	30,853/31,057 mm (1.2147/1.2227 in)
Width of fourth main journal	46,805/46,881 mm (1.8427/1.8457 in)
Fillet radii of main journal	2,39/2,77 mm (0.094/0.109 in)
Fillet radii of crank pins	3,96/4,37 mm (0.156/1.172 in)
Diameter of crank pins	51,110/57,130 mm (2.2484/2.2492 in)
Width of crank pins	39,67/39,75 mm (1.562/1.565 in)
Crankshaft end-float (CP)	0,05/0,36 mm (0.002/0.014 in)
Crankshaft end-float (CR)	0,05/0,36 mm (0.002/0.014 in)
Maximum permissible end-float	0,50 mm (0.020 in)
Maximum permissible wear on main journals and crank pins	0,038 mm (0.0015 in)
Undersize journals and crank pins	- 0,25 mm (0.010 in); - 0,51 mm (0.020 in); - 0,76 mm (0.030 in)

Crankshaft heat treatment

No heat treatment	Part number 31312734
Induction hardened	Part numbers 31312733, 31312737
Tufftrided	Part numbers 31312738, 31312739

Main bearings

Type	Steel back, aluminium tin face
Width of first bearing	32,11/32,36 mm (1.264/1.274 in)
Width of second and third bearing	23,55/23,80 mm (0.927/0.937 in)
Width of fourth bearing	38,91/39,17 mm (1.532/1.542 in)
Thickness at centre of bearing	2,096/2,102 mm (0.0825/0.0828 in)
Inside diameter	69,875/69,914 mm (2.7510/2.7525 in)
Bearing clearance	0,043/0,102 mm (0.0017/0.0040 in)
Available undersize bearings	- 0,25 mm (0.010 in); - 0,51 mm (0.020 in); - 0,76 mm (0.030 in)

Crankshaft thrust washers

Type	Steel back, aluminium tin face
Position	Each side of rear main bearing
Thickness:	
Standard	3,07/3,12 mm (0.121/0.123 in)
Oversize	3,26/3,31 mm (0.128/0.130 in)

Crankshaft overhaul

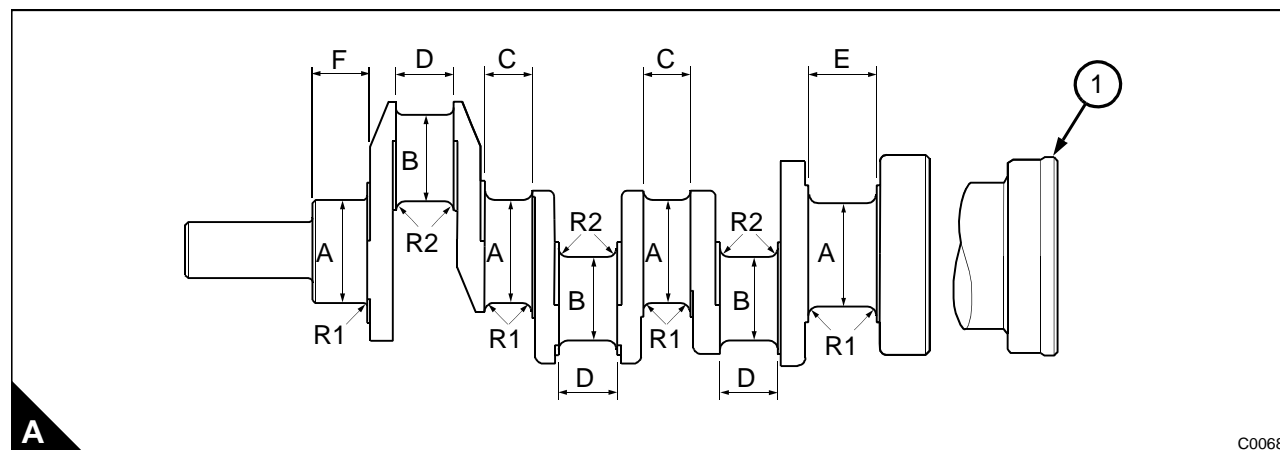
Notes:

- Induction hardened crankshafts need not be hardened after they have been machined undersize.
- Tufftrided crankshafts must be hardened again each time they are machined. If this process is not available, they can be nitrided for 20 hours. If neither process is available, a new crankshaft, or Power Exchange crankshaft, must be fitted.
- Check the crankshaft for cracks before and after it is ground.
- Demagnetise the crankshaft after it has been checked for cracks.
- After the crankshaft has been machined remove any sharp corners from the lubricating oil holes.
- Surface finish and fillet radii must be maintained.

The finished sizes for corrected crankshafts (A) are given in the table below:

Item	0,25 mm (0.010 in) Undersize	0,51 mm (0.020 in) Undersize	0,76 mm (0.030 in) Undersize
A	69,56/69,58 mm (2.7385/2.7393 in)	69,30/69,32 mm (2.7285/2.7293 in)	69,05/69,07 mm (2.7185/2.7193 in)
B	56,86/56,88 mm (2.2384/2.2392 in)	56,60/56,62 mm (2.2284/2.2292 in)	56,35/56,37 mm (2.2184/2.2192 in)

C	31,184 mm (1.22775 in) maximum
D	40,00 mm (1.575 in) maximum
E	47,27 mm (1.861 in) maximum
F	35,64/36,643 mm (1.403/1.443 in)
R1, all journals.	2,38/2,78 mm (0.0937/0.1093 in)
R2, all crankpins ..	3,97/4,36 mm (0.1562/0.1718 in)
Finished surface of journals and crankpins ..	0,40 microns (16 micro inches)
Fillet radii, centre line average maximum ..	1.3 microns (50 micro inches)
Crankshaft palm (A1) minimum diameter ..	133,17 mm (5.243 in)



Notes:

- The end of the crankshaft palm must not be ground. This will ensure that a spigot 4,8 mm (0.19 in) remains for location of the flywheel.
- Remove the minimum material to remove the wear marks.
- Magnetic crack detection DC Current- 2 amps, AC current - 1300 amps

Maximum taper and out of round for journals and crankpins

Taper.. ... 0,009 mm (0.00035 in)

Out of round... ... 0,010 mm (0.00039 in)

Maximum run-out with crankshaft mounted on end journals:

Crankshaft pulley diameter (total indicator reading) 0,025 mm (0.001 in)

Rear oil seal diameter (total indicator reading) 0,025 mm (0.001 in)

Flywheel flange diameter (total indicator reading) 0,025 mm (0.001 in)

Run-out

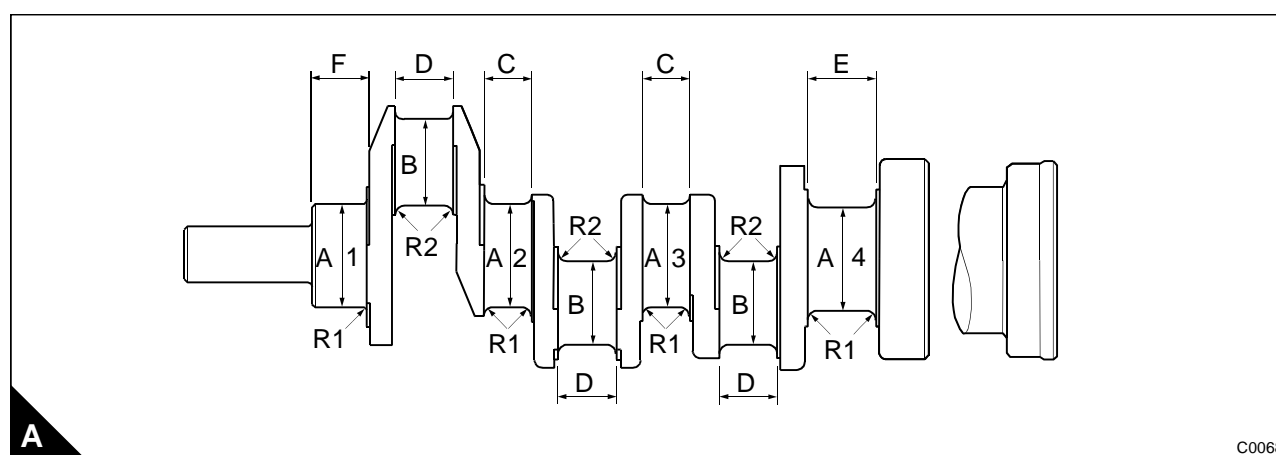
With the crankshaft on mountings at the front and rear journals, the maximum run-out (total indicator reading) at the journals must not be more than shown below:

A1... .. Mounting

A2... .. 0,5 mm (0.002 in)

A3... .. 0,5 mm (0.002 in)

A4... .. Mounting



Timing case and drive assembly

Camshaft

Diameter of camshaft journals. 47,450/47,475 mm (1.8681/1.8691 in)

Clearance of journals in cylinder block 0,125/0,200 mm (0.0050/0.0080 in)

Cam lift:

- Inlet 7,63/7,73 mm (0.300/0.304 in)

- Exhaust 7,90/8,00 mm (0.311/0.315 in)

Spigot diameter for gear .. 50,76/50,79 mm (1.9985/1.9995 in)

Maximum permissible camshaft journal wear.. 0,05 mm (0.002 in)

Maximum permissible end-float... 1,25 mm (0.049 in)

Camshaft gear

Number of teeth... 50

Diameter of bore.. 50,787/50,825 mm (1.9995/2.001 in)

Clearance fit of gear on spigot. 0,000/0,063 mm (0.0000/0.0025 in)

Fuel pump gear

Number of teeth... 50

Bore diameter 44,45/44,48 mm (1.750/1.751 in)

Spigot diameter of pump 44,40/44,42 mm (1.748/1.749 in)

Clearance fit of gear on spigot. 0,03/0,08 mm (0.0012/0.0030 in)

Crankshaft gear

Number of teeth... 25

Diameter of bore.. 38,087/38,125 mm (1.4995/1.5010 in)

Diameter of crankshaft nose 38,100/38,113 mm (1.5000/1.5005 in)

Transition fit of gear on crankshaft -0,026/+0,025 mm (-0.0010/+0.0010 in)

Idler gear and hub

Number of teeth... 90

Diameter of bore in gear.. 53,98/54,02 mm (2.1250/2.1266 in)

Diameter of hub 53,92/53,94 mm (2.1230/2.1238 in)

Clearance of gear on hub 0,030/0,092 mm (0.0012/0.0036 in)

Width of gear 33,465/33,592 mm (1.3175/1.3225 in)

Width of hub 33,719/33,846 mm (1.3275/1.3325 in)

End-float of gear 0,13/0,38 mm (0.005/0.015 in)

Maximum permissible end-float... 0,46 mm (0.018 in)

Backlash for all gears 0,08 mm (0.003 in) minimum

Cylinder block assembly

Cylinder block

Height between top and bottom faces	349,01/349,09 mm (13.740/13.744 in)
Diameter of cylinder bore	97,012/97,037 mm (3.8193/3.8203 in)
Maximum permissible wear in bore	0,18 mm (0.007 in)
Diameter of parent bore for main bearing	74,079/74,105 mm (2.9165/ 2.9175 in)
Diameter of bores for camshaft	47,600/47,651 mm (1.8740/1.8760 in)
Diameter of bore for front journal bush	50,80/50,83 mm (2.00/2.0012 in)
Maximum permissible wear in bore for camshaft	0,05 mm (0.002 in)

To fit a liner

Diameter of parent bore for cylinder liner	97,108/97,133 mm (3.823/3.824 in)
Parent bore finish grade	1,8 micrometers maximum Ra
Parent bore chamfer	0,10/0,25mm (0.004/0.010 in) at 30° to the vertical

Cylinder liner specifications

Partially finished liner

Interference fit of partially finished liner in parent bore	0,026/0,076mm (0.001/0.003 in)
Inside diameter of partially finished liner	94,894/94,925 mm (3.736/3.7372 in)
Outside diameter	97,159/97,184 mm (3.825/3.826 in)
Inside diameter (finished size)	95,012/95,037 mm (3.7406/3.7416 in)
Finished liner internal top chamfer	1,2 mm (0.00472 in) at 16° to the vertical
Length	215,77/216,03 mm (8.494/8.505)
Relative position of top of liner to top face of cylinder block	- 0,075 / +0,050 mm (0.003/0.020 in)

Surface finish of the preliminary bore

Final size of liner before it is honed	94,894/94,925 mm (3.736/3.7372 in)
Grade of bore finish	2,5 to 4,0 micrometers Ra
Maximum ovality and taper	0,02 mm (0.0008 in)

Surface finish diamond hone

Hone angle (cross hatch)	35°
Finish size, diamond honed	94,987/94,997 mm (3.7396/3.7400 in)
Grade of surface finish	2,2 to 3,0 micrometers Ra
Maximum ovality and taper	0,012 mm (0.0005 in)

Surface finish of the Silicone carbide base hone

Hone angle (cross hatch)	35°
Finish size, silicon carbide base hone	95,012/95,032 mm (3.7406/3.7414 in)
Grade of bore finish	1,5 to 2,0 micrometers Ra
Maximum ovality and taper	0,010 mm (0.0004 in)

Silicone carbide plateau hone finish

Final finish size, silicon carbide (plateau hone)	95,012/95,037 mm (3.7406/3.7416 in)
Final finish grade, silicon carbide (plateau hone)	0,65/1,3 micrometers Ra
Chamfer	1,2 mm (0.0472 in) at 16° to the vertical
Maximum permissible wear in bore	0,18 mm (0.007 in)

Timing data

Delphi fuel injection pump, locked

Make Delphi DP200 Series
 Direction of rotation Clockwise from drive end
 Fuel pump code letters⁽¹⁾ AN, BN
 Fuel pump lock angle AN-88°, BN-88°
 No. 1 outlet Letter "U"

(1) Fuel pump lock angle - static timing

An example of the pump code is 2644A000AN/2/2270. The fuel pump code begins with the pump part number, followed by two letters, then a number for the governor spring position and lastly the maximum no-load speed. For identification purposes, only the two code letters are used. This information can be found on the data plate of the fuel pump.

The mark on the flange of the pump can be checked with timing tool, Part number 21825610. The lock angle is set with timing tool, Part number 21825610.

Delphi fuel injection pump, pin-timed

Make Delphi DP200 Series, pin-timed, with a locking screw
 Fuel pump code letters CN, DN, EN, FN
 Direction of rotation Clockwise from drive end

The fuel injection pump is timed to the engine with the engine set at TDC No.1 cylinder on the compression stroke.

Stanadyne fuel injection pump, pin-timed

Type Stanadyne DB4, pin-timed, with a locking screw
 Fuel pump code letters GN
 Direction of rotation from drive end Clockwise from drive end

Lubrication system

Lubricating oil pump

Type	Differential rotor, gear driven
Number of lobes	Inner rotor 3, outer rotor 4
Clearance of outer rotor to pump body	0,23/0,33 mm (0.009/0.013 in)
Inner rotor to outer rotor	0,064/0,114 mm (0.0025/0.0045 in)
Inner rotor end clearance	0,038/0,089 mm (0.0015/0.0035 in)
Outer rotor end clearance	0,025/0,076 mm (0.0010/0.0030 in)

Lubricating oil pump drive gear

Number of teeth	19
Diameter of bore	12,624/12,644 mm (0.4970/0.4978 in)
Diameter of drive shaft for pump	12,675/12,687 mm (0.4990/0.4995 in)
Interference fit of gear on shaft	-0,031/ -0,063 mm (-0.0012/-0.0025 in)

Idler gear for lubricating oil pump

Number of teeth	21
Diameter of bore for bush	19,050/19,075 mm (0.7500/0.7510 in)
Outside diameter of bush	19,101/19,139 mm (0.7520/0.7535 in)
Interference fit of bush in gear	-0,026/-0,089 mm (-0.0010/-0.0035 in)
Inside diameter of bush - fitted	16,667/16,693 mm (0.6562/0.6572 in)
Shaft diameter for gear	16,632/16,645 mm (0.6548/0.6553 in)
Clearance of gear on shaft	0,022/0,061 mm (0.0009/0.0024 in)
End-float of gear	0,20/0,58 mm (0.008/0.023 in)

Lubricating oil relief valve

Diameter of bore in pump body	14,237/14,288 mm (0.5605/0.5625 in)
Outside diameter of plunger	14,186/14,211 mm (0.5585/0.5595 in)
Clearance fit of plunger in bore	0,03/0,10 mm (0.001/0.004 in)
Length of spring (fitted)	32,5 mm (1.28 in)
Load on spring (fitted)	34,5/ 36,7 N (7.76/8.24 lbf) 3,5/3,7 kgf
Setting pressure	.345/448 kPa (50/ 65 lbf/in ²) 3,52/4,57 kgf m ²

Lubricating oil filter

Type	Full flow, screw-on type canister
Pressure to open by-pass valve	55/ 120 kPa (8/17 lbf/in ²) 0,56/1,22 kgf/cm ²

Fuel system

Delphi fuel injection pump, naturally aspirated engines

Make Delphi DP200 Series (locked)
 Direction of rotation Clockwise from drive end
 Fuel pump code letters ⁽¹⁾ AN, BN
 Fuel pump lock angle AN-89°, BN-88°
 No. 1 outlet Letter "U"

(1) Fuel pump lock angle - static timing

An example of the pump code is 2644A000AN/2/2270. The fuel pump code begins with the pump part number, followed by two letters, then a number for the governor spring position and lastly the maximum no-load speed. For identification purposes, only the two code letters are used. This information can be found on the data plate of the fuel pump.

The mark on the flange of the pump can be checked with timing tool, Part number 21825610. The lock angle is set with timing tool Part number 21825610.

The fuel injection pump is timed to the engine with the engine set at TDC No.1 cylinder on the compression stroke.

Delphi fuel injection pump, turbocharged and naturally aspirated engines

Make Delphi DP200 Series, (pin-timed)
 Direction of rotation Clockwise from drive end
 Fuel pump code letters ⁽¹⁾ CN, DN, EN and FN
 Fuel pump lock angle AN-89°, BN-88°
 No. 1 outlet Letter "U"

(1) Fuel pump lock angle - static timing

The fuel injection pump is timed to the engine with the engine set at TDC No.1 cylinder on the compression stroke.

Stanadyne fuel injection pump, naturally aspirated engines

Make Stanadyne DB4 (pin-timed)
 Direction of rotation Clockwise from drive end
 Fuel pump code letters GN

Fuel filter

Type. Single element canister type or Stanadyne quick release

Atomiser service settings

Code	Holder	Nozzle	Set and reset pressure		
			atm	(lbf/in ²)	MPa
KB	2645A308	2645A624	300	4410	30,4
KS	2645A316	2645A637	294	4322	29,8
KL	2645A312	2645A633	294	4322	29,8
KM	2645A313	2645A634	294	4322	29,8
PF	2645L311	2645L620	280	4115	28,4

Notes:

- The code letters are stamped on the side of the atomiser body just below the connection for the nut of the high pressure pipe.
- Fuel lift pump

Type Diaphragm
 Method of drive Eccentric on camshaft
 Static pressure - no delivery 41/69 kPa (6/ 10 lbf/in²) 0,4/0,7 kgf/cm²
 Test pressure at 1000 rev/ min. 42/70 kPa (6/10 lbf/ in²) 0,4/0,7 kgf/cm²

Cooling system

Type Thermostat controlled - pump assistance

Coolant pump

Type Centrifugal, belt driven
 Diameter of shaft 15,905/15,918 mm (0.6262/0.6267 in)
 Diameter of bore in pulley 15,847/15,867 mm (0.6239/0.6247 in)
 Interference fit of pulley on shaft -0,038/ -0,071 mm (-0.0015/-0.0028 in)
 Diameter of bore in impeller... .. 15,872/15,893 mm (0.6250/0.6257 in)
 Interference fit of impeller on shaft. 0,012/0,046 mm (0.0005/0.018 in)
 Interference fit of water seal in body -0,005/0,281mm (-0.0002/ -0.0111 in)
 Interference fit of water seal on shaft. -0,047/-0,136 mm (-0.0019/-0.0054 in)
 Clearance between impeller blades and pump body. 0,25/0,50 mm (0.010/0.020 in)
 Dimension, pulley face for fan to rear face of pump body.. ... 114,3 mm (4.5 in)

Thermostat

Type Wax
 "Starts to open" temperature.. ... 80/84 °C (176/183 °F)
 "Fully open" temperature 96 °C (20 °F)

Valve lift:

Starts to open. 0,2 mm (0.008 in)
 Fully open 9,0 mm (0.350 in)

Electrical equipment**Alternator**

Make Magneti Marelli A127-65
Rating 12V/65A

Starter motor

Make Magneti Marelli M127
Voltage 12V
Number of teeth on pinion 10
Maximum starter cable resistance at 20 °C (68 °F). 0.0012 ohm

Starting aid

Type. Electrically operated heater, with a fuel supply
Voltage 12V
Flow rate of fuel through starting aid 3,5/5,9 ml/min

Thread sealant

When setscrews or studs are fitted into holes that are tapped into the body of the engine, a suitable sealant should be used. Perkins have introduced the use of Micro Encapsulated Anaerobic Sealant (M.E.A.S) fasteners.

There is no requirement to use any other jointing compound or sealant when the fasteners are fitted into holes through oil or coolant galleries. The fasteners are identified by a red, blue, or other colour sealant around the fastener threads.

When M.E.A.S. sealed studs are used, ensure that the sealed end is fitted into the cylinder head / cylinder block etc. Threaded holes must have a 1,59 mm (0.0625 in) 45° chamfer, to prevent the removal of M.E.A.S. sealant when new fasteners are fitted. If the fasteners have to be removed and fitted again, the threads must be cleaned and a suitable sealant applied.

Standard torque tensions

Most of the torque tensions on the engine are standard. Special torque tensions are listed in the separate special torque tables. The standard torque tensions listed in the tables below can be used when a special torque is not necessary. The torque tensions below apply to components lubricated lightly with clean engine oil before they are fitted.

Standard torque for UNF/UNC setscrews and nuts

Thread size	Torque		
	Nm	lbf ft	kgf m
$\frac{1}{4}$	11	8	1,1
$\frac{5}{16}$	21	15	2,1
$\frac{3}{8}$	37	27	3,8
$\frac{7}{16}$	60	44	6,1
$\frac{1}{2}$	92	68	9,4
$\frac{9}{16}$	130	96	13,3
$\frac{3}{4}$	186	137	19,0

Standard torque for metric setscrews and nuts

Thread size	Torque		
	Nm	lbf ft	kgf m
M6 x 1,00	9	7	0,9
M8 x 1,25	22	16	2,2
M10 x 1,50	44	33	4,5
M12 x 1,75	78	58	8,0
M14 x 2,00	124	91	12,6
M16 x 2,00	190	140	19,3

Standard torque for pipe threaded parts

Thread size	Torque		
	Nm	lbf ft	kgf m
$\frac{1}{8}$ PTF	9,5	7	0,97
$\frac{1}{4}$ PTF	17	13	1,73
$\frac{3}{8}$ PTF	30	22	3,1
$\frac{1}{2}$ PTF	30	22	3,1
$\frac{3}{4}$ PTF	45	33	4,6
$\frac{3}{4}$ - 16 UNF	45	33	4,6

Standard torque for studs (metal end)

Thread size	Torque		
	Nm	lbf ft	kgf m
M8 x 1,00	11	9	1,1
M10 x 1,25	18	14	1,8
M12 x 1,50	25	19	2,5

Special torque tensions

Special torque for setscrews and nuts

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

Description	Thread size	Torque		
		Nm	lbf ft	kgf m
Cylinder head assembly				
Setscrews, cylinder head	M12/M14	(see Operation 3-10)		
Fasteners, rocker shaft brackets	M10	(see Operation 3-3)		
Cap nuts, rocker cover - metal cover	M10	30	22	3,0
Cap nuts, rocker cover - plastic cover	M10	20	15	2,0
Setscrews, inlet manifold to cylinder head	M8	22	16	2,2
Nuts, exhaust manifold to cylinder head	M8	22	16	2,2
Setscrews, engine lift bracket	M10	44	32	4,5
Temperature switch	⁵ / ₈ UNF	30	22	3,1
Temperature switch	³ / ₈ PTF	30	22	3,1
Piston and connecting rod assembly				
Nuts, connecting rods	⁷ / ₁₆ UNF	77,5	57	7,9
Crankshaft assembly				
Setscrews, main bearings	⁹ / ₁₆ UNF	152,5	112	15,6
Setscrews, crankshaft pulley	⁷ / ₈ UNF	325	240	33,1
Setscrews, crankshaft pulley with washer	⁷ / ₈ UNF	365	269	37,2
Setscrews, flywheel to crankshaft	¹ / ₂ UNF	105	77	10,7
Setscrews, rear oil seal housing	M8	22	16	2,2
Setscrew, balance weight to crankshaft	⁷ / ₁₆ UNF	73	54	7,4
Capscrew, adaptor to crankshaft pulley	³ / ₈ UNC	37	27	3,8
Setscrews, rear oil seal housing to cylinder block	M8	22	16	2,2
Timing case and drive assembly				
Setscrews, timing case to cylinder block	M8	22	16	2,2
Setscrews, bottom cover to timing case	M8	22	16	2,2
Setscrews, front cover to timing case	M8	22	16	2,2
Setscrews, front cover to timing case	M6	9	7	0,9
Setscrews, front cover to bridge piece, bottom cover	M8	22	16	2,2
Setscrews, camshaft gear	M8	27	20	2,8
Setscrews, idler gear	¹ / ₂ UNF	65	48	6,6
Setscrews, idler gear	M12	78	57	8,0
Cylinder block				
Setscrew sump clamping bracket	M12	78	58	8,0
Mazak plug, block front mounting clip	M12	3,5	3	0,4
Nut engine from mounting bracket	M12	78	58	8,0
Aspiration system				
Setscrew, inlet manifold to cylinder head	M8	22	16	2,2
Nuts, exhaust manifold to cylinder head	M8	22	16	2,2
Nuts, turbocharger to manifold (engine type CR)	M8	22	16	2,2
Elbow, turbocharger oil drain (engine type CR)	¹ / ₂ PTF	24	18	2,4
Induction heater	⁷ / ₈ UNF	30,5	22	3,1
Induction heater	M22	30,5	22	3,1

Description	Thread size	Torque		
		Nm	lbf ft	kgf m
Fuel system				
Nut, low pressure pipe (tank to pump inlet)	$\frac{1}{2}$ UNF	9	7	0,9
Nut, low pressure fuel pipe (vent to tank)	$\frac{1}{2}$ UNF	9	7	0,9
Nut, low pressure fuel pipe (vent)	M10	6	4	0,6
Nuts, high-pressure fuel pipes	M12	27	20	2,7
Banjo bolt fuel filter	$\frac{1}{2}$ UNF	23	17	2,3
Setscrews, atomiser clamp (engine type CP)	M8	22	16	2,2
Gland nut, atomiser	-	30	22	3,1
Setscrews for the gear of the fuel injection pump	M10	27	20	2,7
Torx screw, for the gear of the fuel injection pump	M10	27	20	2,7
Setscrews, fuel lift pump	M8	22	16	2,2
Banjo bolt leak-off pipe	M6	3	2	0,3
Setscrews, pump support bracket to cylinder block	M8	22	16	2,2
Nut, pump support bracket to fuel injection pump	M8	22	16	2,2
Nut, Hub of fuel injection pump	M14	80	59	8,2
Nuts, flange of fuel injection pump	M8	22	16	2,2
Locking screw of DP 200 fuel injection pump	10 A/F	10	7	1
Setscrews, Hub to fuel injection pump gear	M8	28	21	2,9
Lubrication system				
Plug, lubricating oil sump	$\frac{3}{4}$ UNF	34	25	3,5
Nuts and setscrews, lubricating oil sump	M8	22	16	2,2
Setscrew sump to block (engine type CR)	M8	30	22	3,1
Setscrews phosphated 12,9, sump to clamping bracket	M16	370	273	38,0
Setscrews, sump to clamping bracket block (engine type CR)	M16	170	125	17,3
Nut, sump to timing case stud (engine type CR)	M8	25	18	2,5
Olive nut lubrication oil pump pipe connection	$\frac{7}{8}$ UNF	55	41	v
Setscrews, oil pump to front bearing cap	M8	22	16	2,2
Setscrews, suction pipe to main bearing cap	M6	9	7	0,9
Setscrews, filter head	M10	44	32	4,5
Nuts and setscrews, lubricating oil sump with brackets	M8/M12	(see Operation 10-5)		
Cooling system				
Setscrews, adaptor plate to timing case	M8	22	16	2,2
Setscrews and nuts, coolant pump to timing case, front cover and adaptor plate	M8	22	16	2,2
Setscrews, fan to coolant pump pulley	M8	22	16	2,2
Flywheel and housing				
Setscrews, flywheel to crankshaft	$\frac{1}{2}$ UNF	105	77	10,7
Setscrews, flywheel housing adaptor plate	M10	44	32	4,5

Description	Thread size	Torque		
		Nm	lbf ft	kgf m
Electrical equipment				
Nut, alternator pulley (Lucas A127)	M17	80	59	8,2
Screw, adjusting lever to alternator pulley	M8	18	13	1,8
Adaptor for adjusting lever	³ / ₄ UNF	35	26	3,6
Screw and nut, starter motor	M10	55	41	5,6
Body of wax rotor	-	2	1	0,2
Oil pressure switch	¹ / ₈ PTF	9,5	7	1,0
Fuelled start aid to induction manifold	⁷ / ₈ UNF	31	23	3,1
Port heater to induction heater	M22	60	44	6,1
Pipe clips				
Up to and including 19 mm outside diameter	9 mm wide	3	2	0,3
Range 16 mm to 25 mm diameter	13 mm wide	5	4	0,5
Above 25 mm outside and up to 41 mm outside diameter	13 mm wide	5	4	0,5
Above 41 mm and up to 63 mm outside diameter	13 mm wide	6	4	0,6
Above 63 mm outside diameter	13 mm wide	7	5	0,7

Compression test data

Tests have shown that many factors affect compression pressures. Battery and starter motor condition, ambient conditions and the type of gauge used can give a wide variation of results for a given engine.

It is not possible to give accurate data for compression pressure, but tests have shown that the results should be within 2000/3500 kPa (300/500 lbf/in²) 21,0/35,0 kgf/cm² for diesel engines.

Compression tests should only be used to compare between the cylinders of an engine. If one or more cylinders vary by more than 350 kPa (50 lbf/in²) 3,5 kgf/cm², then those cylinders may be faulty.

Compression tests should not be the only method used to show the condition of an engine, but they should be used together with other symptoms and tests.

How to do a compression test

Caution: Before the compression test, ensure that the battery is in good condition and that it is fully charged. Also ensure that the starter motor is in good condition.

- 1 Ensure that the valve tip clearances are set correctly.
- 2 Remove the atomisers.
- 3 Fit a suitable gauge into the atomiser hole of the cylinder to be tested.
- 4 Ensure that the engine cannot start:
Disconnect the stop solenoid or put the stop control in the no-fuel position.
Operate the starter motor and note the pressure indicated on the gauge.
Repeat for each cylinder.

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3

Cylinder head assembly

General description

In a diesel engine there is little carbon deposit and for this reason the number of hours run is no indication of when to overhaul a cylinder head assembly. The factors that 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.

The valve sequence for number one cylinder is inlet then exhaust. This sequence continues for the remainder of the cylinders.

The face angle of the exhaust valves is 45°, and the face angle of the inlet valves is 35°. The angle of the valve seats in the cylinder head are 46° for the exhaust and 36° for the inlet.

Valve seat inserts for the inlet valves are fitted in the cylinder head of certain low rated engines. Other engines have valve seat inserts for the inlet valves and the exhaust valves.

The valves move in valve guides that can be renewed. The valve guides are the same for the inlet and the exhaust valves. Each valve guide has a counterbore at the valve head end of the guide.

Generally both valve stems are fitted with oil seals that fit over the top of the valve guides. Certain engines do not have an oil seal for the inlet valve.

The tappets are fitted in the cylinder head.

Rocker cover

To remove and to fit

Operation 3-1

Early engines are supplied with an aluminium rocker cover. The latest engines have a plastic rocker cover. Both of these covers have a seal (B1) fitted in the flange.

To remove

- 1 Disconnect the breather pipe, if fitted.
- 2 Remove the two cap nuts (A1). Each cap nut has a steel washer (A2), a shim washer (A3) and a rubber seal (A4).

Note: The shim washers are not used with the plastic rocker covers.

- 3 Lift off the rocker cover.

To fit

- 1 Check the condition of the rubber seals (A4), the steel washers (A2) and the shim washers (A3) for the cap nuts (A1). If necessary, the seals for the cap nuts can be renewed.

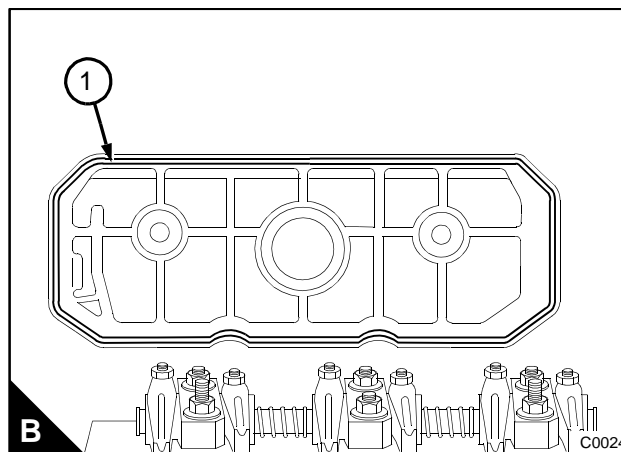
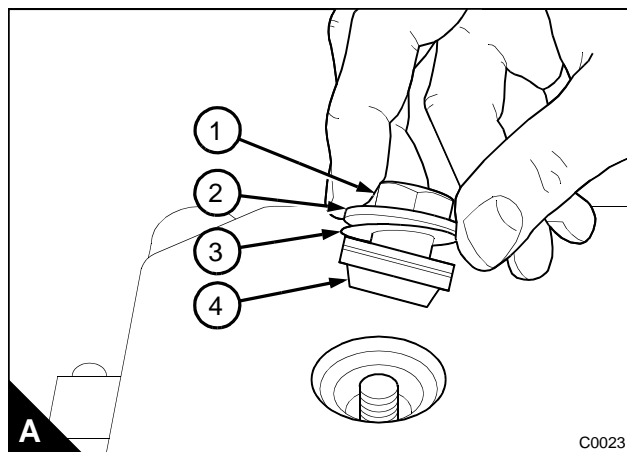
Note: The shim washers are not used with the plastic rocker covers.

- 2 Check the condition of the rocker cover seal (B1). If necessary, the seal can be renewed.
- 3 Clean the seal face of the cylinder head and fit the rocker cover.
- 4 Fit the steel washer, the shim and the seal to each cap nut and fit the cap nuts.

Caution: Damage to the seals can occur if the cap nuts are not tightened centrally through the sealing washer and the rocker cover. If the seals are damaged they must be renewed.

- 5 Tighten the cap nuts to 30 Nm (22 lbf ft) 3,1 kgf m for the aluminium rocker cover, or 20 Nm (15 lbf ft) 2,0 kgf m for the plastic rocker cover.

- 6 Fit breather pipes as necessary.



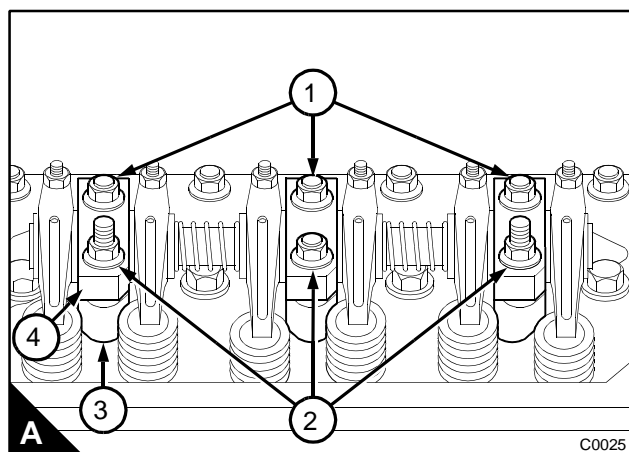
Rocker assembly

To remove

Operation 3-2

- 1 Remove the rocker cover, see Operation 3-1.
- 2 Release the nuts (A2) which are toward the valves. Release the nuts (A1) which are toward the push rods. Remove the nuts and lift off the top half-brackets (A4).
- 3 Lift off the rocker assembly together with the centre, lower half-brackets. If necessary, lift off the outer, lower half-brackets (A3).

Note: There is a hollow pin in the centre, lower half-bracket to correctly position the rocker shaft. The shaft is in the correct position when the hollow pin is located in the rocker shaft. This is to ensure correct lubrication of the rocker shaft assembly.



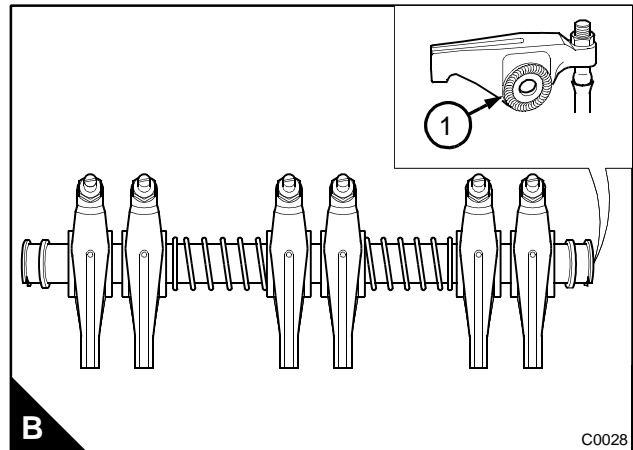
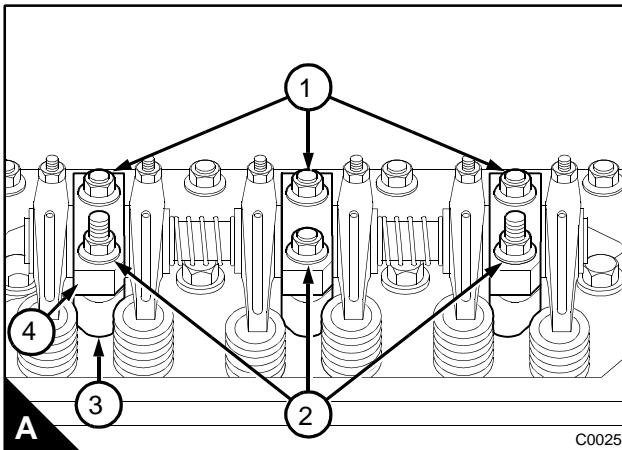
To fit

Operation 3-3

Cautions:

- Before the rocker shaft assembly is fitted, ensure that the open ends of the clips at each end of the rocker shaft assembly are toward the bottom of the rocker shaft. If this is not done, the clips can contact a cylinder head setscrew. This can cause damage to the setscrew and also cause the rocker assembly to be fitted incorrectly. Later rocker shaft assemblies are fitted with spring clips (B1) that do not need to be aligned on the rocker shaft.
- The rocker shaft must be fitted and tightened before the push rods are fitted.

1 Put the outer, lower half-brackets (A3) in position on the cylinder head. The tapered end of the lower half-brackets must be towards the valves. If they are not fitted correctly, the lubrication of the rocker shaft assembly will be affected.

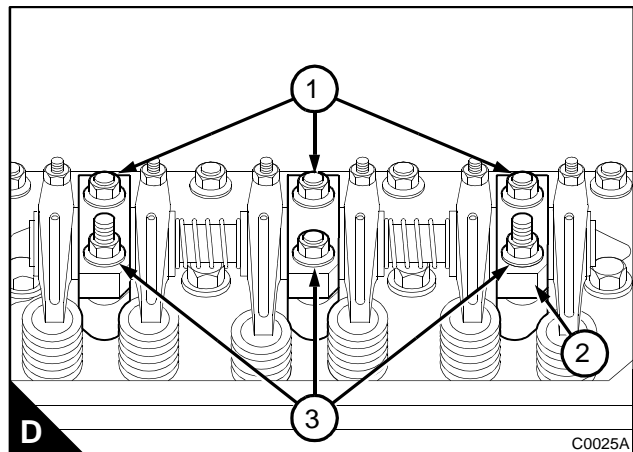
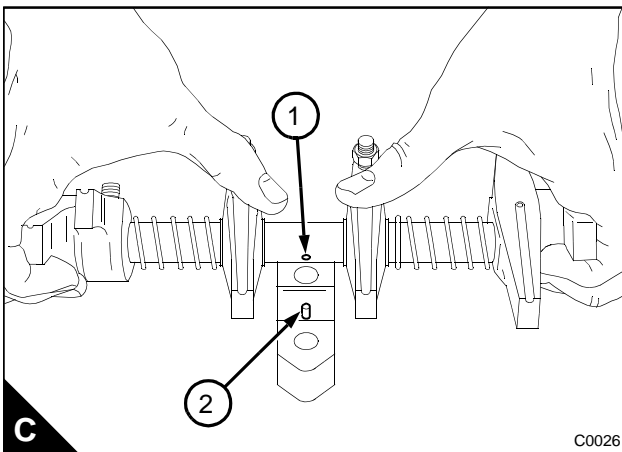


2 Ensure that the hollow pin (C2) is fitted fully into the centre, lower half-bracket. Ensure that the tapered end of the centre, lower half-bracket is towards the valve end of the rockers. Fit the rocker shaft onto the hollow pin, ensure that the pin enters the hole (C1) fully.

3 Put the rocker shaft assembly in position on the outer, lower half-brackets. It will be necessary to move the second and fifth rocker levers against the spring pressure to seat the rocker shaft correctly in the lower, half-brackets. Ensure that the hollow pin is still in the rocker shaft.

4 Fit the upper half-brackets. The chamfer (D2) on the upper half-brackets must be towards the valves.

Note: The upper half-brackets fitted to the latest engines do not have a chamfer. The part number, stamped on top of the bracket, must be towards the push rods.



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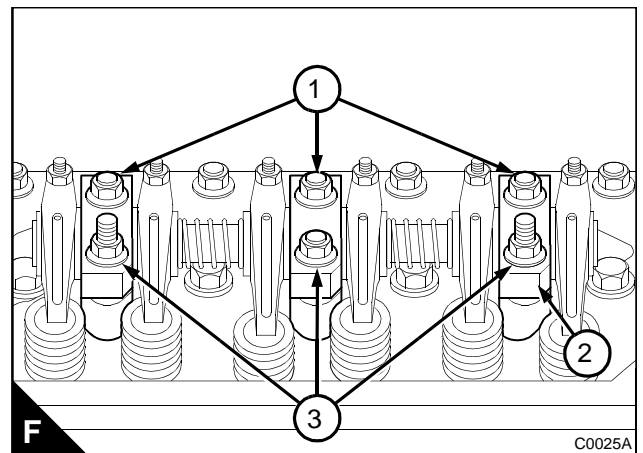
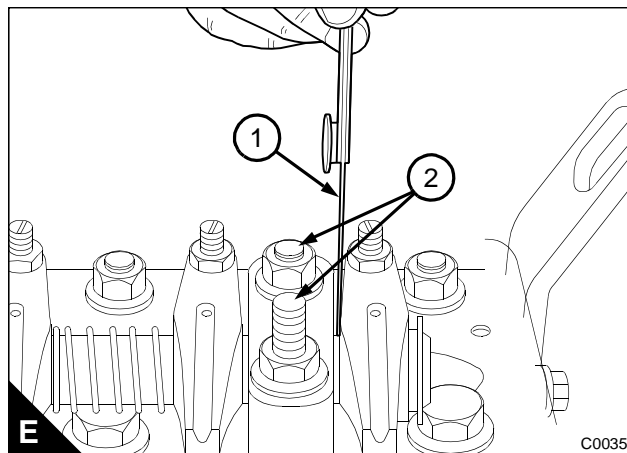
Caution: If the brackets are not fitted correctly, the upper brackets will not be able to fit over the rocker shaft and be aligned to the studs (E2).

5 Fit the six nuts for the rocker shaft brackets and tighten them finger tight.

Caution: When the nuts for the rocker shaft brackets are tightened to the correct torque, there will be a small gap between the upper and lower half-brackets at the push rod end of the brackets. It is important that the nuts are not tightened again or the tightness checked, as this could close the gap. If the gap is closed and the nuts are tightened further, damage could occur to the upper half-bracket.

6 It is necessary to ensure that the movement of the rocker shaft is centred. To do this:

Push the rocker shaft at one end and measure the gap between the rocker lever and the rocker bracket at the other end with feeler gauges (E1). Make a note of the measurement. Select feeler gauges equal to half of the measurement. Put the feeler gauges between the first or the last rocker lever and the rocker bracket. Push on the opposite end of the rocker shaft to close the gap onto the feeler gauges. Tighten the three nuts (F3) which are toward the valves to 44 Nm (32 lbf ft) 4,5 kgf m. Tighten the three nuts (F1) which are toward the push rods to 44 Nm (32 lbf ft) 4,5 kgf m. Remove the feeler gauges.



7 Release the lock nut for the adjustment screw on each rocker lever. Set the adjustment screws to the fully out position.

8 Rotate the crankshaft in the normal direction of rotation until the camshaft is in a position where the inlet valve of any cylinder has just opened and the exhaust valve of the same cylinder has not closed completely. All of the tappets will now be close to their lowest position. This will enable the push rods to be fitted more easily.

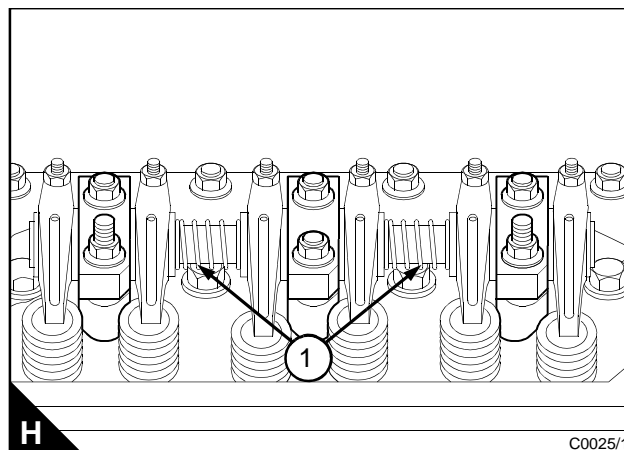
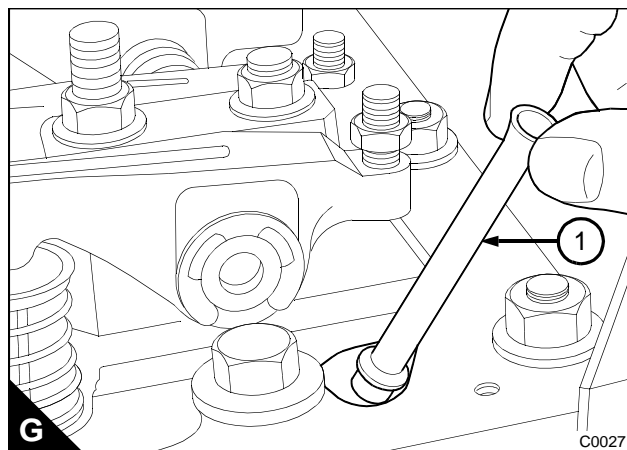
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9 Fit the push rods (G1) correctly in the sockets of the tappets. Set the adjustment screw in the rocker lever to just contact the socket in the push rod.

10 Set the valve tip clearances, see Operation 3-6.

11 Lubricate thoroughly the rocker shaft assembly, the valves and the push rods with clean engine lubricating oil.

Note: It is possible that after assembly, the rocker shaft springs may be in contact with the cylinder head fasteners (H1). This is acceptable, only if the side to side movement of the spring is not restricted and is free to operate normally.



To dismantle and to assemble

Operation 3-4

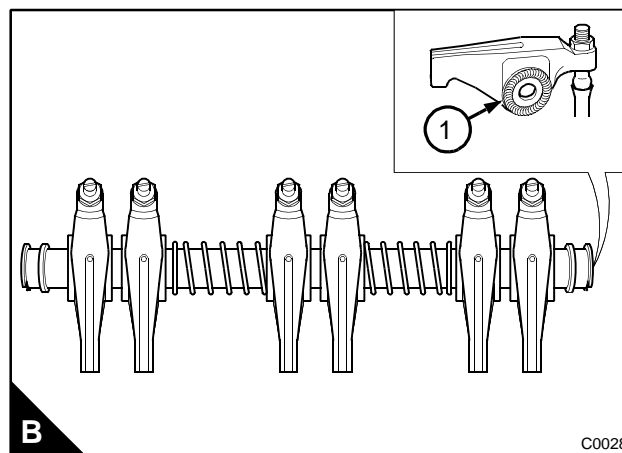
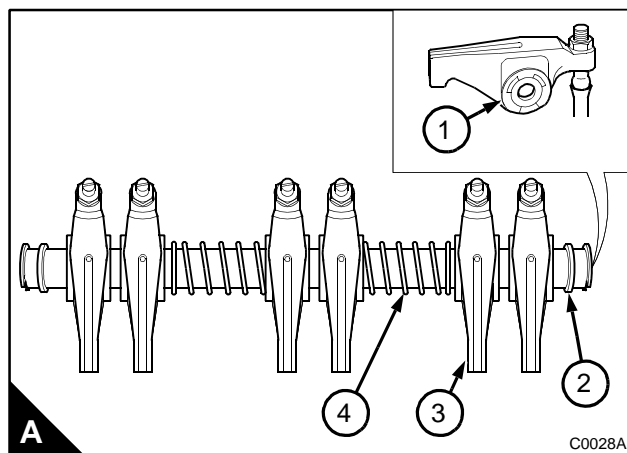
To dismantle

- 1 Remove the clips (A1) or (B1) from both ends of the rocker shaft. Ensure that the ends of the rocker shaft are not damaged.
- 2 Remove the spacer (A2), the rocker levers (A3) and the springs (A4).

To assemble

Caution: When the clips (A1) are fitted, ensure that the open ends are toward the bottom of the rocker shaft. If this is not done, the clips can contact a cylinder head setscrew when the rocker assembly is fitted. This can cause damage to the setscrew and can also cause the rocker assembly to be fitted incorrectly. Later engines are fitted with spring clips (B1) that do not have to be aligned.

- 1 Ensure that the oil holes in the rocker shaft and in the rocker levers are not restricted.
- 2 Lubricate the components with clean engine lubricating oil before assembly. Assemble the components in the correct sequence, the rocker levers should be fitted in the original sequence. Fit the clips to the ends of the rocker shaft.



To inspect

Operation 3-5

- 1 Clean and inspect all the components for wear and any other damage.
- 2 Check the clearance between the rocker levers and the rocker shaft. If the clearance is more than 0,13 mm (0.005 in), either renew the rocker lever or the rocker shaft, or both.

Valve tip clearances

To check and to adjust

Operation 3-6

The valve tip clearance is checked with feeler gauges between the top of the valve stem and the rocker lever (A), with the engine hot or cold. The correct clearance is 0,20 mm (0.008 in) for the inlet valves and 0,45 mm (0.018 in) for the exhaust valves. The valve positions are shown at (B).

The sequence of the valves from number 1 cylinder is shown in the table below.

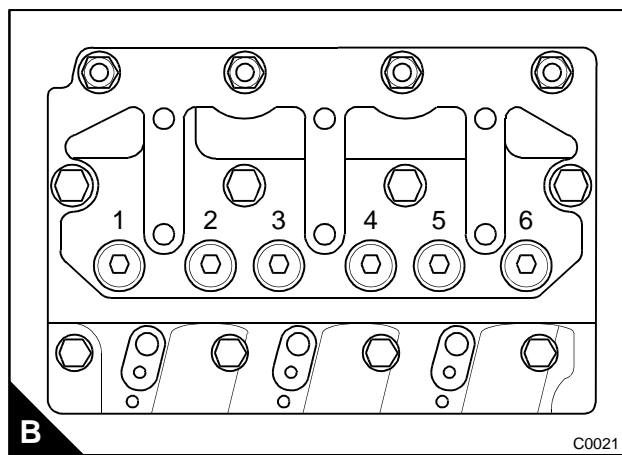
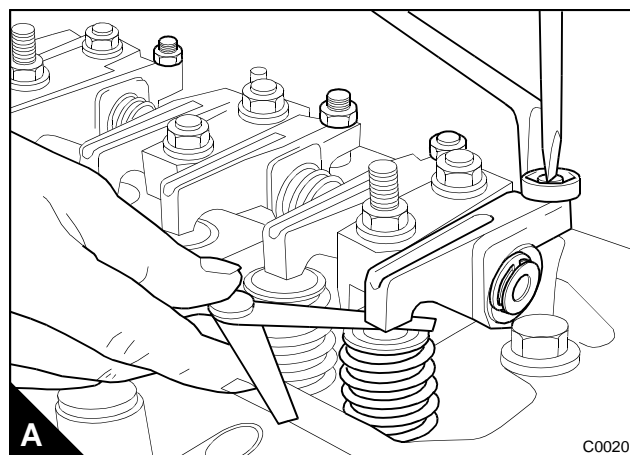
Note: Number 1 cylinder is at the front of the engine.

- 1 Rotate the crankshaft in the normal direction of rotation until the inlet valve of number 1 cylinder has just opened and the exhaust valve of the same cylinder has not closed completely. Check/adjust the clearance of valve number 3 and number 6 and adjust them, if necessary.
- 2 Set the valves of number 2 cylinder as indicated above for number 1 cylinder. Then check/adjust the clearance of valve number 2 and number 5.
- 3 Set the valves of number 3 cylinder. Then check/adjust the clearance of valve number 1 and number 4.
- 4 If necessary, fit a new seal to the rocker cover.

Ensure that the seal is fitted correctly and fit the cover. Fit the nuts which retain the rocker cover and tighten them to:

- Metal cover: 30 Nm (22 lbf ft) 3,1 kgf m
- Plastic cover: 20 Nm (15 lbf ft) 2,0 kgf m

Cylinder	1		2		3	
Valve number	1	2	3	4	5	6
Valve type	inlet	exhaust	inlet	exhaust	inlet	exhaust



Valve springs

To change the valve springs, with the cylinder head fitted

Operation 3-7

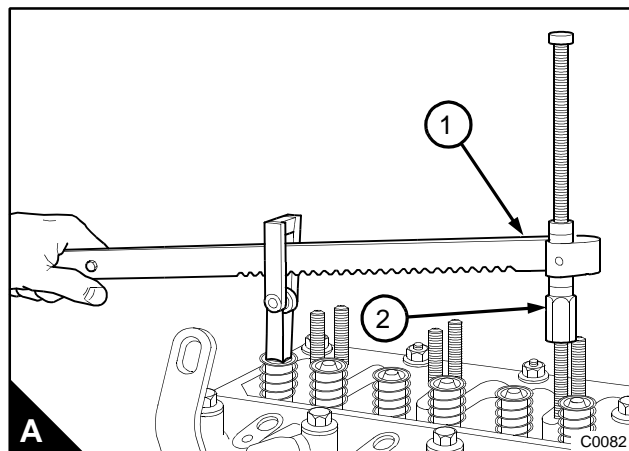
Special requirements

Special tools			
Description	Part number	Description	Part number
Valve spring compressor	21825666	Stud adaptor (used with valve spring compressor)	21825934

Warning! Wear eye protection when the valve spring is compressed.

Note: Steps 1 to 12 refer to a change of valve springs for a single cylinder.

- 1 Remove the rocker cover, see Operation 3-1.
- 2 Turn the crankshaft in the normal direction of rotation until the inlet valve of the relevant cylinder has just opened and the exhaust valve has not fully closed. In this position the piston will be at approximately top dead centre (TDC).
- 3 Remove the rocker assembly, see Operation 3-2.
- 4 Fit the valve spring compressor (A1) together with the adaptor (A2).



- 5 Compress the valve spring and remove the collets. Ensure that the valve spring is compressed squarely or damage to the valve stem can occur.
- 6 Do not turn the crankshaft while the valve springs are removed.
- 7 Release the valve spring compressor and remove the valve spring cap and the valve spring.
- 8 Put a new valve spring in position.
- 9 Fit the valve spring cap.

Caution: Ensure that the valve spring is compressed squarely or damage can occur to the valve stem.

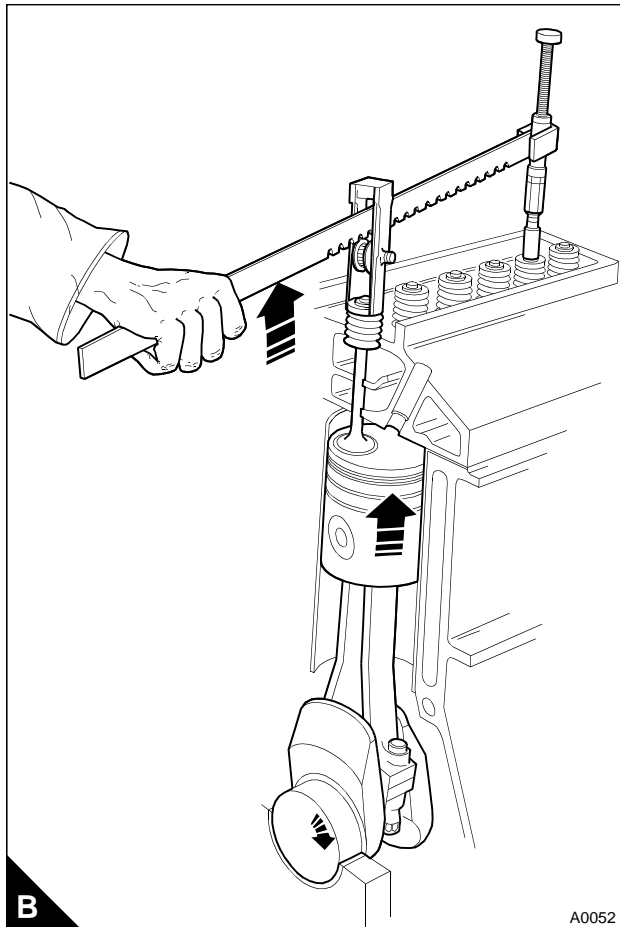
- 10 Fit the valve spring compressor, compress the valve spring and fit the collets. Remove the valve spring compressor.
- 11 Fit the rocker assembly, see Operation 3-3.
- 12 Check the valve tip clearances, see Operation 3-6.
- 13 Fit the rocker cover, see Operation 3-1.

Note: If other or all of the valve springs are to be changed, they can be changed one cylinder at a time in the sequence of cylinders 1, 2 and 3.

Continued

If the rocker assembly has been removed, piston TDC can be found as follows

- 1 Fit the valve spring compressor and compress the valve spring to open the valve.
- 2 Turn the crankshaft, by hand, in the normal direction of rotation until the piston touches the valve.
- 3 Continue to turn the crankshaft, and at the same time, release pressure on the valve spring compressor until the piston is at TDC (B).



Cylinder head assembly

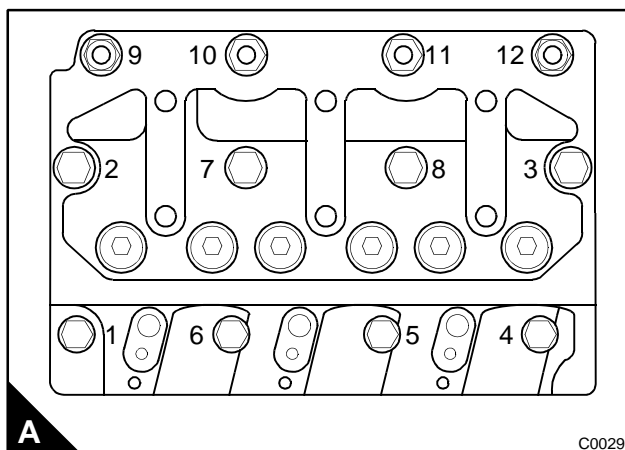
To remove

Operation 3-8

Caution: Coolant will enter the cylinder bores and the threaded holes for the cylinder head setscrews when the cylinder head is removed. Ensure that the coolant is removed immediately to prevent corrosion.

Note: Early engines had nuts and studs fitted in positions (A9) to (A12). On later engines the fasteners in (A10) and (A11) have been changed to M12 setscrews. These setscrews should be released and tightened in the same sequence as in (A9) to (A12) and to the same torque tension as the nuts on (A9) and (A12).

- 1 Drain the cooling system.
- 2 Disconnect the battery terminals.
- 3 Remove the air filter/cleaner hose at the induction manifold.
- 4 Remove the turbocharger if fitted, see Operation 9-1.
- 5 Remove the induction manifold and the gasket.
- 6 Remove the exhaust manifold and the gaskets.
- 7 Remove the vent pipe if fitted between the fuel injection pump and the first atomiser. Disconnect, from the rear of the cylinder head, the clip which retains the fuel pipe between the fuel filter and the fuel lift pump.
- 8 Remove the high-pressure fuel pipes. Fit suitable covers to all open connections on the fuel injection pump.
- 9 Remove the atomiser leak-off pipe.
- 10 Remove the atomisers, see Operation 11-5 or Operation 11-7. Fit suitable covers to the nozzles and to the open connections.
- 11 Release the clips on the hoses for the thermostat assembly and move the thermostat assembly away from the cylinder head.
- 12 Disconnect the coolant temperature sender unit.
- 13 Remove the rocker cover, see Operation 3-1.
- 14 Remove the rocker assembly, see Operation 3-2.
- 15 Remove the push rods.
- 16 Release the cylinder head fasteners evenly and gradually in the reverse sequence to that shown in (A). Remove the fasteners.
- 17 Lift the cylinder head carefully, ensure that the tappets remain on the camshaft. Do not use a lever to separate the cylinder head from the cylinder block. Remove the cylinder head and put it on a surface that will not damage the face of the cylinder head. After the cylinder head has been removed, put the tappets in their parent bores in the cylinder head. Discard the cylinder head gasket.



To fit the cylinder head

Operation 3-9

Cautions:

- The cylinder head gasket must be clean and free from scratches or other damage.
- The gasket must not be used if there is a scratch or other damage on the gasket or debris is on the outer surfaces or has entered between the layers of the gasket.
- The new gasket, the bottom face of the cylinder head and the top face of the cylinder block must be completely clean and free of scratches or other damage. If the faces are dirty or damaged, the gasket will not seal correctly.

Warning! Methyl Ethyl Ketone (MEK), also known as Butanone, is very flammable. Its storage and use must be in accordance with the manufacturers instructions. The vapour from MEK is toxic, therefore ensure that the work area has good ventilation. Protect your hands with gloves suitable for solvents. Wear eye protection.

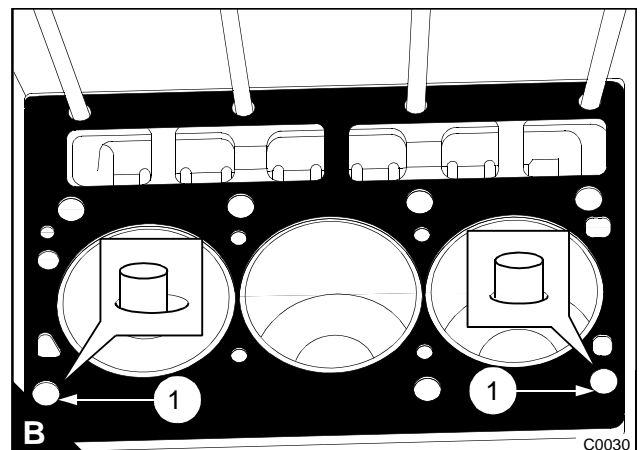
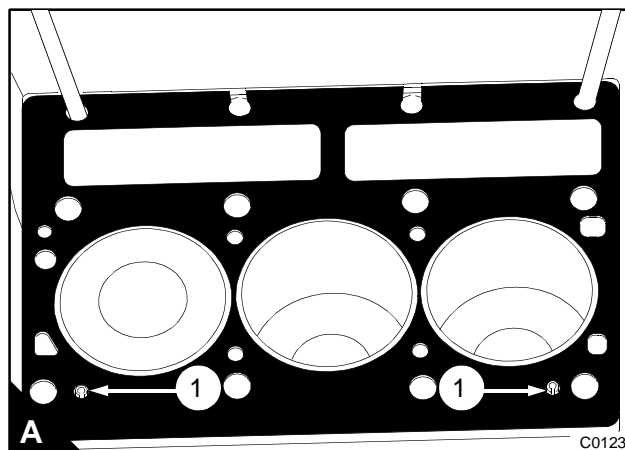
1 With a suitable cleaner, for example MEK, clean thoroughly the bottom face of the cylinder head and the top face of the cylinder block. Hard carbon can be removed with a hard plastic or hard wood scraper. Ensure that the top face of the cylinder block and the bottom face of the cylinder head are free from scratches or other damage.

2 Check that the threaded holes in the cylinder block and the cylinder head setscrews and studs are clean and in good condition. Ensure that there is no debris, coolant or oil in the cylinder bores.

Note: There are two methods used to position the gasket and the cylinder head on the cylinder block. Earlier engines used location pins (A1) and later engines use ring dowels (B1).

Cautions:

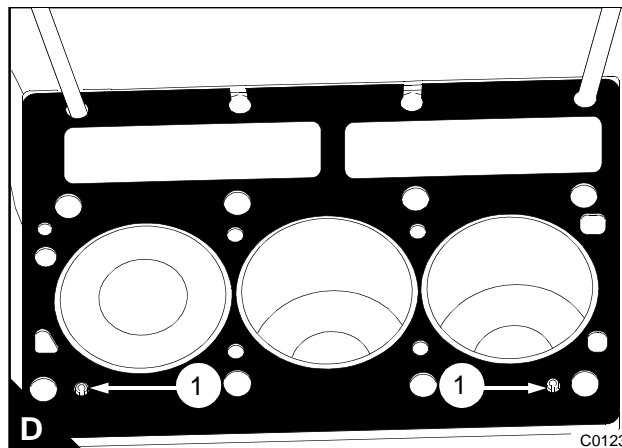
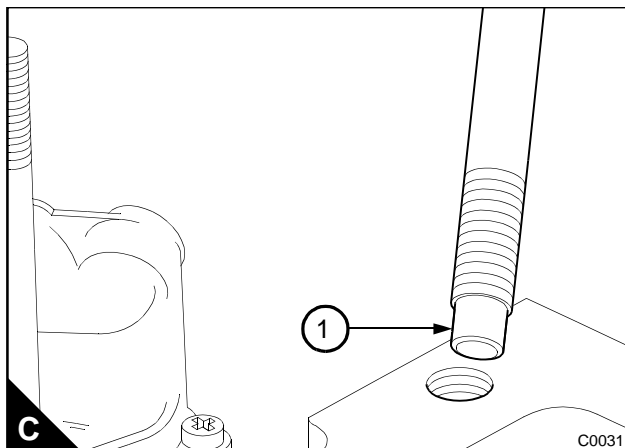
- Ensure that the location pins are pressed into the cylinder block.
- The cylinder head gasket must be fitted without jointing compound.



Continued

3 Ensure that the threads of the studs are clean and in good condition. If the studs were removed earlier, fit the four studs in the cylinder block. The studs are fitted with the non-threaded area (C1) at the end of the stud in the cylinder block. Tighten the studs to 25 Nm (18 lbf ft) 2,5 kgf m.

Warning! The gasket has sharp edges which can cut your hands. Protect your hands with gloves.

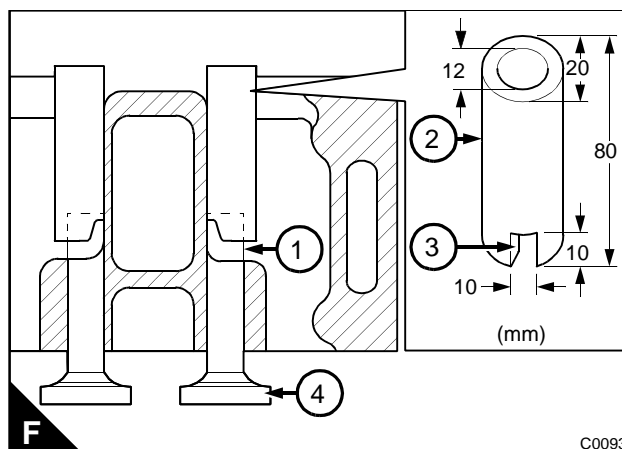
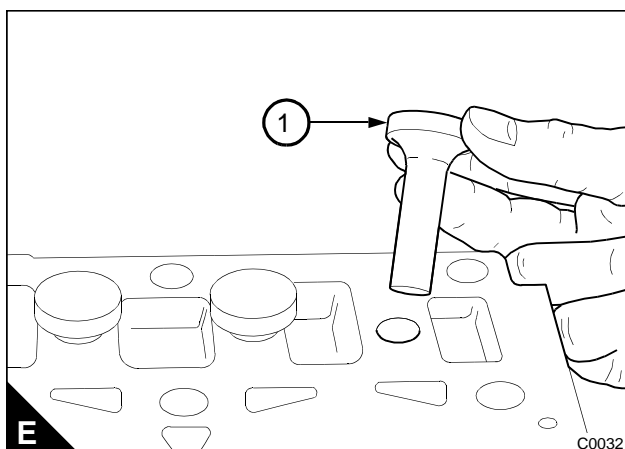


Caution: To ensure that the gasket remains clean, do not remove it from its container until it is to be fitted.

4 Check that the top face of the cylinder block is still clean.

5 Remove the cylinder head gasket from its container and put it in position on the two pins (D1) in the cylinder block. The part number, stamped on the gasket, must be to the top when the gasket is fitted.

6 Clean and dry the tappets and their parent bores in the cylinder head. Fit the tappets (E1) into their parent bores.



7 If the surface of the cylinder head gasket is damaged, the gasket must be renewed. Therefore, it is important to ensure that the tappets do not fall onto the gasket when the cylinder head is put in position. To do this, use six pieces of rubber hose (F2) to retain each tappet (F4). Cut a piece out of one end of each hose (F3); push this end onto the end of the tappet (F1). The gap in the hose is necessary because there is very little clearance between the cylinder head and the tappet.

Continued

-
- 8** Check that the bottom face of the cylinder head is clean. Carefully fit the cylinder head. Ensure that the cylinder head is fully onto the two location pins, but do not damage the gasket.
 - 9** Remove the pieces of hose that retained the tappets. Lubricate thoroughly the tappets with clean engine lubricating oil. Check that the tappets are free to move in their parent bores.
 - 10** Lightly lubricate the threads of the ten cylinder head setscrews and the thrust faces of the setscrew heads. Lightly lubricate the threads of the studs and the thrust faces of the two nuts. Fit the setscrews and the nuts and tighten them finger tight.
 - 11** Tighten the cylinder head setscrews and fasteners using the procedure given in Operation 3-10.
 - 12** Fit all ancillary components, see Operation 3-11.

To tighten the cylinder head setscrews and fasteners

Operation 3-10

Special requirements

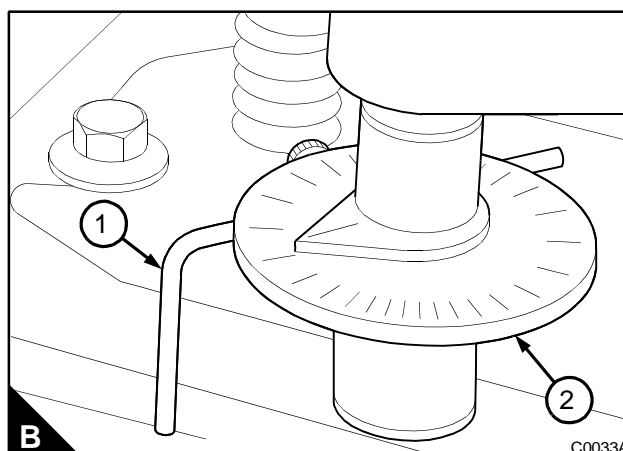
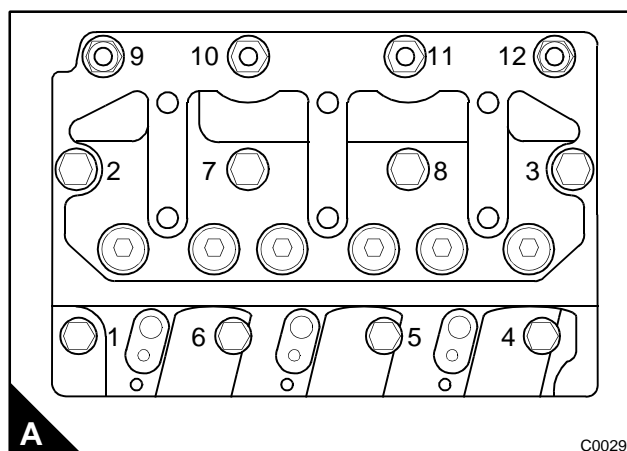
Special tools	
Description	Part number
Angle gauge	21825607

To tighten the cylinder head setscrews in positions 1 - 8

Cautions:

- The cylinder head setscrews are tightened in **four increments**, see steps 1 to 4. Cylinder head fasteners that are tightened in one operation can loosen in service.
- Do not tighten the cylinder head fasteners again with the engine hot or after a limited period in service.

- 1 Tighten setscrews 1 - 8 in the correct sequence (A) to 70 Nm (52 lbf ft) 7,1 kgf m.
- 2 Repeat step 1 to ensure that all the setscrews are tightened to the correct torque.
- 3 Tighten further the setscrews by 60° (1 flat), in the correct sequence. A special tool, Part number 21825607 (B2) can be used for this operation, see step 5.
- 4 Tighten the setscrews, in the correct sequence, a further 60° (1 flat).
- 5 To tighten the setscrews with the special tool. Fit the tool between the socket spanner and the handle. Position the stop (B1) against a suitable protrusion on the cylinder head to prevent movement of the degree dial in a clockwise direction. Turn the pointer to align with the 60° mark on the degree dial. Tighten the setscrew until the pointer on the tool is aligned with the zero position on the degree dial.



Continued

6 If no tool is available, make a suitable mark on the cylinder head in line with a corner of each setscrew (C). Make another mark, at the correct angle (counter-clockwise), on the edge of the flange of each setscrew. Tighten each setscrew in the correct sequence until the marks on the flange are next to, and in line with, the marks on the cylinder head.

To tighten the cylinder head fasteners in positions 9 -12

Cautions:

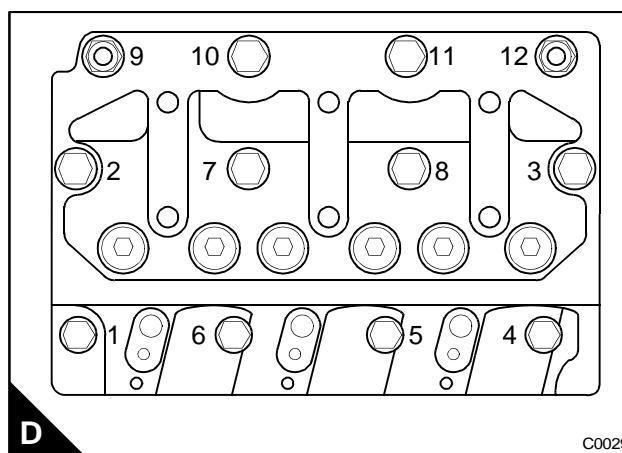
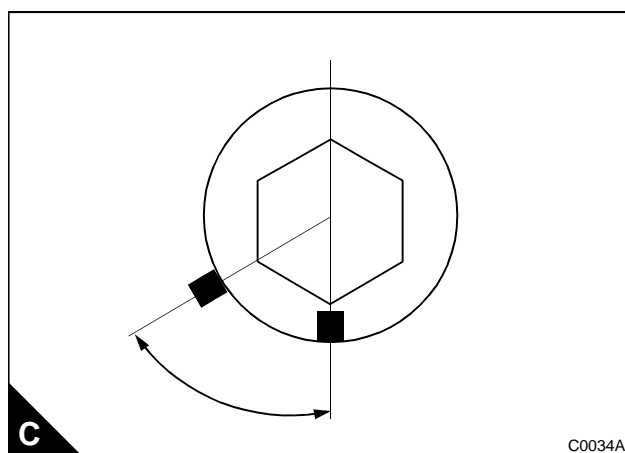
- These fasteners are tightened in **three increments**, see steps 7 to 9. Cylinder head fasteners that are tightened in one operation can loosen in service.
- Do not tighten the cylinder head fasteners again with the engine hot or after a limited period in service.

Note: Early engines had studs and nuts in positions (D10 and D11).

7 Tighten fasteners 9 -12 in the correct sequence (D) to 50 Nm (37 lbf ft) 5,1 kgf m.

8 Repeat step 7 to ensure that the fasteners are tightened to the correct torque.

9 Tighten further the fasteners by 60° (1 flat), in the correct sequence by the method shown for setscrews, see step 5.



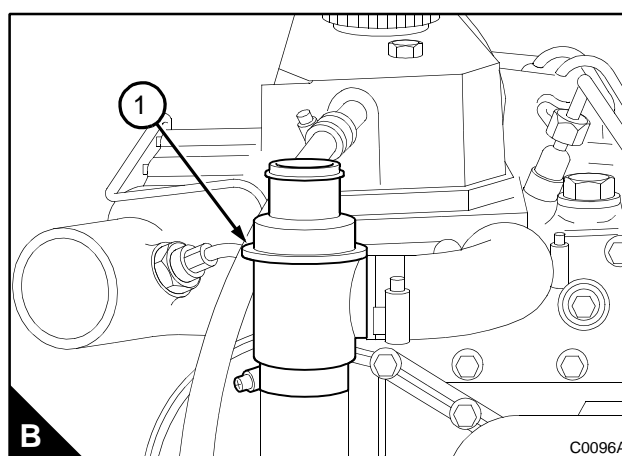
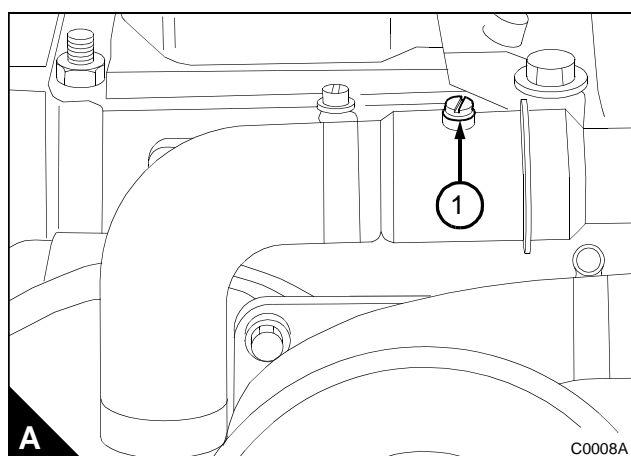
To fit ancillary components

Operation 3-11

- 1 Fit the rocker assembly, see Operation 3-3.
- 2 Set the valve tip clearances, see Operation 3-6.
- 3 Fit the atomisers, see Operation 11-6 or Operation 11-8.
- 4 Renew the sealing washers and fit the leak-off pipe. Tighten the banjo bolt to 9,5 Nm (7,0 lbf ft) 1,0 kgf m.
- 5 Fit the high-pressure fuel pipes; tighten the union nuts to 22 Nm (16 lbf ft) 2,2 kgf m.
- 6 Fit the vent pipe if fitted between the fuel injection pump and the first atomiser. Connect, to the rear of the cylinder head, the clip that retains the fuel pipe between the fuel filter and the fuel lift pump.

Caution: If the thermostat is fitted incorrectly, the engine will overheat.

- 7 Connect the brass thermostat assembly. Tighten the clips. If the thermostat assembly is in the horizontal position, the assembly is fitted correctly when the vent screw (A1) is at the top. If the thermostat assembly is fitted in the vertical position (B), the shoulder (B1) will be at the top.

**Notes:**

- If a plastic thermostat assembly is fitted, connect the hose from the radiator to the outlet marked 'RAD' on the thermostat housing. Connect the hose from the coolant pump by-pass to the opening opposite the outlet marked 'RAD'. Connect the hose from the cylinder head to the outlet in the centre of the thermostat housing and at 90° to the coolant pump and radiator outlets.
- On the latest plastic thermostats, the outlets are marked 'RAD', 'ENG' and 'PUMP' with arrows to indicate coolant flow.

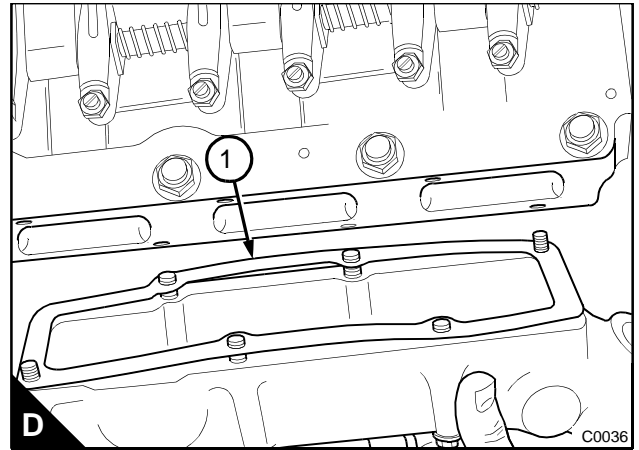
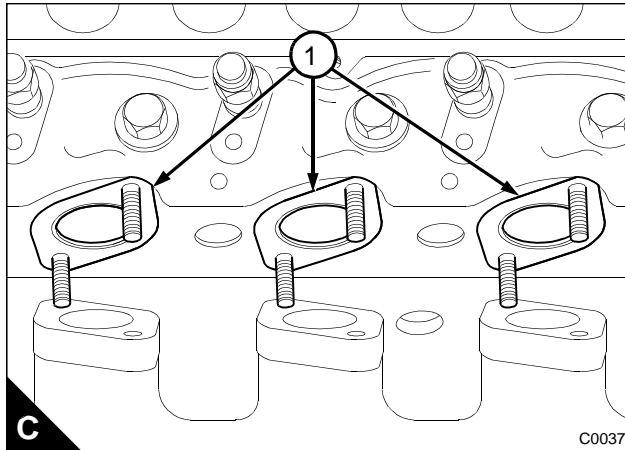
Continued

8 Fit the exhaust manifold; use new gaskets (C1) without jointing compound. The metal gaskets can be fitted either way around. Tighten the nuts to 22 Nm (16 lbf ft) 2,2 kgf m.

9 Fit the turbocharger if necessary, see Operation 9-2.

10 Fit the induction manifold; use a new joint (D1) without jointing compound. Tighten the setscrews to 22 Nm (16 lbf ft) 2,2 kgf m.

11 Fit the electrical connection to the coolant temperature sender unit.



12 Fill the cooling system, see Operation 12-3. If the thermostat is fitted in the horizontal position (E), air must be removed from the system. To do this; release the vent screw (E1) until it just tightens. When the coolant is free from air, close and tighten the vent screw.

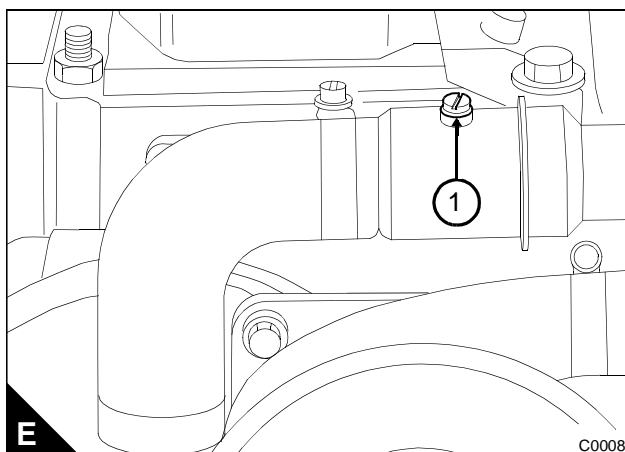
13 Connect the air filter.

14 Connect the battery.

15 Eliminate air from the fuel system, see Operation 11-19 for Delphi fuel injection pumps or Operation 11-22 for Stanadyne fuel injection pumps.

16 Start the engine and run it at low speed. Check that oil flows from the holes in the rocker levers. If the oil flow is correct, fit the rocker cover, see Operation 3-1.

Caution: Do not tighten the cylinder head fasteners again with the engine hot or after a limited period in service.



Valves and valve springs

To remove

Operation 3-12

Special requirements

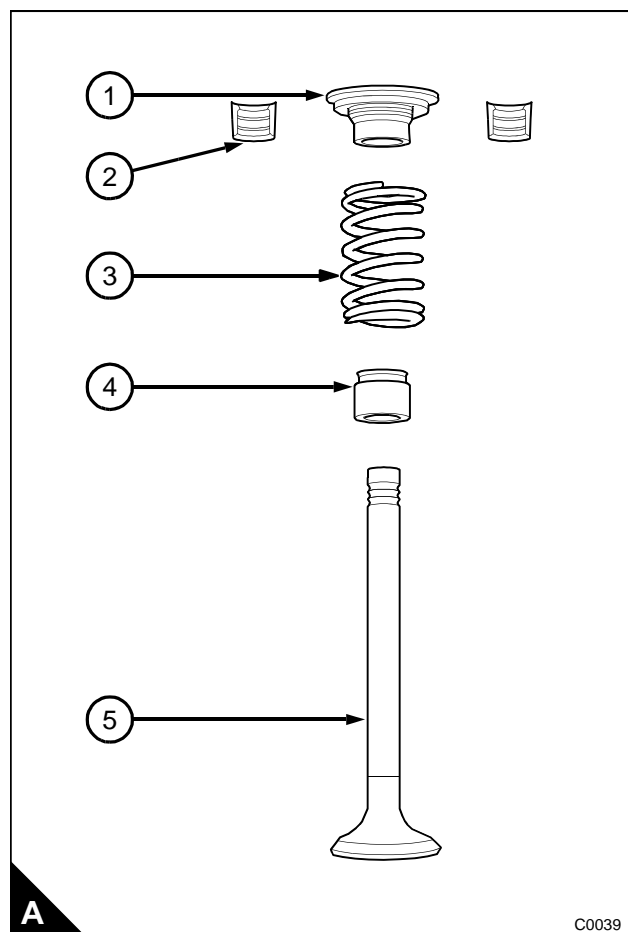
Special tools			
Description	Part number	Description	Part number
Valve spring compressor	21825666	Stud adaptor	21825934

Warning! Wear eye protection when the valve spring is compressed.

Caution: Ensure that the valve springs are compressed squarely or the valve stem (A5) can be damaged.

Note: There are no valve stem seals (A4) fitted to turbocharged engines.

- 1 Remove the cylinder head, see Operation 3-8.
- 2 Clean the bottom face of the cylinder head and check the depth of the valve heads below the face of the cylinder head, see Operation 3-14.
- 3 Make a suitable mark on the heads of the valves to ensure that the valves can be fitted in their original positions, if they are to be used again.
- 4 Use the valve spring compressor and the adaptor to compress the valve spring (A3) and remove the collets (A2).
- 5 Release the valve spring compressor and remove the valve spring cap (A1), valve spring and the valve stem seal (A4), if fitted.
- 6 Repeat steps 4 and 5 for the other valves. Remove the valves.



To fit

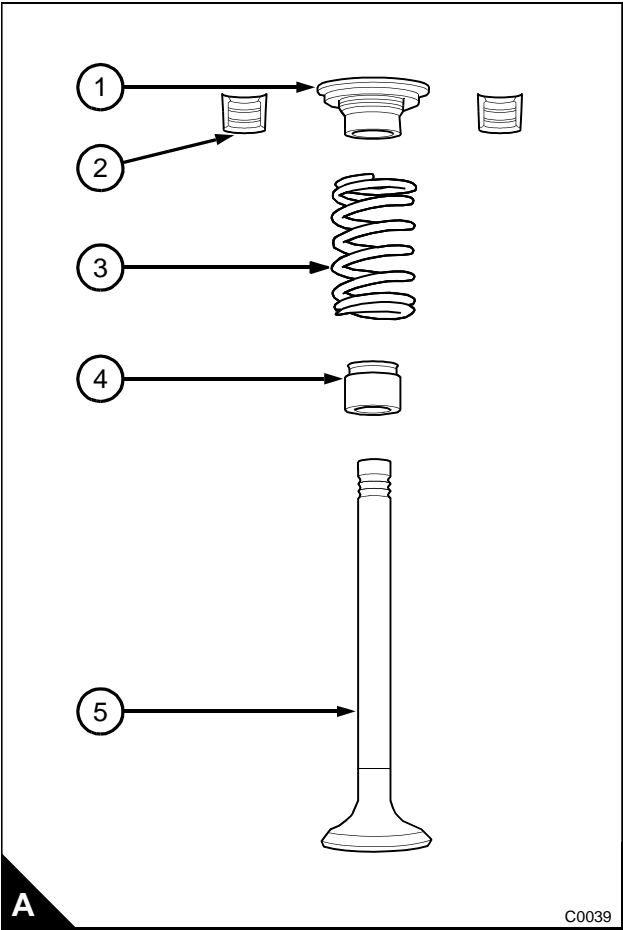
Operation 3-13

Special requirements

Special tools			
Description	Part number	Description	Part number
Valve spring compressor	21825666	Stud adaptor	21825934

Caution: Ensure that the valve springs are compressed squarely or damage can occur to the valve stem.

- 1 Lubricate the valve stems and valve guides with clean engine oil and fit the valves in their respective guides.
- 2 Fit new valve stem seals (A4), where necessary, on the valve guides.
- 3 Fit the valve spring cap (A1). Use the valve spring compressor and the adaptor to compress the valve spring (A3), and fit the collets (A2).



To inspect and to correct

Operation 3-14**Special requirements**

Special tools			
Description	Part number	Description	Part number
Gauge, valve depth	21825496	Dial gauge (for use with gauge, valve depth)	21825617

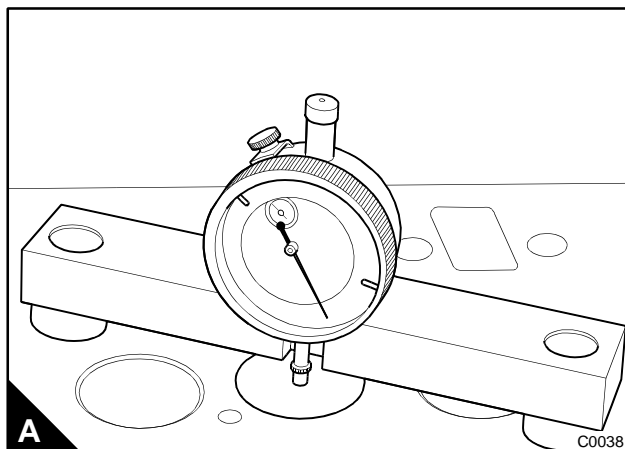
1 Check the depth of the valves below the face of the cylinder head before the valve springs are removed. Ensure that the heads of the valves and the bottom face of the cylinder head are clean. Put the valve depth gauge on the face of the cylinder head and zero the dial gauge. Carefully put the valve depth gauge in position over the head of each valve (A) and make a note of the measurement. The maximum depth, in service, is given in the relevant Data and dimensions for "Inlet and exhaust valves" on page 13.

2 If a valve is below the depth limit, check the valve depth with a new valve in position. If the valve depth is still below the limit, the valve seat insert(s) must be renewed, see Operation 3-20.

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

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

5 Check that the load on the valve springs is correct at their fitted length, refer to the relevant Data and dimensions for "Valve springs" on page 12. Fit new valve springs at every complete engine overhaul.



Valve guides

To inspect

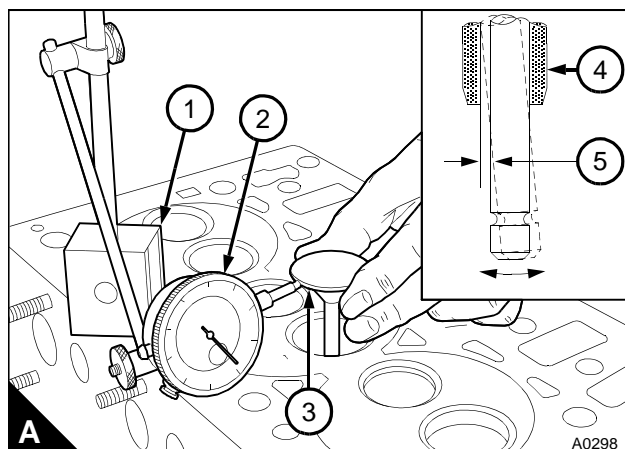
Operation 3-15

To check the valve guides for wear:

The maximum clearance (A5), between the valve stem and the bore of the guide is 0,15 mm (0.006 in) for inlet valves and 0,14 mm (0.005 in) for exhaust valves. If the clearance, with a new valve fitted, is more than the limit, then a new valve guide (A4) must be fitted.

It is recommended that the procedure given below is used to check the valve guide clearance:

- 1 Put a new valve in the valve guide.
- 2 Put a dial test indicator with a magnetic base (A1) onto the face of the cylinder head.
- 3 With the valve lifted 15,0 mm (0.6 in) and the gauge (A2) in contact with the edge of the valve head (A3), move the valve radially away from the gauge. With the valve held in this position, set the gauge zero.
- 4 Move the valve radially across the axis of the cylinder head towards the gauge. Make a note of the reading on the gauge. If the reading is equal to or greater than the data given below, a new valve guide (A4) must be fitted.
- 5 Maximum permissible clearance with a valve lift of 15,0 mm (0.6 in):
 - Inlet guide: 0,24 mm (0.009 in)
 - Exhaust guide: 0,28 mm (0.011)

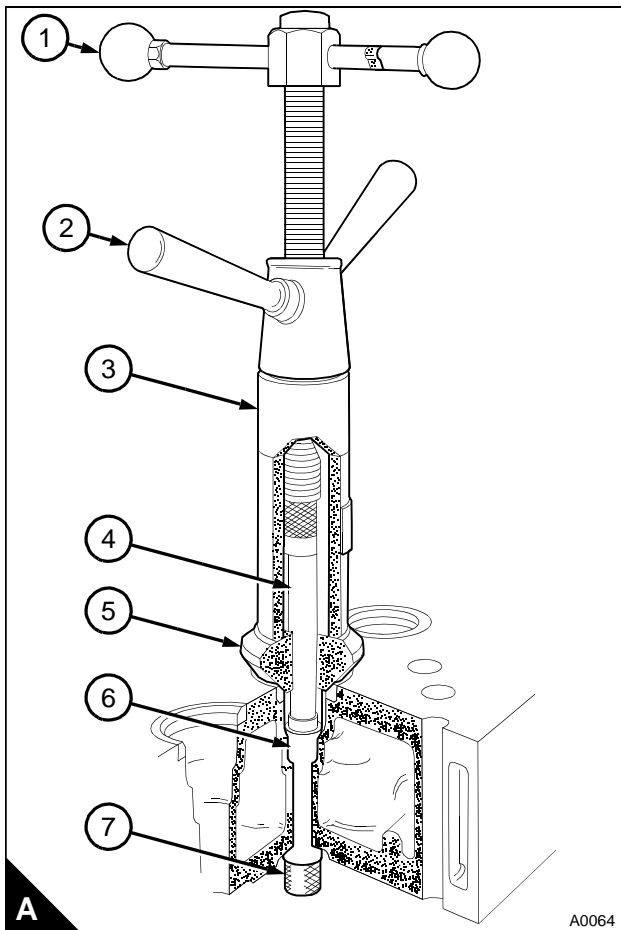


To remove

Operation 3-16**Special requirements**

Special tools			
Description	Part number	Description	Part number
Remover/replacer for valve guides	21825478	Adaptor	21825552

- 1 Fit the adaptor (A4) into the remover/replacer tool (A3).
- 2 With the adaptor fitted to the tool, put the spacer (A5) in position on the tool. Pass the adaptor through the valve guide (A6) and put the spacer and tool in position on the valve seat.
- 3 Fit the attachment (A7) to secure the adaptor to the valve guide.
- 4 Hold the top handle (A1) and turn the bottom handle (A2) clockwise to pull the valve guide out of the cylinder head.



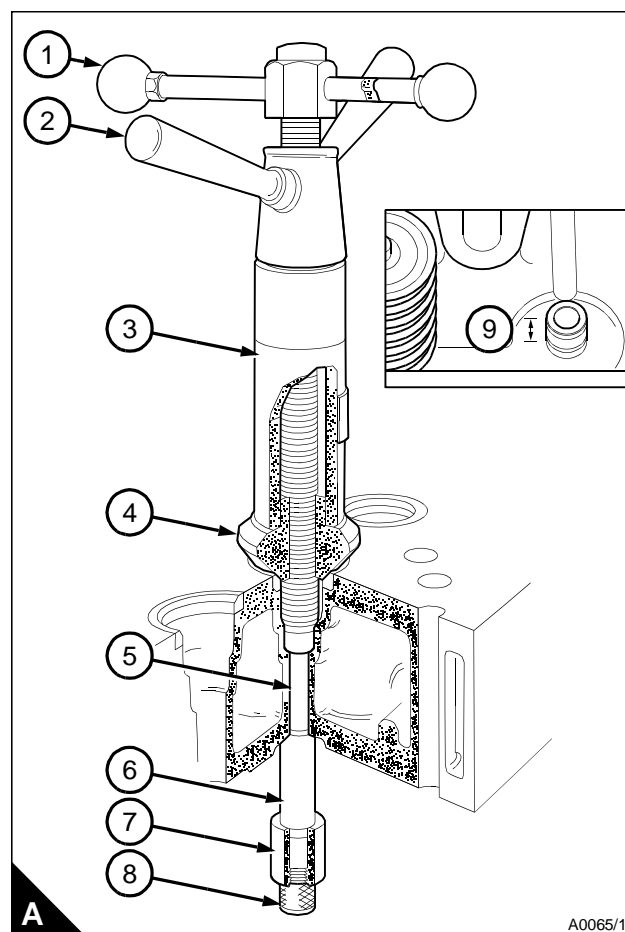
To fit

Operation 3-17

Special requirements

Special tools			
Description	Part number	Description	Part number
Remover/replacer for valve guides	21825478	Distance piece (used with remover/replacer and adaptor)	21825937
Adaptor	21825552		

- 1 Clean the parent bore in the cylinder head for the valve guide.
 - 2 Lubricate the outer surface of the new valve guide (A6) with clean engine lubricating oil.
 - 3 Fit the adaptor (A5) into the remover/replacer tool (A3).
 - 4 With the adaptor fitted to the tool, put the spacer (A4) in position on the tool. Pass the adaptor through the cylinder head and put the spacer and tool assembly in position on the valve seat.
 - 5 Put the new valve guide in position on the adaptor and fit the distance piece Part number 21825937 (A7). Fit the attachment (A8) to secure the valve guide to the adaptor.
- Note:** The internal recess in the valve guide must be towards the tool.
- 6 Hold the top handle (A1) and turn the bottom handle (A2) clockwise to pull in the valve guide until the distance piece touches the cylinder head.
 - 7 When the valve guide is fitted correctly, the top of the valve guide will have a protrusion of 11,10/11,40 mm (0.437/0.449 in) above the valve spring seat (A9).



Cylinder head

To inspect and to correct

Operation 3-18

- 1 Remove the cylinder head assembly, see Operation 3-8.
- 2 Inspect the cylinder head for signs of gas or coolant leakage.
- 3 Remove the valve springs and the valves, see Operation 3-12.
- 4 Clean the face of the cylinder head and the passages for coolant and for lubricating oil. The water jacket can be cleaned with a special solvent, which must be used in accordance with the manufacturer's instructions.
- 5 Test the cylinder head for leaks at the pressure given in the Data and dimensions for the "Cylinder head" on page 12.
- 6 When the cylinder head is thoroughly clean, check it for cracks. Check carefully the areas around the valve seats and around the holes for the atomiser nozzles.
- 7 The bottom face of the cylinder head can be machined if: there is distortion; there are deep scratches; the valve depths are below the service limit.
- 8 Use a straight edge and feeler gauges to check the cylinder head for distortion across and along its bottom face and refer to "Maximum permissible cylinder head distortion" on page 12. If the distortion is more than the limit given, the bottom face can be machined.

Cautions:

- *Remove only the minimum material and then not more than 0,40 mm (0.016 in).*
 - *The nozzle protrusion for the engine must be measured with the nozzle seat washer fitted, after the head has been machined. See "Maximum protrusion of the atomiser nozzle" on page 12.*
 - *After the cylinder head has been machined the valve seats must be corrected to give the correct valve head depth. It is better to work to the minimum limit to allow for later wear.*
 - *If a new valve seat insert is to be fitted, the back face must be surface ground to ensure that there is no protrusion above the bottom face of the cylinder head, see Operation 3-20.*
- 9 Check the valve seats for wear and for damage.
 - 10 Before any work is done on the valve seats, new valve guides must be fitted, see Operation 3-16 and Operation 3-17.
 - 11 Where there is little damage, the valve and valve seat can be lapped. When the valve seats are lapped keep the seat as narrow as possible and ensure that all the compound used to lap the valve and the seat is removed.
 - 12 More badly damaged valve seats can be corrected by use of the cutter tool, see Operation 3-19, or new inserts can be fitted to the inlet and exhaust valves, see Operation 3-20.

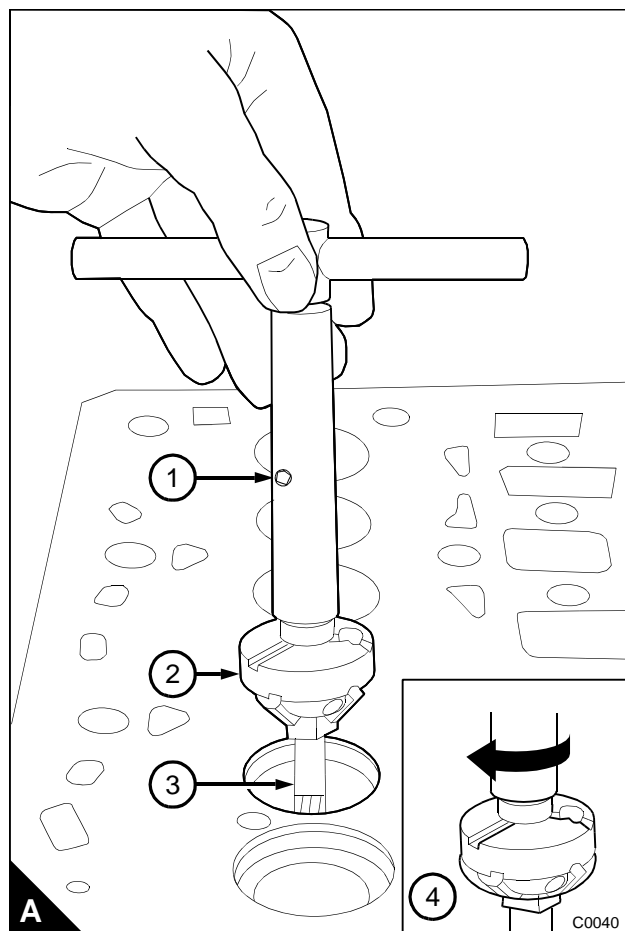
To correct a valve seat with a valve seat cutter

Operation 3-19

Special requirements

Special tools			
Description	Part number	Description	Part number
Cutter for exhaust valve seats	21825633	Pilot for use with valve seat cutters	21825550
Cutter for inlet valve seats	21825977	Handle set for use with valve seat cutters	21825619

- 1 Before any work is done on the valve seats, new valve guides must be fitted, see Operation 3-16 and Operation 3-17.
- 2 Fit the pilot (A3) in the valve guide and tighten the pilot.
- 3 Select the relevant cutter (A2). 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 (A1). Ensure that the cutter is not allowed to fall on to the seat as this can damage the blades.
- 4 Carefully rotate the cutter in a clockwise direction (A4). 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 given in the relevant Data and dimensions for "Inlet and exhaust valves" on page 13.
- 8 If a valve seat has become too damaged or too worn to correct, a valve seat insert can be fitted, see Operation 3-20.



To fit a valve seat insert

Operation 3-20

Note: A cylinder head with valve seat inserts fitted is available if it is not possible to machine the cylinder head.

- 1 Remove the valve guide, see Operation 3-16, and clean the bore into which the guide is to be fitted.
- 2 Fit new valve guides, see Operation 3-17.
- 3 With the bore of the new valve guide used as a pilot, machine the recess in the cylinder head to the dimensions shown in "Dimensions of a recess for a valve seat insert" on page 14, or machine out the old valve seat insert. Remove all debris and clean the insert recess.
- 4 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 0,85/1,35 mm (0.033/0.053 in) chamfer at $31^\circ \pm 1^\circ$ to the vertical for inlet valve inserts, or $30^\circ \pm 1^\circ$ for exhaust valve inserts.
- 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 with the valve seat insert tool, see "Valve seat insert tool" on page 15.

Caution: Do not use a hammer on the insert and do not use lubrication. Use a hydraulic press or a hand press in one continuous movement.

- 6 To ensure that the bottom of the valve seat insert is in contact with the bottom of the recess, check the depth of the insert below the face of the cylinder head. Measure in two places at 90° to each other. The depths are:
 - Valve seat insert for inlet 3,61/3,81 mm (0.142/0.150 in)
 - Valve seat insert for exhaust 3,66/3,76 mm (0.144/0.148 in)
- 7 Cut the valve seat at 36° (an included angle of 108°) for inlet valves, or 46° (an included angle of 88°) for exhaust valves, see Operation 3-19. Ensure that the depth of the valve head below the face of the cylinder head is within the production limits, refer to the relevant Data and dimensions for "Inlet and exhaust valves" on page 13.

Note: Work as near as possible to the minimum figure to allow for future wear on the valve seat.

4

Piston and connecting rod assembly

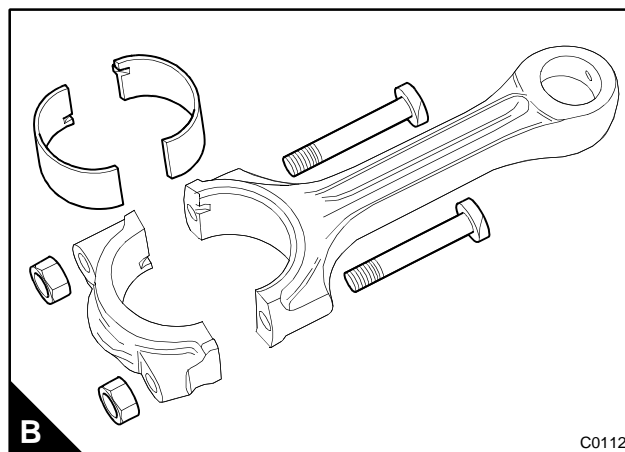
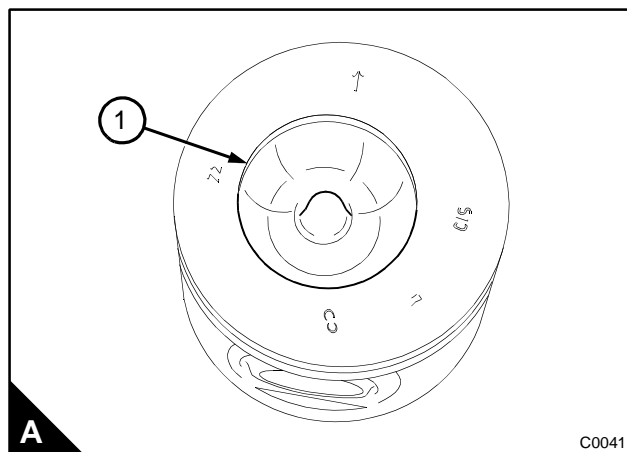
General description

The pistons used in the 900 Series engines have a special combustion chamber (A1) in the top of the piston to give an efficient mix of fuel and air. The pistons are available with two height grades to ensure close control of compression ratio and emission control.

The naturally aspirated (CP) and turbocharged (CR) engines both have two compression rings and an oil control ring. All the piston rings are above the gudgeon pin. The (CR) engine has a hard metal insert to reduce wear of the groove and a wedge shaped top ring. Axial location of the fully floating gudgeon pin is by circlips.

Note: Always use the full engine number to order new parts.

The connecting rods (B) are machined from "H" section forgings of molybdenum steel. The big end cap is retained by two special bolts and nuts. The naturally aspirated (CP) engine big end has aluminium-tin shell bearings and the turbocharged (CR) engine has lead-bronze shell bearings. Both engines have lead-bronze small end bushes.



Big end bearing

To remove

Operation 4-1

Caution: *Ensure that the bolts for the connecting rod do not damage the crank pin when the connecting rod is moved. If necessary, fit a temporary plastic sleeve to the big end bolts.*

- 1 Drain the engine lubricating oil.
- 2 Remove the lubricating oil sump, see Operation 10-4 or Operation 10-6.
- 3 Remove the lubricating oil strainer and suction pipe, see Operation 10-8.
- 4 Rotate the crankshaft until the relevant connecting rod is at its lowest position.
- 5 Release the nuts and remove the bearing cap.
- 6 Remove the lower half of the shell bearing from the cap, but keep it with its cap.
- 7 Carefully push the connecting rod up the cylinder bore just enough to allow access to the upper half of the shell bearing. Remove the bearing from the connecting rod. Keep the bearings from the connecting rod and cap together.

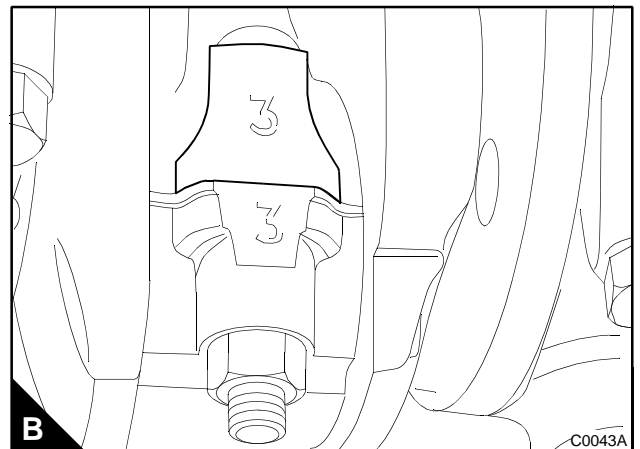
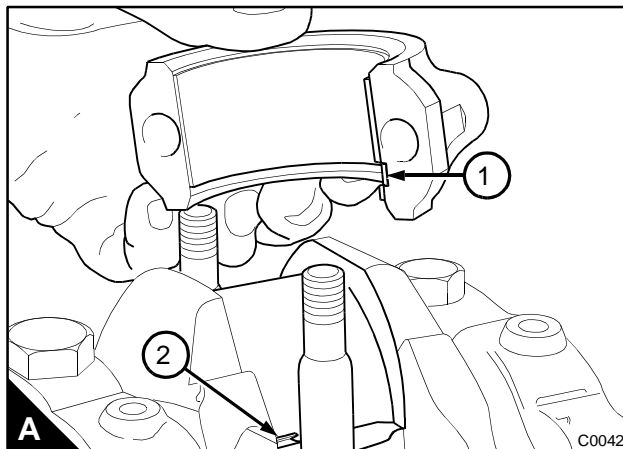
To fit

Operation 4-2

- 1 Clean the bearing faces of the connecting rod and the crank pin.
- 2 Clean the complete bearing and lubricate the bearing surface and the crank pin with clean engine lubricating oil. Fit the upper half of the shell bearing to the connecting rod; ensure that the location tag is fitted correctly in its recess (A2). Fit the connecting rod to the crank pin; ensure that the assembly number (B) on the connecting rod is on the same side as the other connecting rods.

Note: The assembly number must be towards the left side of the engine, when seen from the rear.

- 3 Clean, lubricate and fit the lower half of the shell bearings into the cap; ensure that the location tag is fitted correctly in its recess (A1). Fit the connecting rod bolts with the flat side of the head of the bolts towards the connecting rod. Lubricate the threads of the bolts.
- 4 Fit the cap to the connecting rod. Ensure that the assembly number on the cap is the same as that on the connecting rod and that both of the assembly numbers are on the same side (B). Fit the nuts and tighten them finger tight.
- 5 Tighten the nuts gradually and evenly to the recommended torque of 77 Nm (57 lbf ft) 7,9 kgf m.
- 6 Ensure that the crankshaft rotates freely.
- 7 Fit the lubricating oil strainer and suction pipe, see Operation 10-8.
- 8 Fit the lubricating oil sump, see Operation 10-5 or Operation 10-7, and fill the sump to the correct level with lubricating oil of an approved grade.



To inspect

Operation 4-3

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

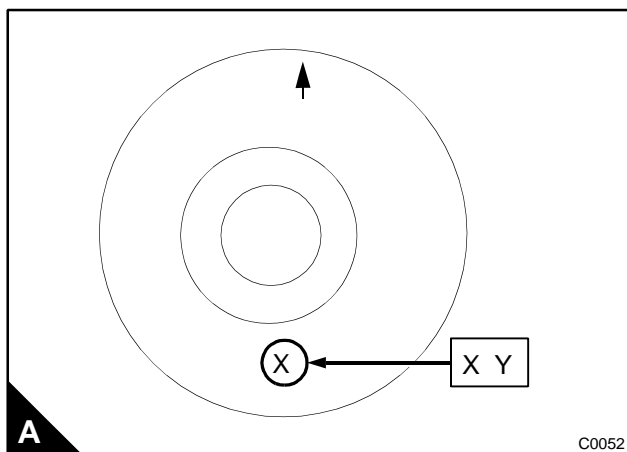
Piston and connecting rod assembly

To remove

Operation 4-4

Caution: Ensure that the bolts for the connecting rod do not damage the crank pin when the connecting rod is removed or fitted. If necessary, fit a temporary plastic sleeve to the big end bolts.

- 1 Drain the lubricating oil and the cooling system.
- 2 Remove the cylinder head assembly, see Operation 3-8.
- 3 Remove all carbon from the top of the bores of the cylinders or liners.
- 4 Remove the lubricating oil sump, see Operation 10-4 or Operation 10-6.
- 5 Remove the lubricating oil strainer and suction pipe, see Operation 10-8.
- 6 Check the height of the piston above the top face of the cylinder block, see Operation 4-6. Make a note of the piston grade letter (A).
- 7 Remove the big end caps and the big end bearings from the connecting rods, see Operation 4-1.
- 8 Push the piston and the connecting rod out through the top of the cylinder. Keep the bearings and caps together to ensure that they can be fitted in their original positions.
- 9 Inspect the crank pins for damage.



To fit

Operation 4-5

Special requirements

Special tools	
Description	Part number
Piston ring compressor	21825491

Cautions:

- If a new piston is fitted, ensure that it is of the same height grade as the original.
- Ensure that the bolts for the connecting rod do not damage the crank pin when the connecting rod is removed or fitted. If necessary, fit a temporary plastic sleeve to the big end bolts.
- Ensure that the piston and connecting rod assembly is fitted to the same cylinder bore from which it was removed.

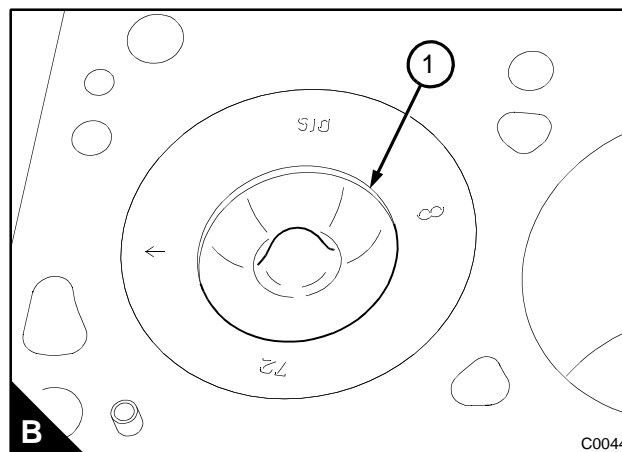
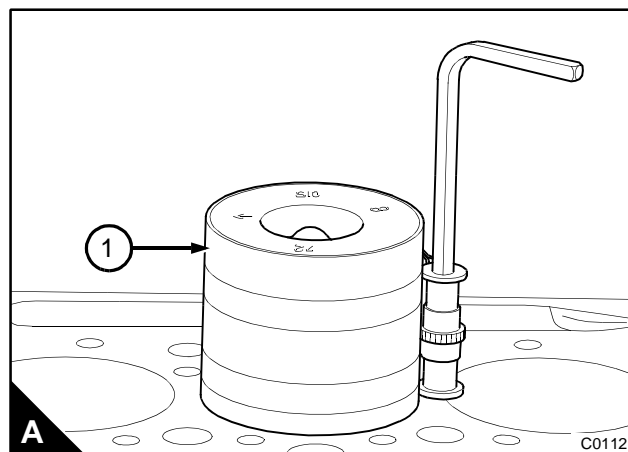
1 Ensure that the piston, the cylinder bore, the crank pin and the big end of the connecting rod are clean. Lubricate the piston and the cylinder liner with clean engine lubricating oil.

2 Rotate the crankshaft until the relevant crank pin is at its highest position. Lubricate the crank pin with clean engine lubricating oil.

3 Fit the upper half of the shell bearings to the connecting rod. Ensure that the location tag is fitted correctly in its recess (C2). Lubricate the bearing with clean engine lubricating oil. Lubricate the threads of the two bolts for the big end. Put the bolts into position in the connecting rod. Ensure that the flat side of the head of the bolts are towards the connecting rod.

4 Put the piston ring gaps 120° apart. Lubricate the piston rings with clean engine lubricating oil. Fit the tool (A1) to compress the piston rings.

5 The arrow or "FRONT" mark on the top of the piston must be towards the front of the engine. Fit the piston and connecting rod assembly into the correct cylinder bore. In this position the combustion bowl (B1) in the top of the piston will be towards the left side of the engine when seen from the rear.



Continued

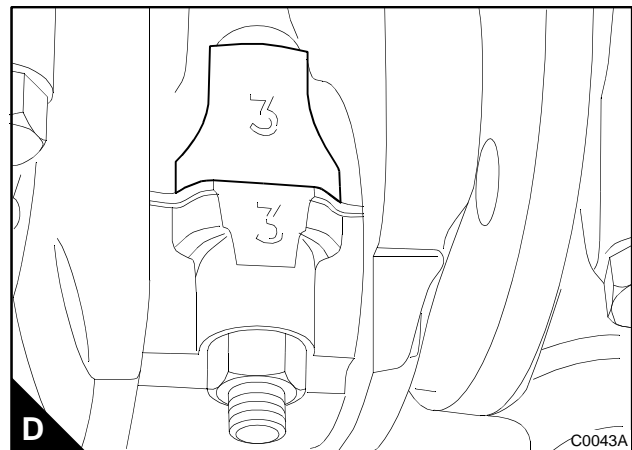
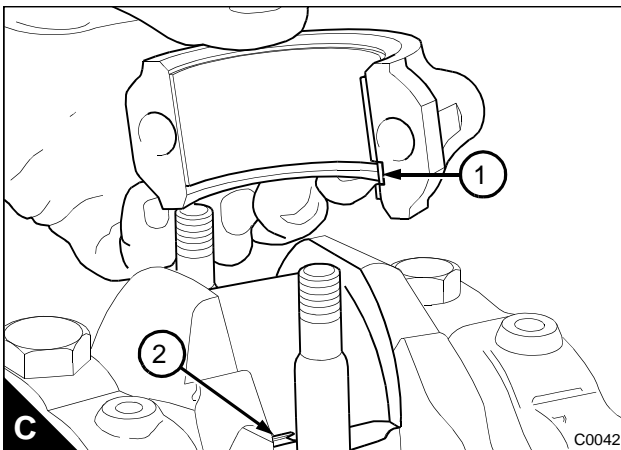
6 Carefully push the piston through the piston ring compressor and check that the connecting rod is onto the crank pin.

7 Rotate the crankshaft counter-clockwise, when seen from the front, until the crank pin is at its lowest position. At the same time carefully apply pressure to the top of the piston with a suitable piece of wood or plastic. This will keep the big end in contact with the crank pin.

Note: The crankshaft is rotated counter-clockwise to ensure that the shell bearing in the big end remains in position.

8 Clean the connecting rod cap and the lower half of the shell bearings. Fit the bearing to the cap; ensure that the location tag is fitted correctly in its recess (C1). Lubricate the bearing with clean engine lubricating oil.

9 Fit the cap and ensure that the assembly number is the same as that on the connecting rod and that the numbers (D) are on the same side. Fit the nuts finger tight; ensure that the flat side of the head of the bolts is towards the connecting rod. Tighten the nuts gradually and evenly to the recommended torque of 77 Nm (57 lbf ft) 7,9 kgf.



10 Check that the crankshaft will rotate freely.

11 Check the piston height above the top face of the cylinder block, see Operation 4-6.

12 Fit the lubricating oil strainer and suction pipe, see Operation 10-8.

13 Fit the lubricating oil sump, see Operation 10-5 or Operation 10-7.

14 Fit the cylinder head assembly, see Operation 3-9.

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

16 Fill the cooling system.

To check the piston height above the cylinder block

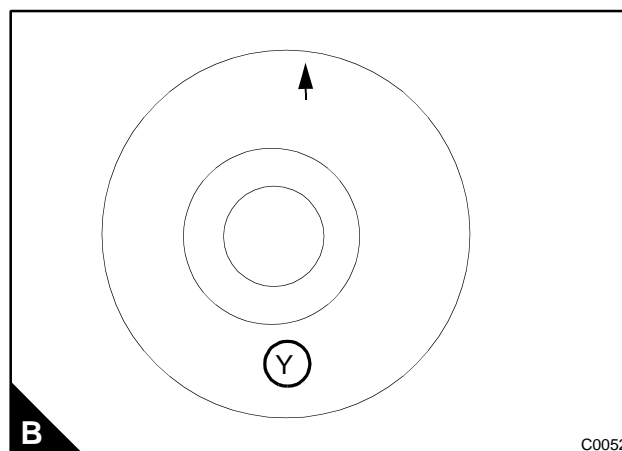
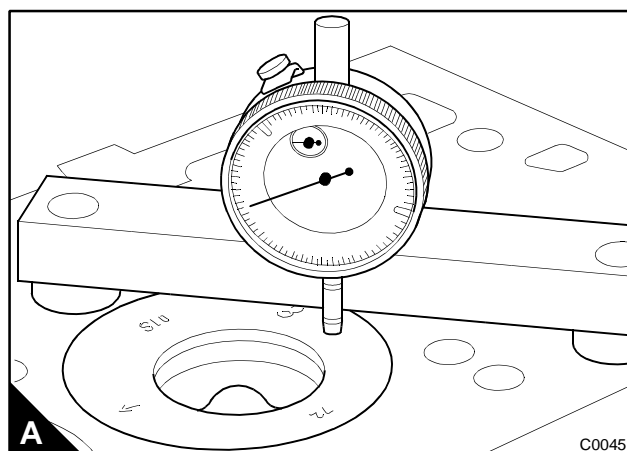
Operation 4-6

Special requirements

Special tools			
Description	Part number	Description	Part number
Piston height tool	21825496	Dial gauge	21825617

- 1 Put the piston height tool on the face of the cylinder block and rotate the dial of the gauge to the zero position.
- 2 Rotate the crankshaft until the piston is just before top dead centre (TDC).
- 3 Carefully put the tool (A) over the top of the piston with the plunger of the gauge in contact with the piston above the axis of the gudgeon pin. Rotate the crankshaft to ensure that the piston is at the highest position and make a note of the gauge indication. The piston height above the face of the cylinder block should be 0,23/0,35 mm (0.009/0.014 in).
- 4 If the piston protrusion exceeds 0,35 mm (0.014 in) and the lowest height grade of piston (Y) has been fitted, remove the piston, see Operation 4-4, from the cylinder block.
- 5 Machine the piston crown to remove the material in excess of the 0,23/0,35 mm (0.009/0.014 in) protrusion. Etch the piston grade and the "Front" arrow data (B) on the piston crown and fit the piston into the cylinder block, see Operation 4-4.
- 6 Check the piston height again.

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



To check the height grade of a piston

Operation 4-7

Piston height grades B, C and D have been used in production engines. This is now reduced to two grades, X and Y.

Identification of the height grade of each piston is by a letter that is stamped on the top of the piston (A). There are two grade letters, X and Y. Letter X is the higher grade and letter Y is the lower grade.

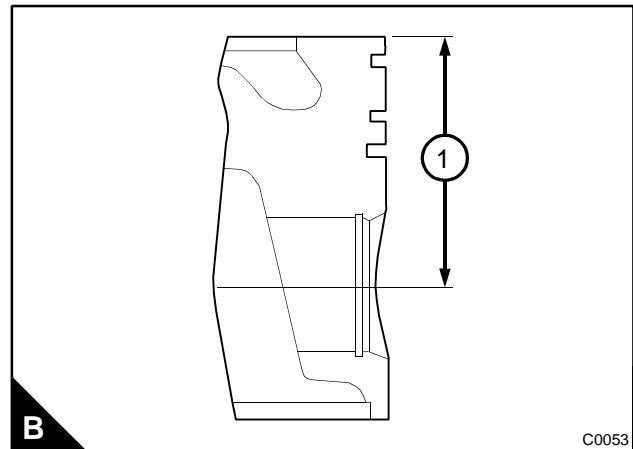
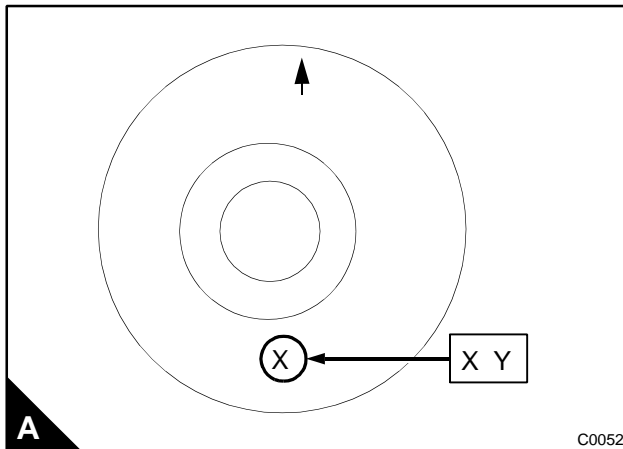
If a new piston is fitted, ensure that it is of the correct height grade. The height grade can be checked by measurement, from the centre of the gudgeon pin to the top of the piston (B1).

- The dimension for grade X is 62,10/62,15 mm (2.445/2.447. in).
- The dimension for grade Y is 62,02/62,07 mm (2.442/2.444 in).

The table below shows the equivalent height grade needed when a new piston is to be fitted.

Old Grade	New Grade
B and C	X
D	Y

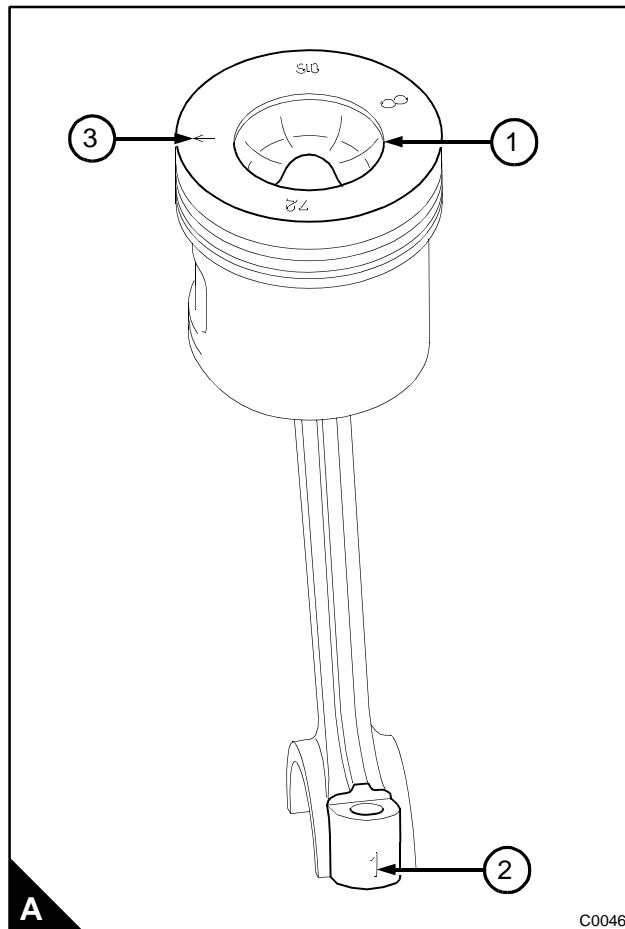
When a new piston assembly has been fitted, check that the height of the piston above the top face of the cylinder block is 0,23/0,35 mm (0.009/0.014 in), see Operation 4-6.



To dismantle

Operation 4-8

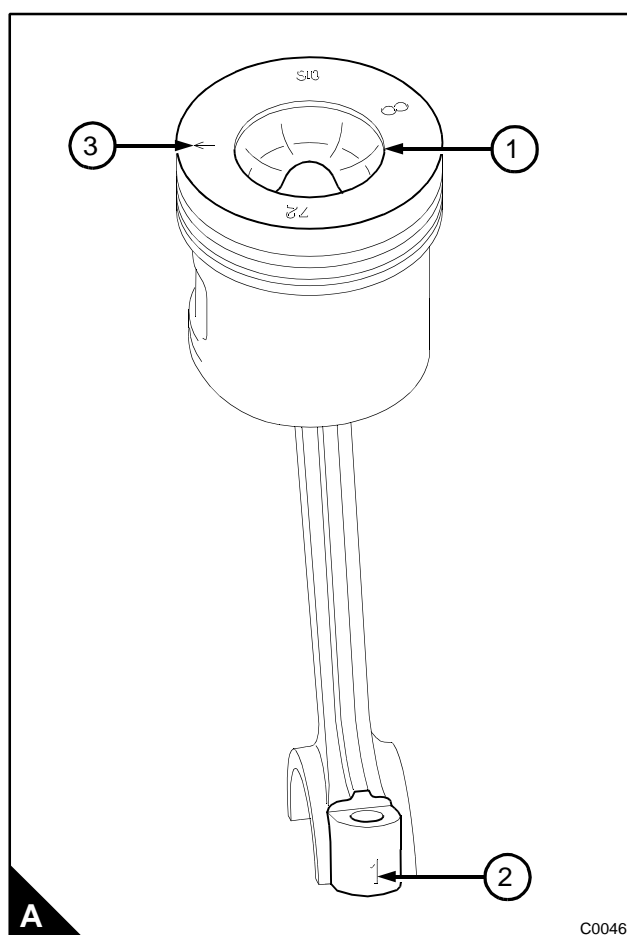
- 1 Remove the piston rings, see Operation 4-10.
- 2 Remove the circlips that retain the gudgeon pin.
- 3 Put a mark on the piston to indicate the cylinder number as shown on the connecting rod. Put the mark on the piston on the same side as the mark on the big end to ensure that they are assembled correctly (A).
- 4 Push the gudgeon pin out by hand. If the gudgeon pin is tight, heat the piston to 40/50 °C (100/120 °F) for easy removal of the gudgeon pin.



To assemble

Operation 4-9

- 1 Clean the bore of the small end bush and lubricate it with clean engine lubricating oil.
- 2 Fit a new circlip in the circlip groove of one of the gudgeon pin bosses. Ensure that it fits correctly in the groove.
- 3 Fit the connecting rod to the piston. The piston and connecting rod are correctly assembled when the combustion bowl (A1) in the top of the piston is toward the assembly number (A2) on the connecting rod. In this position, the arrow (A3) on the top of the piston will be towards the front of the engine. If the original piston is used, ensure that it is assembled to the correct connecting rod and is used in the original cylinder. If a new piston is fitted, ensure that it is of the correct height grade, see Operation 4-7.
- 4 Lubricate the gudgeon pin bosses with clean engine lubricating oil and push in the gudgeon pin towards the circlip. If the gudgeon pin is a tight fit in the piston, heat the piston to 40/50 °C (100/120 °F) before the gudgeon pin is fitted.
- 5 Fit a new circlip in the groove in the other gudgeon pin boss. Ensure that it fits correctly in the groove.
- 6 Fit the piston rings, see Operation 4-10.



Piston rings

To remove and to fit

Operation 4-10

Caution: Only expand the ring gaps enough to ensure that the ends of the rings do not damage the piston when the ring is removed or put into position.

To remove

Remove the piston rings with a suitable ring expander. Keep the rings with their relevant piston.

To fit

Use a suitable piston ring expander to fit the piston rings.

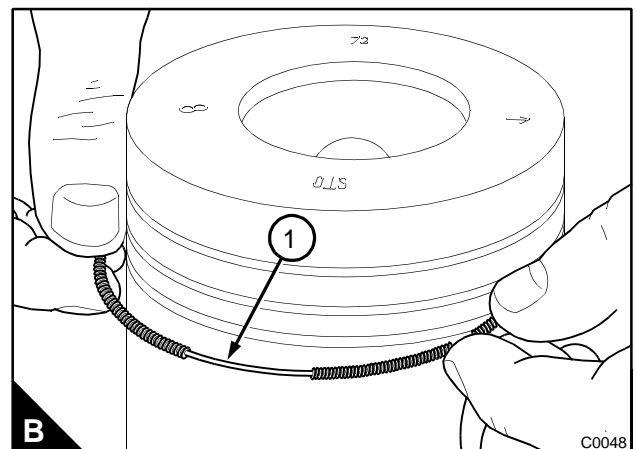
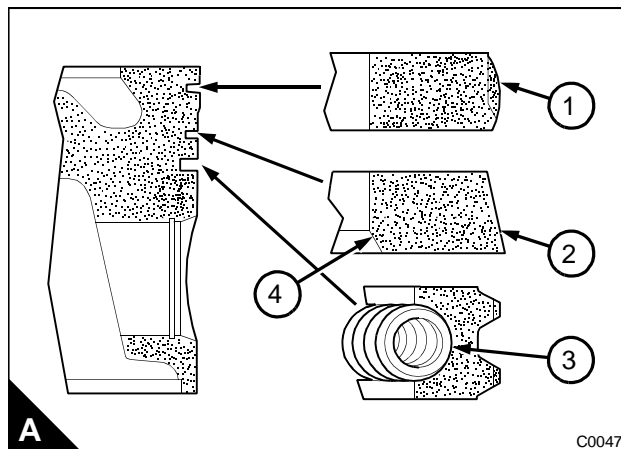
1 Fit the spring (A3) of the oil control ring in the bottom groove of the piston, with the latch pin (B1) inside both ends of the spring. Fit the oil control ring over the spring. Ensure that the ring gap is at 180° to the latch pin. The manufacturers symbol or the word 'TOP', must be towards the top of the piston.

A new oil control ring has a blue identification mark that must be on the left of the ring gap when the ring is fitted and the piston is upright.

2 Fit the cast iron ring with the taper face (A2) into the second groove of the piston. The manufacturer's symbol or the word 'TOP', must be towards the top of the piston.

3 New second rings have a green identification mark that must be on the left of the ring gap when the ring is fitted and the piston is upright.

4 The second ring has a chamfer (A4) on the inner, bottom face.

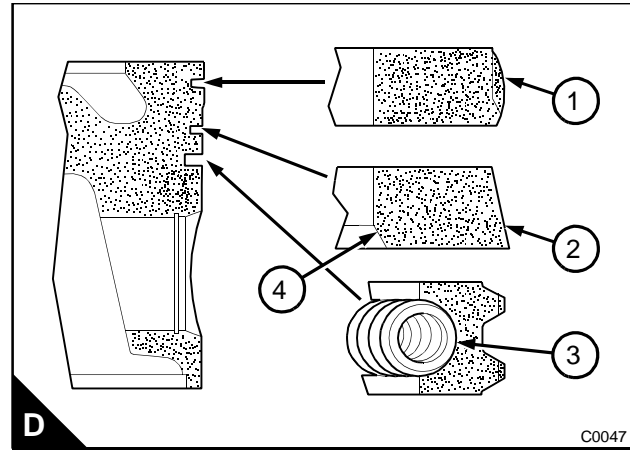
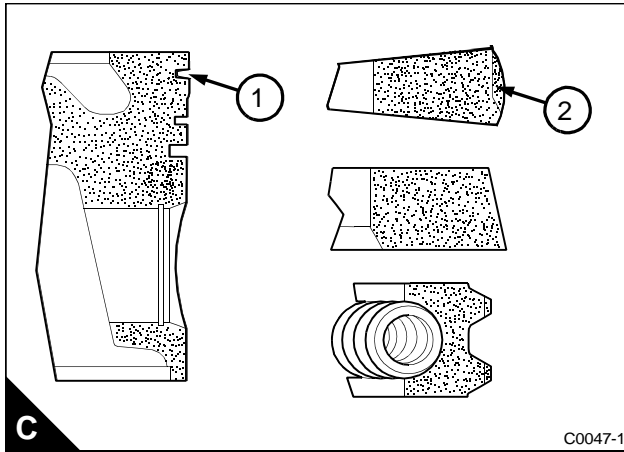


Continued

Caution: Turbocharged (CR) engines have a hard metal insert to reduce wear of the groove (C1) and a wedge shaped top ring (C2). Ensure that the full engine number is used to order new pistons or rings.

5 Fit the top ring, the manufacturers symbol or the word 'TOP', must be towards the top of the piston. A new top ring has a red identification mark that must be on the left of the ring gap when the ring is fitted and the piston is upright. The top ring has a small curve on the outer face (C2/D1).

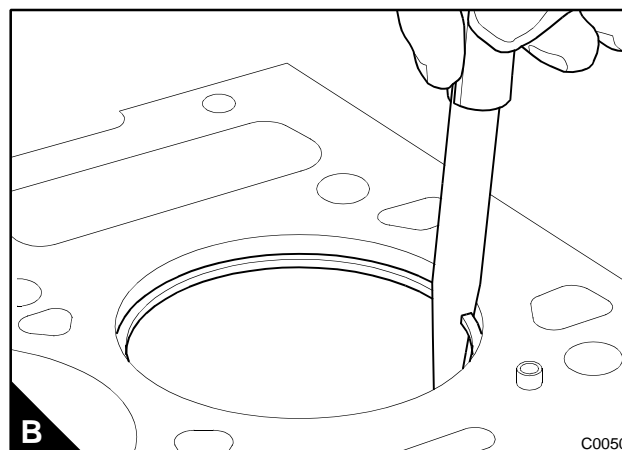
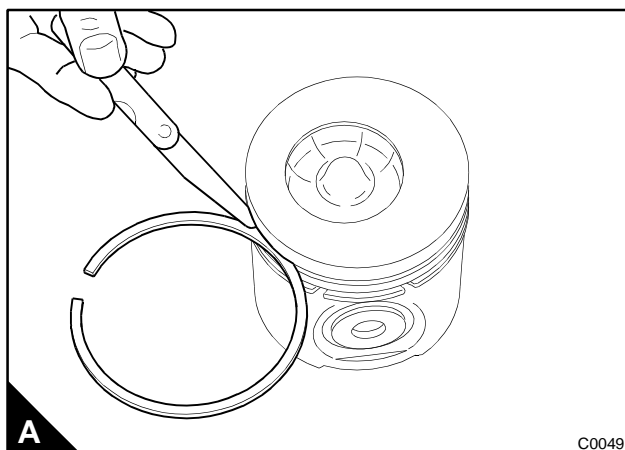
6 Ensure that the ring gaps are 120° apart.



To inspect

Operation 4-11

- 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 rings are not broken.
- 3 Remove the piston rings, see Operation 4-10, and clean the piston ring grooves and the piston rings.
- 4 Fit new piston rings in the grooves in the piston and check for wear of the grooves with feeler gauges (A). Compare the piston ring clearance in the groove to that given for new components in the relevant Data and dimensions for "Pistons and connecting rods" on page 16. Renew the piston, if the grooves are worn too much.
- 5 Clean all carbon from the top of the cylinder liners. Fit each of the piston rings in the top part of the cylinder liner and measure the ring gap with feeler gauges (B).
- 6 The coil spring must be fitted to the oil control ring when the gap of this piston ring is measured. The piston ring gaps for new components are given in the relevant Data and dimensions for "Piston rings" on page 16.



Connecting rod

To inspect

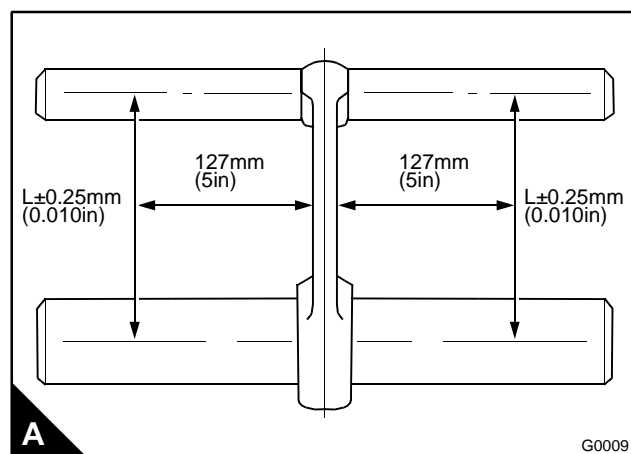
Operation 4-12

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 $\pm 0,25$ mm (0.010 in) measured 127 mm (5.0 in) each side of the connecting rod axis on a test mandrel. With the small end bush fitted, the limits are reduced to $\pm 0,06$ mm (0.0025 in).

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. Refer to the relevant Data and dimensions for "Gudgeon pins" on page 17.



Small end bush

To remove and to fit

Operation 4-13

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 Ream the bush to get the correct clearance between the gudgeon pin and the bush. Refer to the relevant Data and dimensions for "Small end bushes" on page 17.

5

Crankshaft assembly

General description

The crankshaft is a forging of chromium-molybdenum steel that has four main journals.

The crankshaft rotates in four pre-finished shell bearings that have a steel back and an aluminium-tin face. The shell bearings are held in position by tags that fit into recesses machined in the bearing housings and the bearing caps.

End-float is controlled by two sets of thrust washers fitted on both sides of the rear main bearing.

The crankshaft is fitted with two balance weights of spheroidal graphite (SG) iron to give full rotation balance. One weight is fastened to the front crankshaft web and the other is fastened to the rear crankshaft web.

The front and the rear oil seals are Viton lip seals with a dust lip to the outside of the main lip and with oil return grooves on the face of the main lip.

Warning! Read the safety precautions for "Viton seals" on page 7.

Crankshaft pulley

To remove and to fit

Operation 5-1

To remove

- 1 Remove the drive belt, see Operation 14-3.
- 2 Lock the crankshaft to prevent its counter-clockwise movement.
- 3 Release the setscrew (A2) that retains the pulley and remove the setscrew and the washer (A1). Remove the pulley.

Notes:

- Early engines have a washer, 8,89 mm (0.35 in) thick and a black, steel setscrew fitted.
- On later engines a hardened washer 9,0 mm (0.354 in) thick is fitted instead of the original washer.
- On tractor applications, the new, hardened washer and a green “Dacromet” setscrew have been fitted instead of the original setscrew and washer.

Caution: Remove the device used to lock the crankshaft.

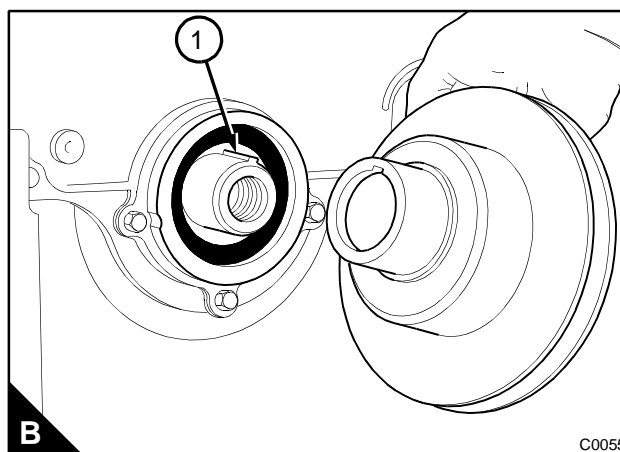
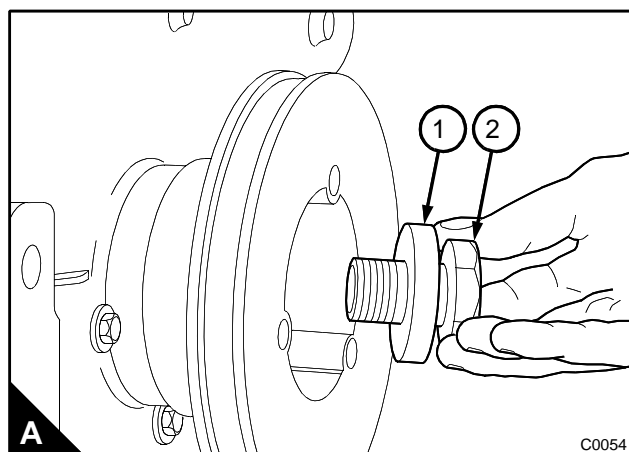
- 4 Clean the components and check for damage. Renew damaged components.

To fit

- 1 Lubricate the main lip of the seal with clean engine oil.
- 2 Fit the pulley onto the key (B1) in the crankshaft nose.
- 3 Lubricate lightly the threads of the setscrew with engine lubricating oil. Fit the washer (A1) to the setscrew (A2) and fit the setscrew finger tight.
- 4 Lock the crankshaft to prevent its clockwise movement.
- 5 Tighten the setscrew to 365 Nm (269 lbf ft) 37,2 kgf m for engines with a hardened washer or green, “Dacromet” setscrew and hardened washer.
- 6 Engines with the original fasteners should be tightened to 325 Nm (240 lbf ft) 33,1 kgf m.

Caution: Remove the device used to lock the crankshaft.

- 7 Fit the drive belt, see Operation 14-3.



Rear oil seal assembly

To remove and to fit

Operation 5-2

Special requirements

Special tools	
Description	Part number
Sleeve guide from the replacer tool for the rear oil seal	21825540

To remove

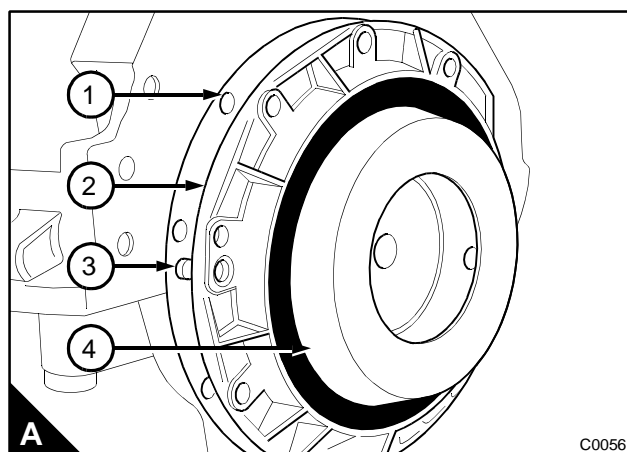
- 1 Remove the drive components from the rear end of the engine.
- 2 Remove the flywheel, see Operation 13-1.
- 3 Remove the flywheel housing, see Operation 13-3.
- 4 Remove the setscrews from the seal housing and remove the housing and seal assembly.

To fit

- 1 Inspect the seal for wear or for damage to the main lip. If there is only a small scratch across the lip, renew the seal, see Operation 5-3.
- 2 Clean the rear face of the cylinder block, the rear face of the rear main bearing cap and the oil seal housing.
- 3 Check that the seal and the outer circumference of the crankshaft flange are not damaged. If a new seal has been fitted, check that it is in the correct position in the housing, see Operation 5-3.
- 4 Ensure that the two dowels (A3) are fitted in the cylinder block. Put a new joint (A1) in position on the dowels, no jointing compound is necessary.
- 5 Put the seal guide (A4) from the seal replacer tool on the crankshaft palm. Lubricate the crankshaft palm, the main lip of the seal and the seal guide with clean engine lubricating oil.

Note: The lubrication of the seal is necessary to prevent damage to the seal when the engine is first started.

- 6 Put the seal and housing assembly (A2) on the seal guide and carefully push the assembly into position on the crankshaft palm and onto the dowels. Remove the seal guide, fit the setscrews. Tighten the setscrews to 22 Nm (16 lbf ft) 2,2 kgf m.



To renew the rear oil seal

Operation 5-3

Special requirements

Special tools	
Description	Part number
Replacer tool for rear oil seal	21825540

There are three positions in which the seal can be fitted in the housing (A).

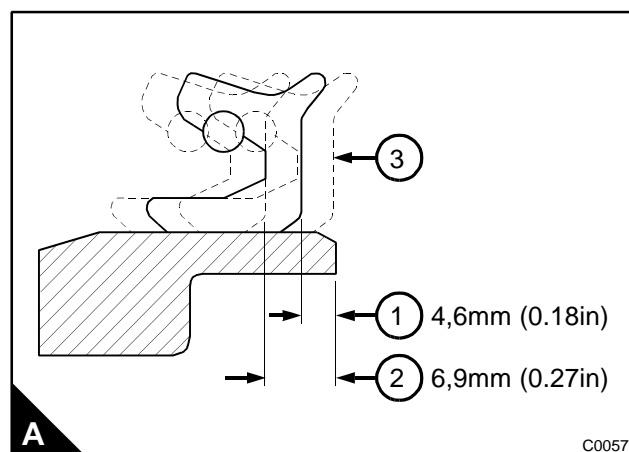
Position "1" (A1) is used when a new seal is first fitted in service.

Position "2" (A2) is used when a new seal is fitted in service and the crankshaft palm is worn in positions "1".

Position "3" (A3) can be used with a new seal in service, if a wet clutch is not used and the crankshaft is new or the crankshaft palm area has been corrected. Ensure that the seal is fitted square in the housing.

If all positions have been used it is permissible to grind the crankshaft palm, refer to "Crankshaft overhaul" on page 19.

- 1 Remove the seal and housing assembly, see Operation 5-2.
- 2 Put the engine side of the housing on a suitable support and press out the seal with a suitable adaptor.
- 3 Lubricate the outer circumference of the seal and the bore of the seal housing with clean engine lubricating oil.
- 4 Put the engine side of the housing on a suitable support. Put the seal into position on the flywheel end of the bore with the spring of the seal towards the housing.
- 5 Use a press and the replacer tool, Part number 21825540, to fit the seal at the correct depth. The special tool has two sides and is used in accordance with either position "1" or "2". Press the seal into the housing to the correct position with the relevant side of the tool.

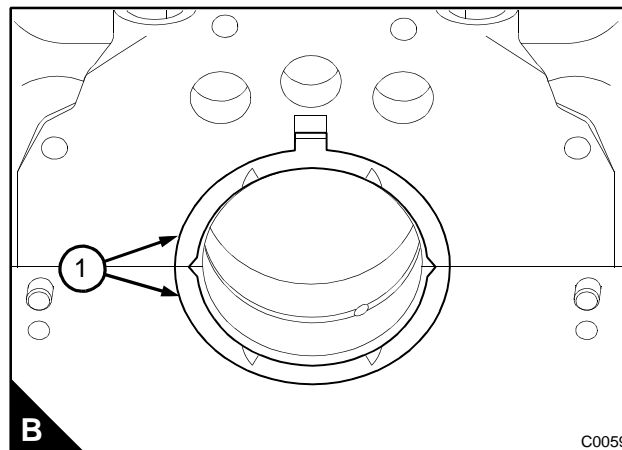
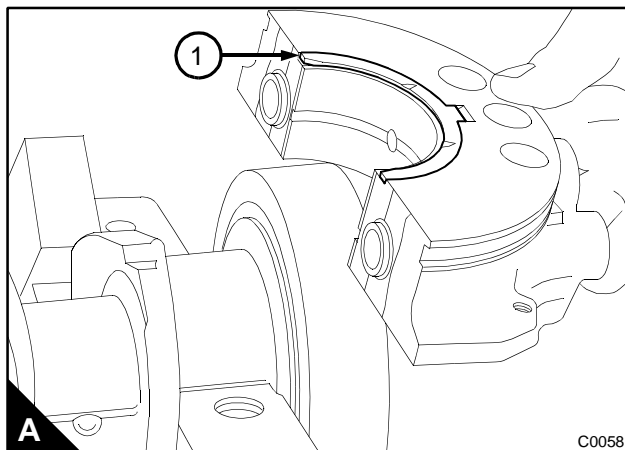


Thrust washers

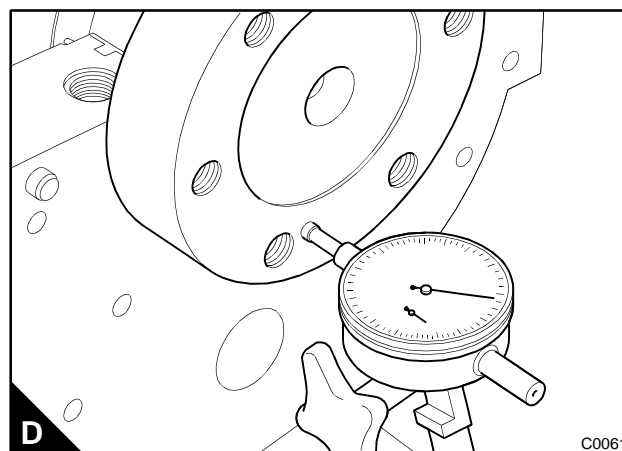
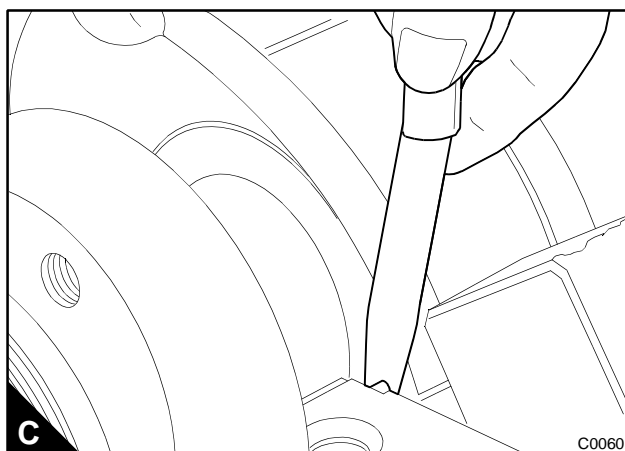
To check crankshaft end-float

Operation 5-4

The axial movement of the crankshaft is controlled by two sets of thrust washers fitted both sides of the rear main bearing (A1 and B1).



The end-float can be checked with a feeler gauge between a thrust washer and the crankshaft (C), or with a dial test indicator on one end of the crankshaft to check the movement (D).



If the end-float is more than the tolerance given in the relevant Data and dimensions for the "Crankshaft" on page 18, thrust washers that are 0,019 mm (0.0075 in) oversize can be fitted to one or to both sides of the main bearing.

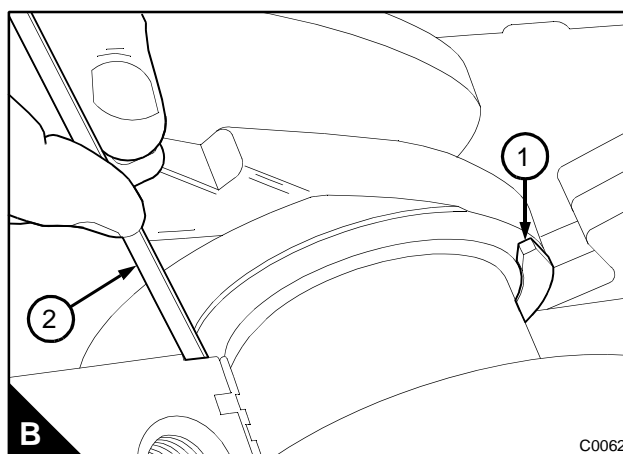
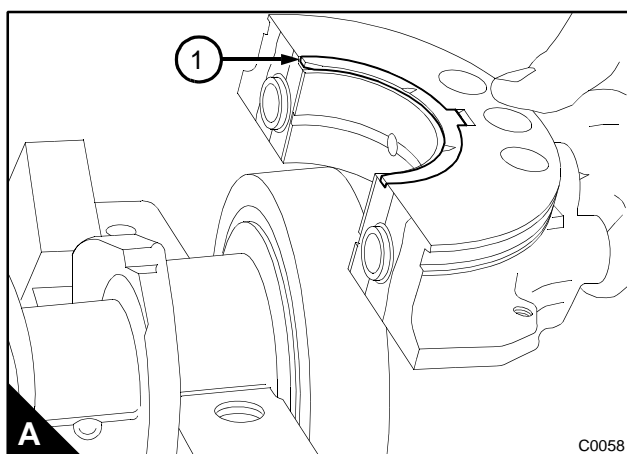
These thrust washers are used instead of the standard size washer to reduce the end-float to the factory tolerances.

To remove

Operation 5-5

The thrust washers fit in recesses machined on each side of the rear main bearing cap. Ensure that the correct size thrust washers are fitted.

- 1 Drain the lubricating oil and remove the lubricating oil sump, see Operation 10-4 or Operation 10-6.
- 2 Remove the flywheel, see Operation 13-1
- 3 Remove the flywheel housing, see Operation 13-3
- 4 Remove the rear oil seal housing, see Operation 5-2.
- 5 Release the two setscrews that retain the rear main bearing cap. Remove the setscrews and carefully remove the bearing cap. Do not damage the cork seal on the bearing cap.
- 6 Remove the two bottom thrust washers (A1) from the rear main bearing cap.
- 7 The two top thrust washers (B1) can be removed by the use of a suitable piece of plastic (B2) to push them out.



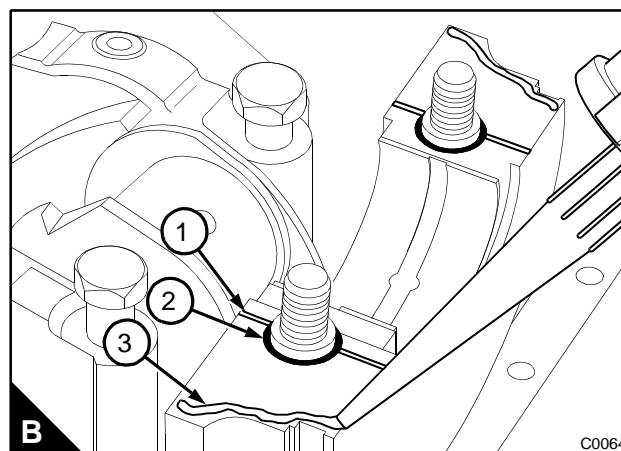
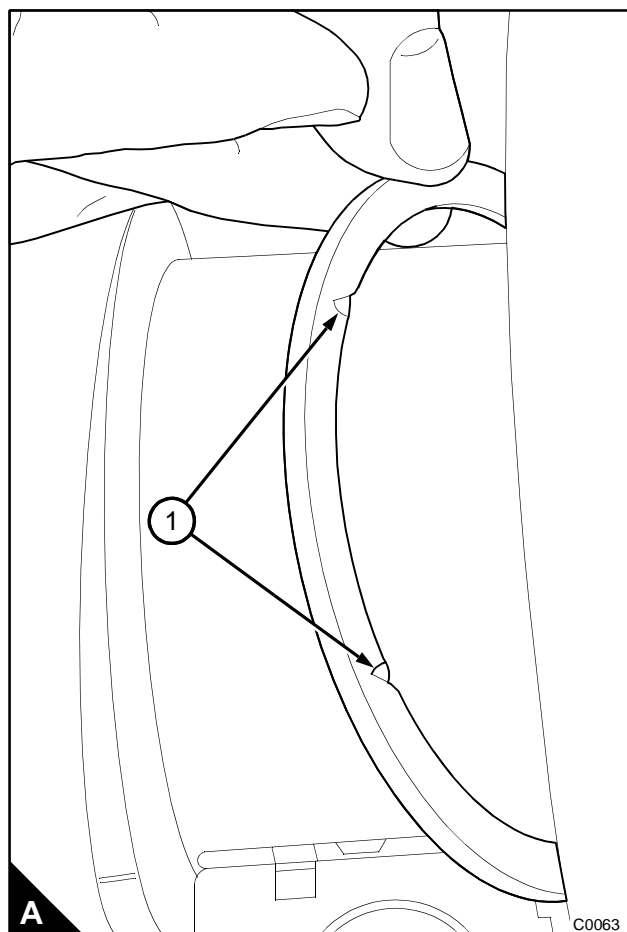
To fit

Operation 5-6

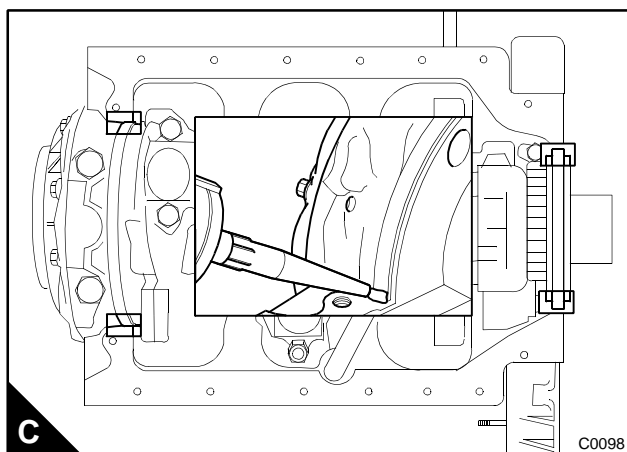
Special requirements

Consumable products			
Description	Part number	Description	Part number
POWERPART Silicone RTV Sealing and jointing compound	1861108	POWERPART Universal jointing compound	1861117

- 1 Lightly lubricate the two top thrust washers with clean lubricating oil. Push each thrust washer into position in the recess on each side of the rear main bearing housing. The grooves (A1) in the thrust washers must be towards the crankshaft.
- 2 Renew the main bearing cap 'O' rings (B2).
- 3 Lightly apply POWERPART Universal jointing compound to the rear main bearing cap mounting faces (B3), outside the grooves machined in the faces (B1). The jointing compound must not go into the grooves.
- 4 Fit a bottom thrust washer on each side of the rear main bearing cap and fit the bearing cap. The grooves in the thrust washers must be towards the crankshaft.
- 5 Inspect the main bearing setscrews for damage or distortion, renew them if necessary.
- 6 Lubricate the bearing with clean engine lubricating oil and put the bearing cap into position.

*Continued*

- 7 Lightly lubricate the setscrew threads with clean engine lubricating oil. Fit the setscrews and tighten them gradually and evenly to 152 Nm (112 lbf ft) 15,5 kgf m. Check the crankshaft end-float, see Operation 5-4.
- 8 Apply POWERPART Silicone sealing and jointing compound to each end of the cork seals at the bridge piece and the rear bearing housing (C).
- 9 Fit the rear oil seal housing, see Operation 5-2.
- 10 Fit the flywheel housing, see Operation 13-3
- 11 Fit the flywheel, see Operation 13-1
- 12 Fit the sump, see Operation 10-5 or Operation 10-7.
- 13 Fill the sump to the correct level with an approved lubricating oil.



Main bearings

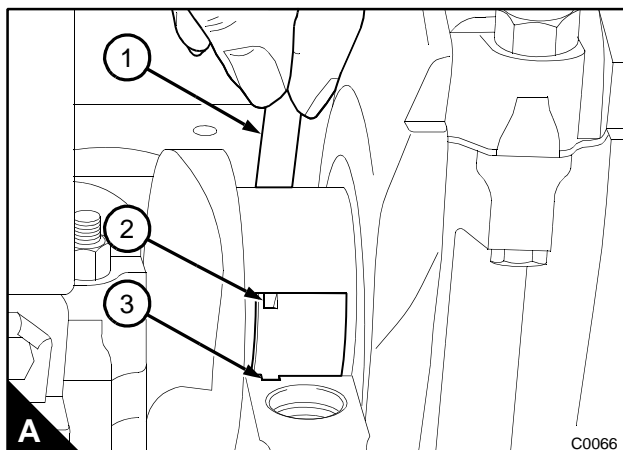
To remove (crankshaft in position)

Operation 5-7

The front and rear main bearings fitted to early naturally aspirated engines have shell bearings with a central groove fitted to the caps. The upper shell bearings fitted to the cylinder block, also have grooves. The remainder of the main bearings have plain shell bearings in the caps and upper shell bearings with grooves. The latest engines both naturally aspirated and turbocharged, have all main bearings with the lower shell bearings plain and the upper shell bearings with grooves.

Note: To order new shell bearings ensure that the full engine number is used.

- 1 Drain the lubricating oil and remove the sump, see Operation 10-4 or Operation 10-6.
- 2 If the front main bearing cap is to be removed, proceed as follows:
 - Remove the cover of the timing case, see Operation 6-1.
 - Remove the front bridge piece, see Operation 6-13.
 - Remove the lubricating oil pump, see Operation 10-10.
 - Release the setscrews of the bearing cap and remove the bearing cap. Remove the lower half of the shell bearing from the cap.
- 3 If the rear main bearing cap is to be removed, proceed as follows:
 - Remove the flywheel, see Operation 13-1 and the flywheel housing, see Operation 13-3.
 - Remove the rear oil seal assembly, see Operation 5-2.
 - Release the setscrews of the bearing cap and remove the bearing cap. Remove the lower half of the shell bearing from the cap.
 - Remove the lower thrust washers.
- 4 To remove the second or third bearing caps, remove the suction pipe from the lubricating oil pump, if necessary. Release the setscrews of the bearing cap and remove the bearing cap. Remove the lower half of the shell bearing from the cap.
- 5 With a suitable tool (A1), push the upper half of the shell bearing from the side opposite to the location tag (A2) to remove the bearing tag (A3) from its recess in the bearing housing. Carefully rotate the crankshaft to release the bearing from its housing. Keep the bearing halves in their relevant positions



To fit (crankshaft in position)

Operation 5-8

Caution: Some shell bearings do not have a hole in the bearing. These shell bearings must only be fitted in the main bearing cap. If this type of shell bearing is fitted to the cylinder block, the bearing will not receive lubricating oil and the bearing and the crankshaft journal will be damaged.

- 1 Clean the upper half of the shell bearing and lubricate the bearing surface with clean engine lubricating oil.
 - 2 Fit the plain end of the upper half of the bearing between the crankshaft journal and the side of the cylinder block that has the recess for the location tag. Slide the bearing into position until the tag on the bearing is fitted correctly in its recess in the cylinder block.
 - 3 Clean the lower half of the bearing and the bearing 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 Ensure that the location thimbles are fitted correctly to the cap or to the cylinder block. Fit the bearing cap with the location tags of both 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. Fit the setscrews and tighten them gradually and evenly to 152 Nm (112 lbf ft) 15,5 kgf m.
 - 7 Ensure that the crankshaft rotates freely. If the thrust washers have been removed and fitted, check the crankshaft end-float, see Operation 5-4.
 - 8 If the front main bearing was removed:
 - Fit the lubricating oil pump, see Operation 10-11.
 - Fit the front bridge piece, see Operation 6-14.
 - Fit the cover of the timing case, see Operation 6-2.
 - 9 Fit the rear oil seal assembly, see Operation 5-2.
 - 10 Fit the lubricating oil sump, see Operation 10-5 or Operation 10-7, and fill it to the correct level with an approved lubricating oil.
 - 11 Fit the flywheel housing, see Operation 13-3 and the flywheel, see Operation 13-1.
-

To inspect

Operation 5-9

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

Crankshaft

To remove

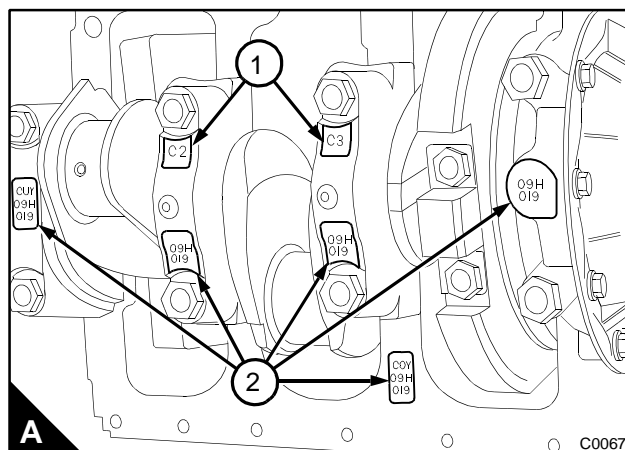
Operation 5-10

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

Note: Perkins recommend, for safety reasons, that this operation is done with the engine upside down. This will ensure that the crankshaft can be lifted out. Also the pistons will be retained in the cylinder bores.

- 1 Before the engine is removed from the vehicle or from the machine, drain the lubricating oil and the coolant.
- 2 Remove the fan and the drive belt, see Operation 14-3.
- 3 Remove the crankshaft pulley, see Operation 5-1.
- 4 Remove the timing case cover, see Operation 6-1.
- 5 Remove the idler gear, see Operation 6-4.
- 6 Remove the front bridge piece, see Operation 6-13.
- 7 Remove the starter motor, see Operation 14-6.
- 8 Remove the flywheel, see Operation 13-1.
- 9 Remove the flywheel housing, see Operation 13-3.
- 10 Remove the rear oil seal housing, see Operation 5-2.
- 11 Remove the lubricating oil sump, see Operation 10-4 or Operation 10-6.
- 12 Remove the lubricating oil pump, see Operation 10-10.
- 13 Release and remove the bolts and nuts of the connecting rods. Remove the big end bearing caps. Keep the bearings and with the relevant caps, see Operation 4-1.
- 14 Ensure that the tops of the main bearing caps are stamped with their relevant position number (A). Release and remove the setscrews for the main bearing caps. Remove the main bearing caps, the lower half of the shell bearings the upper and lower thrust washers. Keep the bearings with the relevant caps.
- 15 Lift out the crankshaft. Remove the upper half of the bearings and keep each bearing with its relevant lower half and cap.

Note: If the main bearings are to be used again, they must be fitted in the same positions from which they were removed.



To fit

Operation 5-11

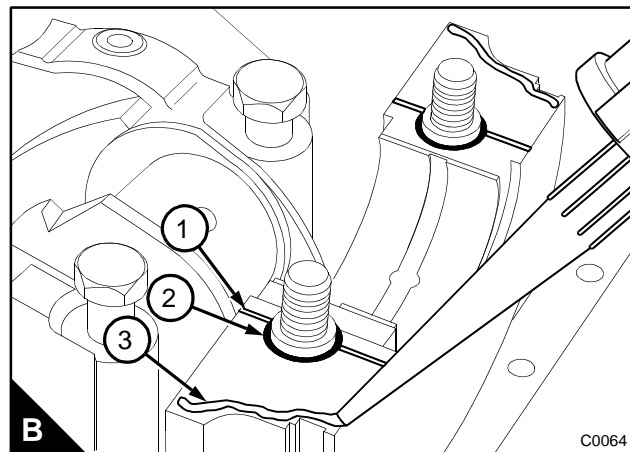
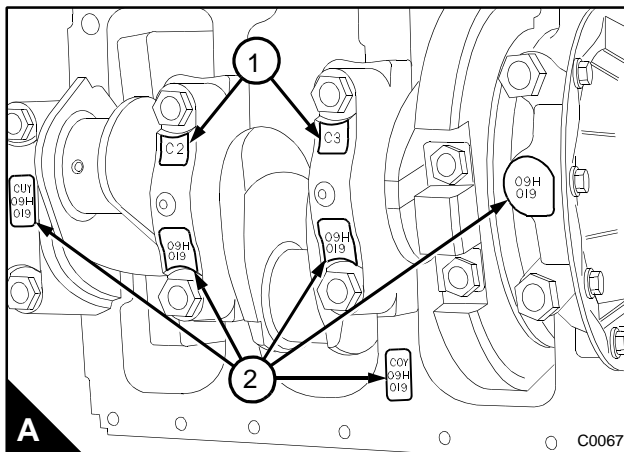
Special requirements

Consumable products	
Description	Part number
POWERPART Silicone sealing and jointing compound	1861108

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

Caution: Some shell bearings do not have a hole in the bearing. These shell bearings must only be fitted in the main bearing cap. If this type of shell bearing is fitted to the cylinder block, the bearing will not receive lubricating oil and the bearing and the crankshaft journal will be damaged.

- 1 Ensure that all lubricating oil passages of the crankshaft are clean and free from restriction.
- 2 Clean the main bearing housings and the upper half of the bearings. Fit the shell bearings with the location tags fitted correctly in their recesses. Lubricate the bearings with clean engine lubricating oil.
- 3 Ensure that the main journals of the crankshaft are clean. Put the crankshaft in position on the upper bearings.
- 4 Clean and lubricate the upper thrust washers. Slide them into their recesses in the rear of the cylinder block. The grooves in the thrust washers must be towards the crankshaft.
- 5 Renew the 'O' rings (B2) for the rear main bearing cap.
- 6 Clean the bearing caps and the lower half of the bearings. Fit the bearings to the caps with the location tags fitted correctly in their recesses. Lubricate the bearings with clean engine lubricating oil.
- 7 Lightly apply Perkins POWERPART Silicone sealing and jointing compound to the mounting faces of the rear main bearing cap (B3), outside the grooves (B1) in the faces. The sealant must not go into the grooves.
- 8 Clean the lower thrust washers and lubricate them with clean engine lubricating oil. Fit the thrust washers on both sides of the rear bearing cap. The grooves in the thrust washers must be towards the crankshaft.
- 9 Check that the location thimbles for the main bearing caps are fitted correctly in the caps or in the cylinder block.
- 10 Put the main bearing caps in their correct positions and ensure that the bottom thrust washers are correctly fitted to the rear bearing cap. Each cap is stamped with a serial number. When the caps are fitted, the serial numbers must be on the same side as the serial number stamped on the bottom face of the cylinder block (A2). The second and the third main bearing caps are marked C2 and C3 respectively (A1).



Continued

- 11 Check the main bearing setscrews for distortion and thread damage and renew them as necessary. Ensure that only the correct setscrews are used. Fit the setscrews to the main bearing caps and tighten the setscrews gradually and evenly to 152 Nm (112 lbf ft) 15,5 kgf m.
- 12 Fit the connecting rod caps, see Operation 4-2. Rotate the crankshaft two turns to ensure free movement.
- 13 Fit the lubricating oil pump, together with the suction pipe and strainer, and the delivery pipe, see Operation 10-11.
- 14 Fit the lubricating oil sump, see Operation 10-5 or Operation 10-7.
- 15 Fit the rear oil seal assembly, see Operation 5-2.
- 16 Fit the flywheel housing, see Operation 13-3.
- 17 Fit the flywheel, see Operation 13-1.
- 18 Fit the starter motor, see Operation 14-6.
- 19 Fit the idler gear, see Operation 6-5.
- 20 Fit the bridge piece, see Operation 6-14.
- 21 Fit the timing case cover, see Operation 6-2.
- 22 Fit the crankshaft pulley, see Operation 5-1.
- 23 Fit the drive belt, see Operation 14-3, and the fan, see Operation 12-8.
- 24 After the engine has been installed in the application, fill the lubricating oil sump to the correct level with an approved oil. Fill the cooling system with antifreeze of the correct specification.

Balance weights

If it is necessary to renew the crankshaft balance weights. These are normally supplied in sets of two and should be fitted as a set. If one weight is renewed, then the weight difference must not exceed 28,3 g (1 oz.). The setscrews that retain the balance weights are tightened to 72 Nm (53 lbf ft) 7,3 kgf m.

Note: On later engines, the balance weights are retained by longer setscrews and steel washers. These are tightened to 72 Nm (53 lbf ft) 7,3 kgf m.

Caution: Do not fit steel washers to the short setscrews as this can cause the balance weights to loosen.

To inspect

Operation 5-12

Check the crankshaft for wear and other damage. The maximum permissible wear and ovality on the crankshaft journals and crank pins is 0,04 mm (0.0016 in).

The main journals and the crank pins of standard size crankshafts can be machined to 0,25 mm (0.010 in), 0,50 mm (0.020 in) or 0,75 mm (0.030 in) undersize on diameter. Refer to the relevant Data and dimensions given in "Crankshaft overhaul" on page 19. Special undersize bearings are available.

If the seal has been used in all of the service positions, the crankshaft palm can be machined to remove the wear marks. Further information can be found in the relevant Data and dimensions for the "Crankshaft assembly" on page 18.

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6

Timing case and drive assembly

General description

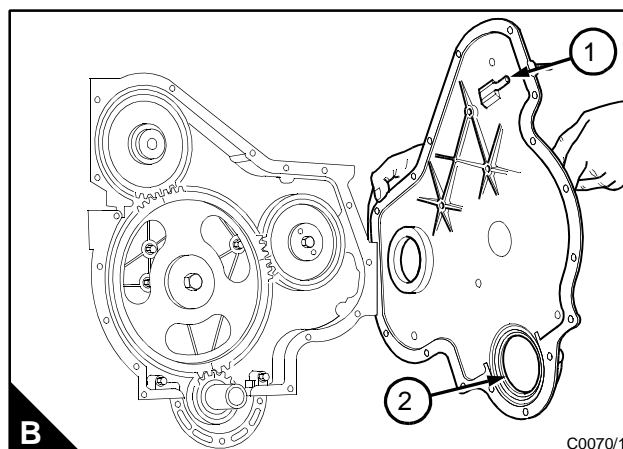
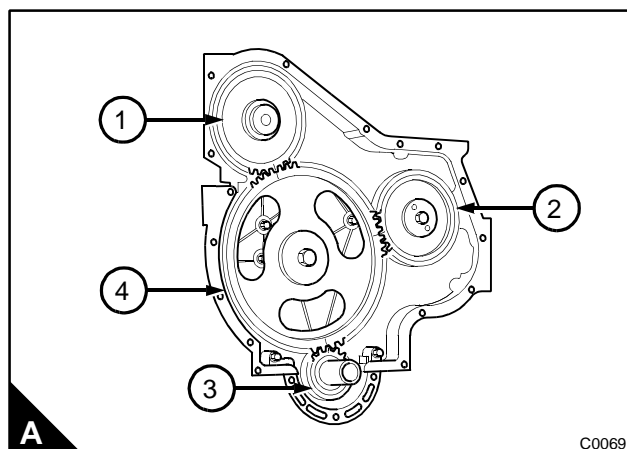
The aluminium timing case contains the timing gears. The gears are made of either cast iron or steel, except for the crankshaft gear, which is always made of steel. Cast iron and steel gears should not be mixed. Some higher rated engines have an idler gear that is fitted with a bush.

The drive from the crankshaft gear (A3) passes through an idler gear (A4) to the camshaft gear (A1) and to the gear for the fuel injection pump (A2). The drive from the crankshaft gear also passes through a lower idler gear to the gear for the lubricating oil pump. The camshaft and the fuel injection pump rotate at half the speed of the crankshaft.

The camshaft is made of cast iron. The cam lobes and the eccentric for the fuel lift pump are hardened.

Warning! Read the safety precautions for "Viton seals" on page 7.

The aluminium cover for the timing case has an oil seal (B2), that is made of Viton. This seal operates on the spigot of the crankshaft pulley. The seal has a dust lip that protrudes from the front of the seal. This lip protects the main lip of the oil seal. There is also a spring (B1) that controls the end-float of the camshaft.

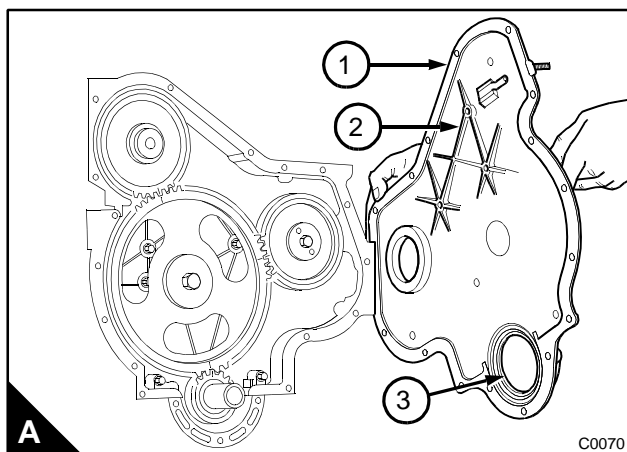


Timing case cover

To remove

Operation 6-1

- 1 Remove the drive belt for the coolant pump and the alternator, see Operation 14-3.
- 2 Drain the coolant and remove the coolant pump, see Operation 12-4.
- 3 Remove the crankshaft pulley, see Operation 5-1.
- 4 Remove the alternator, see Operation 14-4.
- 5 Remove the setscrews for the cover of the timing case. Note the position of the setscrews as they are different lengths and thread sizes.
- 6 Clean the timing case cover. Remove the timing case cover (A2). Ensure that no damage occurs to the oil seal (A3).



To fit

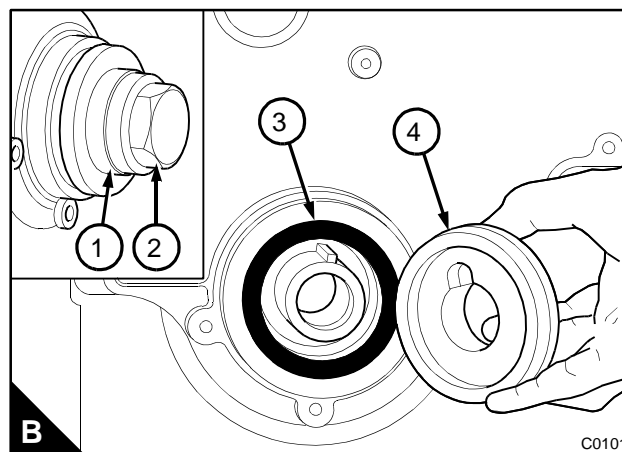
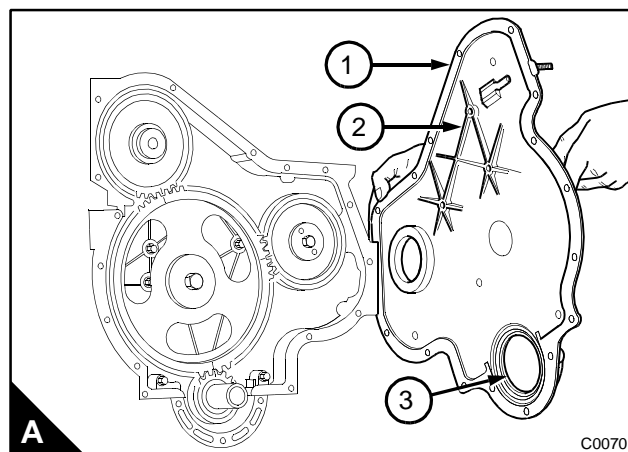
Operation 6-2

Special requirements

Special tools	
Description	Part number
Centralising tool	21825571

- 1 Clean the faces of the timing case cover and of the timing case. Fit a new joint (A1) to the cover, a sealant is not necessary.
- 2 Put the cover together with the new joint in position on the timing case and loosely retain the cover, in balance, with two setscrews. Tighten the setscrews finger tight.
- 3 Fit the centralising tool (B4) to the nose of the crankshaft. Loosely fit the large washer (B1) and the large setscrew (B2) for the crankshaft pulley. Engage the tool with the seal housing (B3) and tighten the setscrew finger tight to centre the cover.
- 4 Fit the remainder of the setscrews for the cover in their correct positions and fully tighten the M8 setscrews to 22 Nm (16 lbf ft) 2,2 kgf m and the M6 setscrews to 9 Nm (7 lbf ft) 0,9 kgf m. Remove the setscrew and the large washer and remove the centralising tool.
- 5 Fit the coolant pump, see Operation 12-5.
- 6 Fit the crankshaft pulley, see Operation 5-1.
- 7 Fit the alternator, see Operation 14-4.
- 8 Fit the drive belt, see Operation 14-3, and adjust the belt tension, see Operation 14-2.
- 9 Fill the cooling system with antifreeze of the correct specification, see Operation 12-3.

Note: See "Coolant specification" in Chapter 5 of the User's handbook for details of the correct coolant to be used in the cooling system.



Front oil seal

To remove and to fit

Operation 6-3

Special requirements

Special tools			
Description	Part number	Description	Part number
Replacer tool for front oil seal (main tool)	21825571	Pressure plate	21825578
		Adaptor for standard seal	21825582

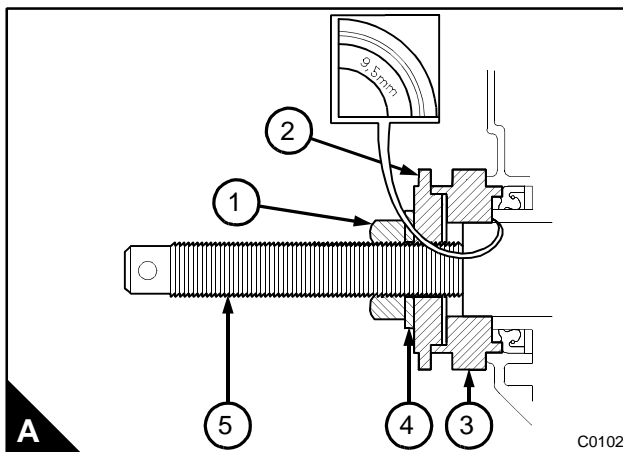
To remove

- 1 Remove the drive belts, see Operation 14-3.
- 2 Remove the crankshaft pulley, see Operation 5-1.
- 3 Remove the oil seal with a suitable lever behind the main lip of the oil seal.

Caution: Do not damage the edge of the oil seal housing.

To fit

- 1 Clean the oil seal housing. Inspect the new seal for damage. If a scratch can be seen across the lip of the seal, do not fit the seal.
- 2 Lubricate the outer circumference of the oil seal with clean engine lubricating oil and enter the seal into the housing. Ensure that the spring loaded lip of the oil seal is towards the inside of the timing case cover and that the oil seal is square to the bore of the seal housing.
- 3 Fit the threaded main tool (A5) to the front of the crankshaft.
- 4 Fit the adaptor (A3) onto the nose of the crankshaft and against the seal. The dimension 9,5 mm, marked on the face of the adaptor, must be toward the seal.
- 5 Fit the pressure plate (A2) to the main tool.
- 6 Fit the washer (A4) and the nut (A1) to the main tool.
- 7 Tighten the nut in order to apply pressure to the plate, this will press the seal into the timing case cover. Ensure that the seal is still square to the timing case cover. Continue to tighten the nut until the shoulder of the adaptor contacts the front of the seal housing. Remove the tool.
- 8 Fit the crankshaft pulley, see Operation 5-1.



Idler gear and hub

To remove

Operation 6-4

Note: Do not rotate the crankshaft when the idler gear is removed. If the crankshaft is rotated, top dead centre (TDC) will have to be set on number 1 cylinder, see Operation 8-1.

1 Remove the timing case cover, see Operation 6-1.

2 Rotate the crankshaft until the marked teeth of the crankshaft gear, the camshaft gear, and the fuel pump gear are aligned with the idler gear (A). The marked teeth of the idler gear will not necessarily be aligned with the marked teeth of the other gears because of the different speed of rotation of the idler gear.

Note: The latest engines do not have a tab washer and use an M12 (M.E.A.S.) setscrew instead of a ½ UNF setscrew.

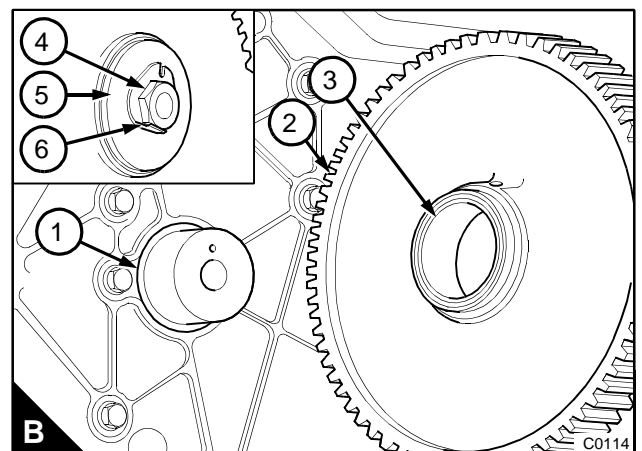
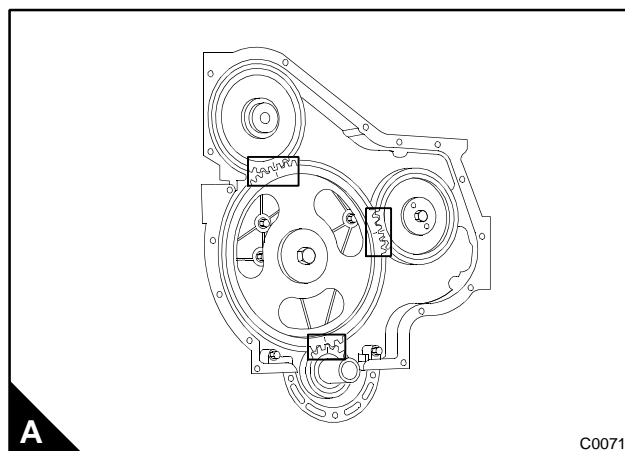
3 Release the tab washer (B6) from the setscrew (B4) that retains the idler gear. Remove the setscrew, the tab washer (if fitted) and the large washer (B5) from the idler gear.

4 Remove the idler gear (B2) from its hub (B1). If necessary, remove the hub from the cylinder block.

Note: Some engines have an idler gear that has a bush.

5 Inspect the gear and the bush (B3) for wear and other damage and renew as necessary. The gear and the bush are available as an assembly, or a separate bush is available.

6 If the bush is to be renewed, remove it with a suitable adaptor and a press.

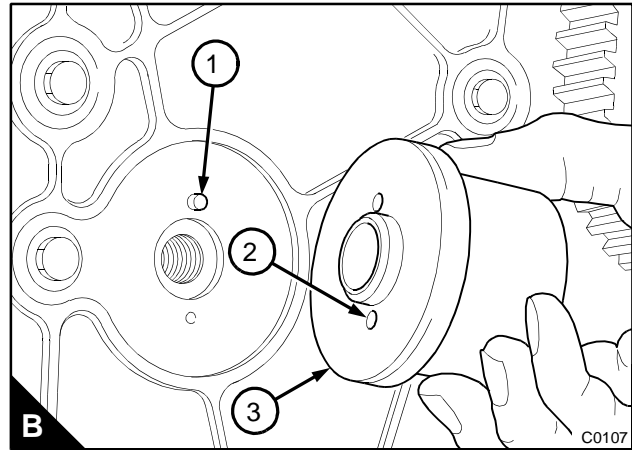
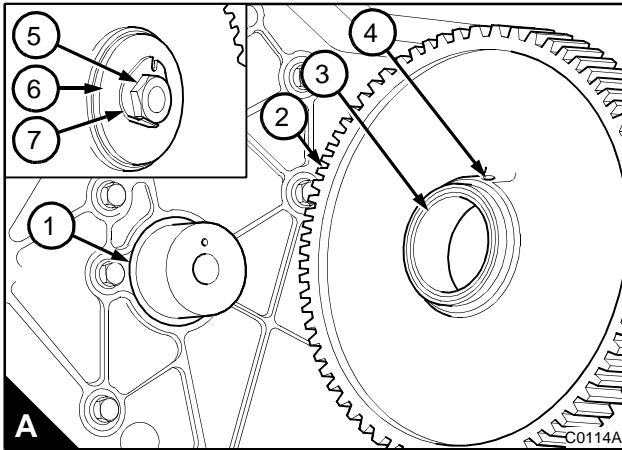


To fit

Operation 6-5

Note: Some engines have an idler gear that has a bush (A3).

- 1 If a new bush is to be fitted, ensure that the hole in the bush aligns with the hole in the gear (A4). Press in the bush with a suitable adaptor. Check that the hole in the bush is aligned with the hole in the gear.
- 2 If the hub (B3) has been removed, put the hub in position on the cylinder block. Ensure that the oil hole (B2) in the hub is at the bottom and that the hub is correctly fitted on its dowel (B1).



- 3 Lubricate the bore of the idler gear, or the bush, with clean engine lubricating oil. Align the timing marks on the idler gear with the marks on the crankshaft, the camshaft and the fuel pump gears, and slide the idler gear into position.

Note: If the crankshaft or the camshaft has to be rotated, it will be necessary to remove the rocker shaft to ensure a piston does not contact a valve.

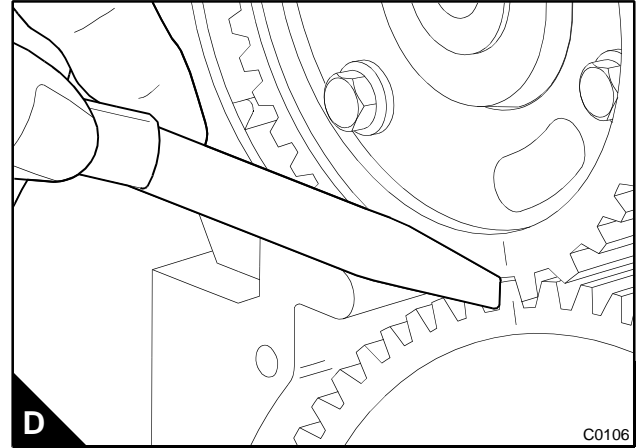
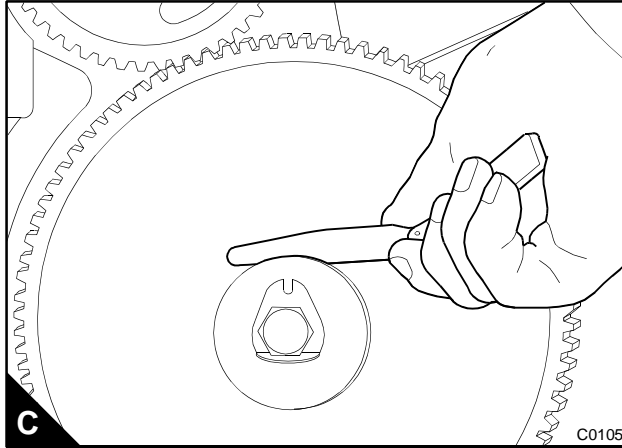
- 4 Check that all the timing marks are in correct alignment.

Note: The latest engines do not have a tab washer and use an M12 M.E.A.S. setscrew instead of a $\frac{1}{2}$ UNF setscrew.

- 5 Fit the large washer (A6), a new tab washer (A7) and the setscrew (A5) that retains the idler gear to the hub. Tighten the $\frac{1}{2}$ UNF setscrew to 65 Nm (48 lbf ft) 6,6 kgf m. For engines with an M12 setscrew, tighten the setscrew to 78 Nm (57 lbf ft) 8,0 kgf m. If a tab washer is used, bend the tab of the tab washer to lock the setscrew.

Continued

- 6** Check that the idler gear has end-float (C) of 0,13/0,38 mm (0.005/0.015 in) on the hub. The maximum permissible end-float is 0,46 mm (0.018 in).
- 7** If a new gear is fitted, check that there is a minimum backlash (D) of 0,08 mm (0.003 in).
- 8** Lubricate the teeth of the gears with clean engine lubricating oil.
- 9** Fit the timing case cover, see Operation 6-2.



Fuel pump gear

To remove a gear from a tapered shaft

Operation 6-6

Special requirements

Special tools			
Description	Part number	Description	Part number
Gear puller	21825565	Adaptors	21825568

1 Remove the timing case cover, see Operation 6-1.

Caution: Check that the shaft of the Delphi fuel injection pump is not locked, see Operation 11-14 and Operation 11-15.

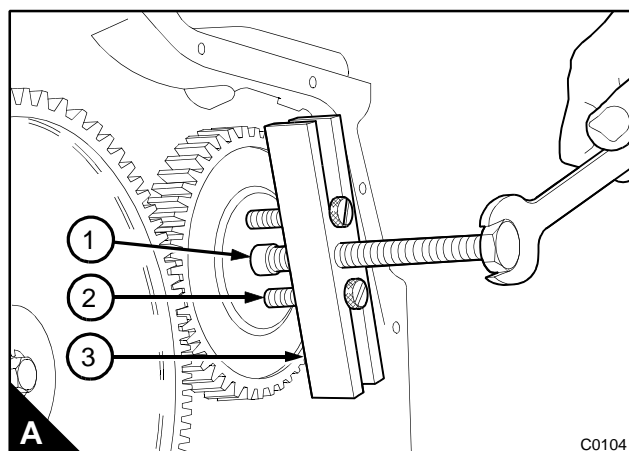
2 Rotate the crankshaft until the marked teeth of the crankshaft gear, the camshaft gear and the fuel pump gear are all aligned with the idler gear. The marked teeth of the idler gear will not necessarily be aligned with the marked teeth of the other gears because of the different speed of rotation of the idler gear.

3 Remove the nut and the spring washer from the fuel pump gear.

4 Remove the idler gear, see Operation 6-4.

5 Fit the gear puller (A3) together with the adaptors (A2) to the gear. Put a spacer (A1) between the end of the pump shaft and the threaded rod of the puller to protect the end of the shaft. Remove the fuel pump gear with the puller. Ensure that the key in the fuel pump shaft is not lost.

6 Inspect the gear for wear and other damage and renew it, if necessary.



To fit a gear to a tapered shaft

Operation 6-7

1 Ensure that the key is fitted correctly in the shaft of the fuel pump. Engage the key in the shaft with the keyway in the gear and push the gear into position. Fit the spring washer and loosely fit the nut.

Note: Check that the fuel pump is not locked, see Operation 11-14 and Operation 11-15.

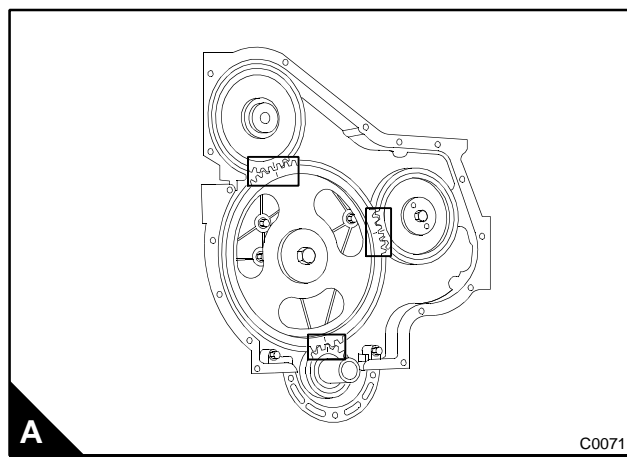
2 Rotate the fuel pump gear to ensure that the relevant marked tooth (A) of the fuel pump gear will align with the marked teeth of the idler gear. Fit the idler gear, see Operation 6-5.

3 Tighten the nut of the fuel pump gear to 80 Nm (59 lbf ft) 8,2 kgf m. The teeth of the drive gear and the idler gear should be fully aligned when the fuel pump gear is tightened onto the hub of the fuel injection pump.

4 If a new gear has been fitted, check that there is a minimum backlash of 0,08 mm (0.003 in).

5 Lubricate the teeth of the gears with clean engine lubricating oil.

6 Fit the timing case cover, see Operation 6-2.



To remove a gear fitted to a hub

Operation 6-8

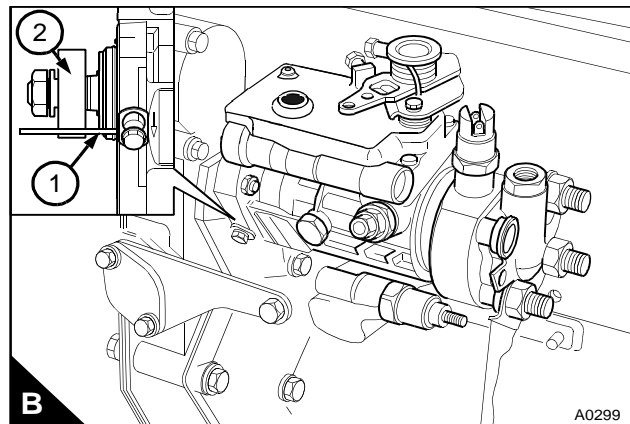
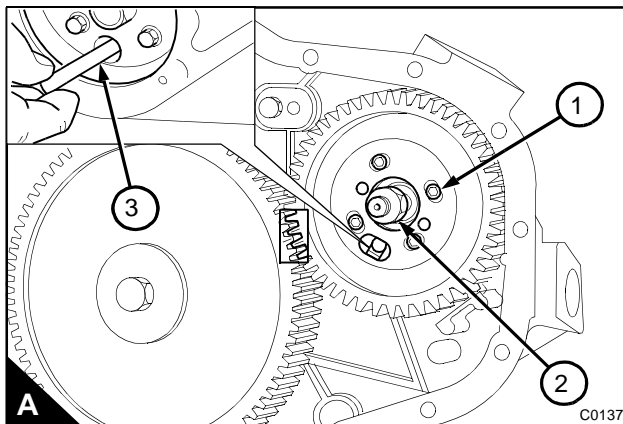
Special requirements

Special tools			
Description	Part number	Description	Part number
Timing pin, Delphi fuel injection pumps	27610033	Torx screw, fuel pump drive gear retaining	27610122
Locking pin for the crankshaft	21836001		

1 Remove the timing case cover, see Operation 6-1.

Caution: Do not lock the shaft of the fuel injection pump, see Operation 11-14 and Operation 11-15.

2 Set the number one piston to TDC on the compression stroke, see Operation 8-1. Fit the timing pin (A3) through the slot in the gear until the small end of the pin (B1) is pushed fully into the recess in the fuel pump body.

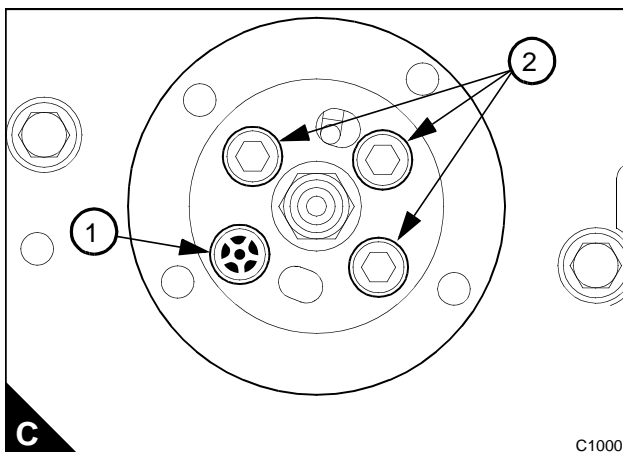


Caution: Do not remove the nut (A2) that retains the hub (B2) to the shaft of the fuel injection pump. The hub is fitted permanently to the shaft. If the hub is removed, it will be necessary for a fuel injection pump specialist to correctly position the hub on the shaft with special test equipment.

3 Remove the four setscrews (A1) from the fuel pump gear and remove the gear from the hub of the fuel pump.

Note: On the latest engines, the fuel pump gear is now retained by one torx screw (C1) and three Allen screws (C2). The torque for all four fasteners is 27 Nm (20 lbf ft) 2,7 kgf m. A special tool to remove the Torx screw is available at your Perkins distributor.

4 Inspect the gear for wear and other damage and renew it, if necessary.



To fit a gear to a hub

Operation 6-9

Special requirements

Special tools			
Description	Part number	Description	Part number
Timing pin, Delphi fuel injection pumps	27610033	Torx screw, fuel pump drive gear retaining	27610122
Locking pin for the crankshaft	21836001		

The fuel pump gear will fit correctly in only one position. The gear is fitted with the letters of the casting number at the front.

Caution: Check that the shaft of the Delphi fuel injection pump is not locked, see Operation 11-14 and Operation 11-15.

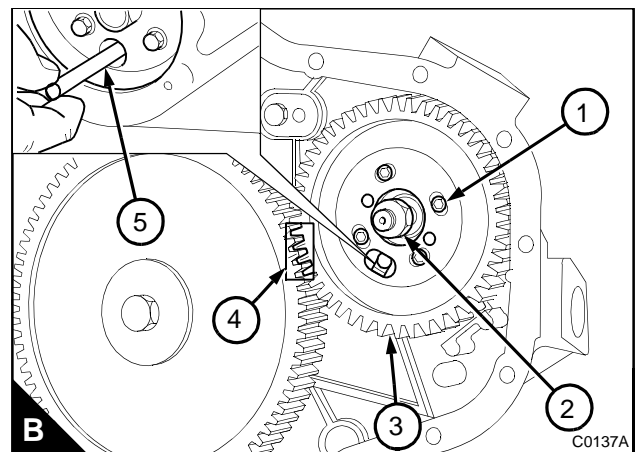
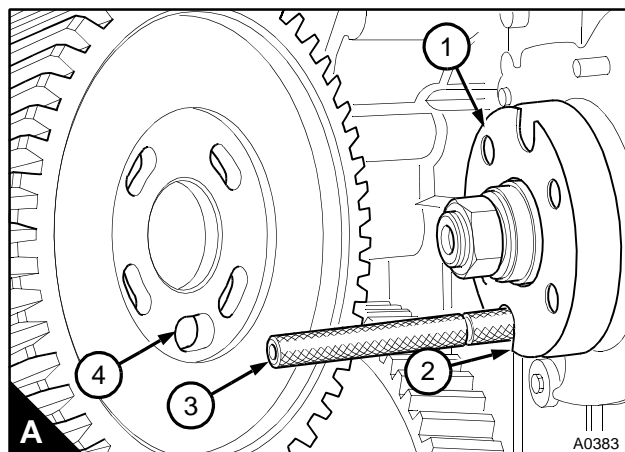
- 1** Ensure that the engine is set to TDC with the number one piston on the compression stroke, see Operation 8-1.
- 2** If the pin (A3) has been removed before the gear is fitted, rotate the hub of the fuel injection pump (A1) until the recess in the pump body can be seen in the slot (A2). Fit the end of the pin fully into the recess in the pump body. Leave the pin in position.
- 3** Fit the fuel pump gear (B3) so that the pin passes through the slot (A4) and the gear fits on the hub in mesh with the idler gear (B4).

Note: If a new gear is to be fitted, ensure that the casting numbers and the timing marks (B4) are towards the front of the engine. Put the gear into position on the hub. If the gear is fitted correctly the four threaded holes in the hub can be seen through the slots (A4) in the gear.

- 4** Loosely fit the four setscrews in the centre of the slots (B1) in the gear.

If the gear is renewed, carefully rotate the gear (B3) counter-clockwise until the backlash between the idler gear and the fuel pump gear has been removed. Do not rotate the crankshaft or it will be necessary to set TDC again.

- 5** Tighten the four setscrews (B1) that retain the gear to 28 Nm (20 lb ft) 2,8 kgf m. Remove the timing pin from the fuel pump.



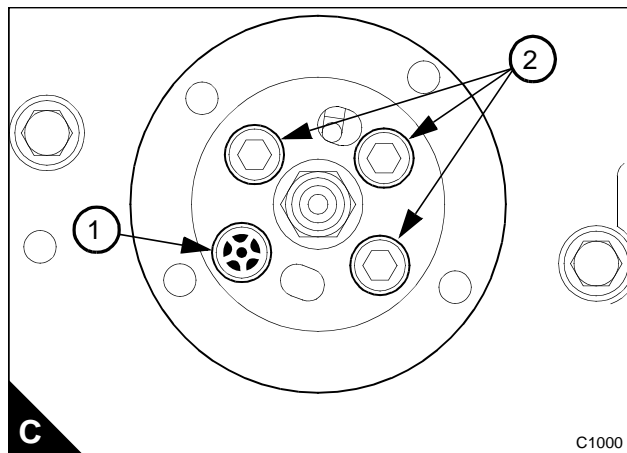
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Note: Some engines have a different arrangement to retain the fuel pump gear. If the gear is retained by one torx screw (C1) and three Allen screws (C2) then tighten the fasteners to 27 Nm (20 lbf ft) 2,7 kgf m. A special tool to remove and fit the Torx screw is available at your Perkins distributor.

6 If a new gear has been fitted, use a feeler gauge to check the backlash.

7 Fit the timing case cover, see Operation 6-2.

8 Fill the cooling system, Operation 12-3.

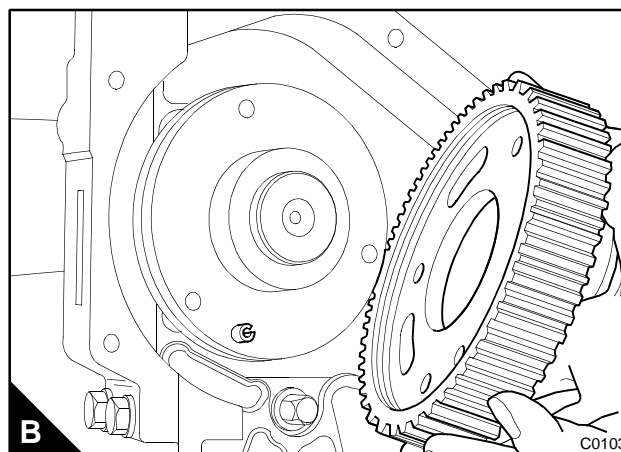
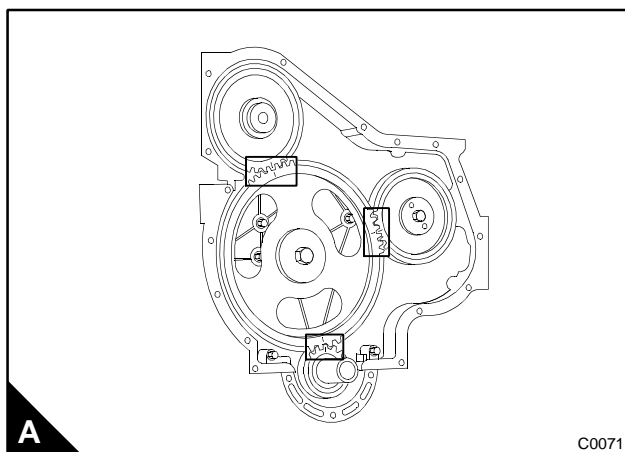


Camshaft gear

To remove

Operation 6-10

- 1 Remove the timing case cover, see Operation 6-1.
- 2 Rotate the crankshaft until the marked teeth (A) of the crankshaft gear, the camshaft gear and the fuel pump gear are all aligned with the idler gear. The marked teeth of the idler gear will not necessarily be aligned with the marked teeth of the other gears because of the different speed of rotation of the idler gear.
- 3 Remove the three setscrews that retain the gear to the camshaft.
- 4 Remove camshaft gear (B) from camshaft.
- 5 Inspect the gear for wear and any other damage and renew it, if necessary.

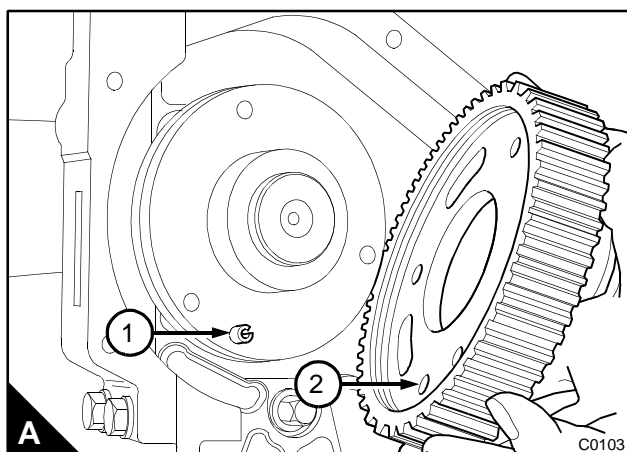


To fit

Operation 6-11

Caution: If the camshaft or the crankshaft has to be rotated, it will be necessary to release the tension on the valve springs to ensure that a piston does not contact a valve. If the nuts for the rocker shaft are released, ensure that they are tightened again correctly, see Operation 3-3.

- 1 Remove the idler gear, see Operation 6-4.
- 2 Ensure that the dowel (A1) in the end of the camshaft is fitted correctly. Align the hole (A2) in the rear face of the gear with the dowel and fit the camshaft gear to the camshaft. Fit the setscrews for the camshaft gear and tighten the setscrews to press the camshaft gear into position. Tighten the setscrew to 27 Nm (20 lbf ft) 2,8 kgf m.
- 3 Fit the idler gear with the marked teeth in correct mesh with the idler gear, see Operation 6-5.
- 4 If a new camshaft gear has been fitted, check that there is a minimum backlash of 0,08 mm (0.003 in).
- 5 Lubricate the teeth of the gears with clean engine lubricating oil.
- 6 Fit the timing case cover, see Operation 6-2.



Crankshaft gear

To remove and to fit

Operation 6-12

To remove

- 1 Remove the timing case cover, see Operation 6-1.
- 2 Rotate the crankshaft until the marked teeth of the crankshaft gear, the camshaft gear and the fuel pump gear are all aligned with the idler gear. The marked teeth of the idler gear will not necessarily be aligned with the marked teeth of the other gears because of the different speed of rotation of the idler gear.
- 3 Remove the idler gear, see Operation 6-4.
- 4 The crankshaft gear is a transition fit on the crankshaft. It may slide off easily or, if it is a tight fit and the gear is to be renewed, it may be necessary to remove the crankshaft, see Operation 5-10, to remove the gear safely.

To fit

Warning! *If heat is used to fit the gear, ensure that suitable leather gloves are worn to protect the hands.*

- 1 The gear can fit easily, or it may be necessary to heat the gear before it will fit onto the crankshaft. If the gear is to be heated, heat it in an oven to not more than 180 °C (226 °F). If an oven is not available, heat it in coolant that is at its boiling point. Do not use a flame as this can cause local damage. Fit the gear with the timing marks to the front.
- 2 Fit the idler gear, see Operation 6-5, and ensure that all the timing marks are correctly aligned.
- 3 Lubricate the teeth of the gears with clean engine lubricating oil.
- 4 Fit the timing case cover, see Operation 6-2.

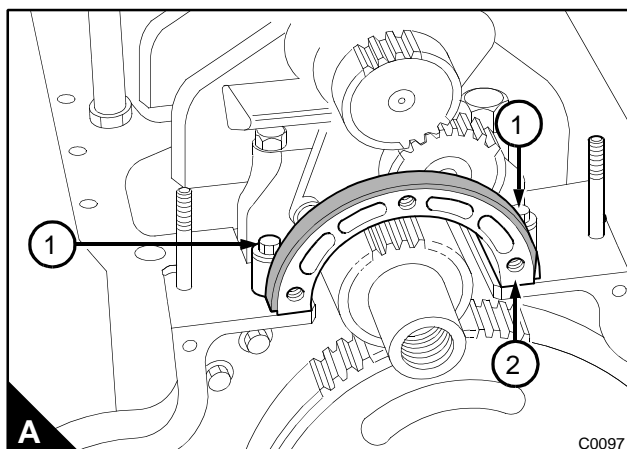
Timing case

To remove

Operation 6-13

Note: Do not rotate the crankshaft when the idler gear is removed. If the crankshaft is rotated, top dead centre (TDC) will have to be set on number 1 cylinder, see Operation 8-1.

- 1 Remove the alternator together with its mounting bracket and front support plate.
- 2 Remove the timing case cover, see Operation 6-1.
- 3 Rotate the crankshaft until the marked teeth of the crankshaft gear, the camshaft gear and the fuel pump gear are all aligned with the idler gear. The marked teeth of the idler gear will not necessarily be aligned with the marked teeth of the other gears because of the different speed of rotation of the idler gear.
- 4 Remove the gear for the fuel injection pump, see Operation 6-6 or Operation 6-8.
- 5 Remove the fuel injection pump, see Operation 11-14, Operation 11-16 or Operation 11-20.
- 6 Remove the idler gear, see Operation 6-4.
- 7 Remove the camshaft gear, see Operation 6-10.
- 8 Drain the lubricating oil and remove the sump, see Operation 10-4 or Operation 10-6.
- 9 Remove the 14 setscrews that retain the timing case to the cylinder block. Note the position of the setscrews and any washers, to ensure a correct assembly later.
- 10 Remove the timing case and the joint, do not allow the idler gear hub to fall.
- 11 Release the two setscrews (A1) and remove the bridge piece (A2).

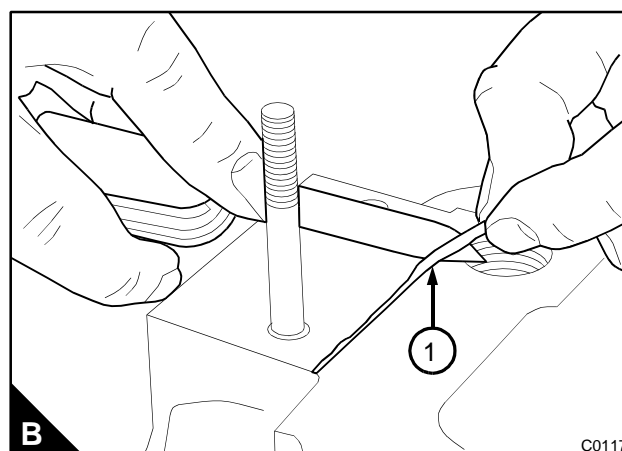
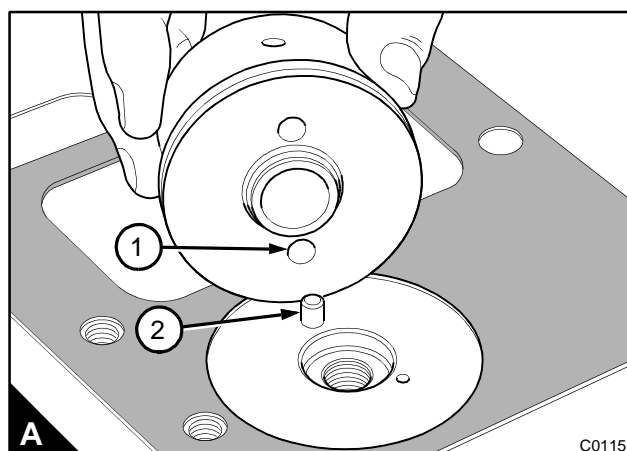


To fit

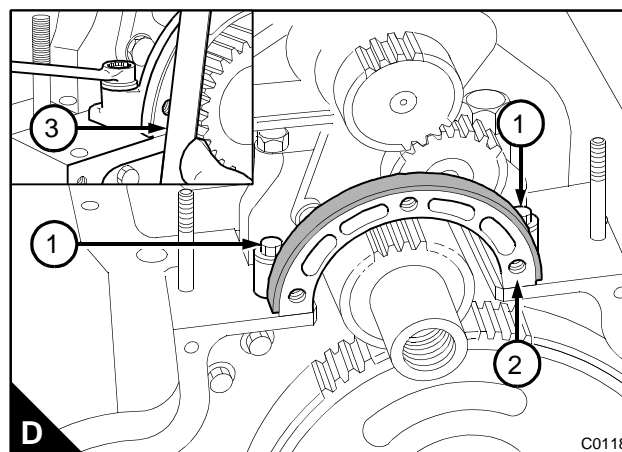
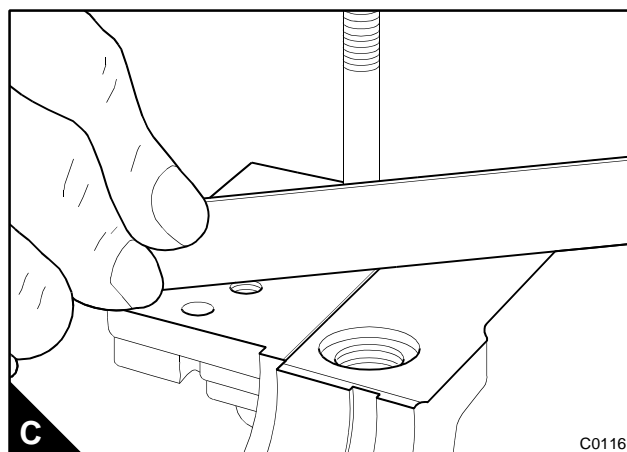
Operation 6-14

Caution: If the camshaft or the crankshaft has to be rotated, it will be necessary to release the tension on the valve springs to ensure that a piston does not contact a valve. If the nuts for the rocker shaft are released, ensure that they are tightened correctly, see Operation 3-3.

- 1 Clean the front face of the cylinder block.
- 2 Align the hole (A1) in the hub with the dowel (A2) in the cylinder block. Ensure that the hub is fully fitted to the cylinder block.
- 3 Put a new joint in position on the front face of the cylinder block. The joint will be kept in position by the hub for the idler gear. If the cylinder head has been removed, ensure that the joint does not protrude above the top face of the cylinder block.
- 4 Clean the rear face of the timing case.
- 5 Put the timing case in position on the hub for the idler gear. Fit the correct setscrews in the correct positions in the timing case and tighten them finger tight. Cut off excess joint material (B1) that protrudes from the bottom face of the cylinder block.



- 6 Use a straight edge to ensure that the timing case aligns with the bottom face of the cylinder block (C) to within 0,1 mm (0.004 in). Tighten the 14 setscrews to 22 Nm (16 lbf ft) 2,2 kgf m.
- 7 Fit the bridge piece (D2) to the bottom of the timing case. Tighten the two setscrews (D1) finger tight. Use a straight edge (D3) to ensure that the bridge piece is square to the timing case to within 0,1 mm (0.004 in). Tighten the two setscrews to 22 Nm (16 lbf ft) 2,2 kgf m.
- 8 Clean the bottom face of the cylinder block and fit a new joint for the sump.
- 9 Fit the sump, see Operation 10-5 or Operation 10-7.



Continued

- 10 Fit the idler gear, see Operation 6-5.
 - 11 Fit the camshaft , see Operation 6-15 together with the camshaft gear.
 - 12 Fit the fuel injection pump, see Operation 11-15, Operation 11-17 or Operation 11-21.
 - 13 Fit the gear for the fuel injection pump, see Operation 6-7 or Operation 6-9.
 - 14 Ensure that the timing marks on the gears are correctly aligned.
 - 15 Fit the timing case cover, see Operation 6-2.
 - 16 Fit the coolant pump, see Operation 12-5.
 - 17 Fit the crankshaft pulley, see Operation 5-1.
 - 18 Fit the alternator bracket and the alternator, see Operation 14-3. Ensure that the belt tension is correct, see Operation 14-2.
 - 19 Fill the sump to the correct level with lubricating oil of the correct specification.
 - 20 Fill the coolant system with coolant of the correct specification, see Operation 12-3.
- Note:** See "Coolant specification" in Chapter 5 of the User's handbook for details of the correct coolant to be used in the cooling system.

Camshaft

To remove and to fit

Operation 6-15

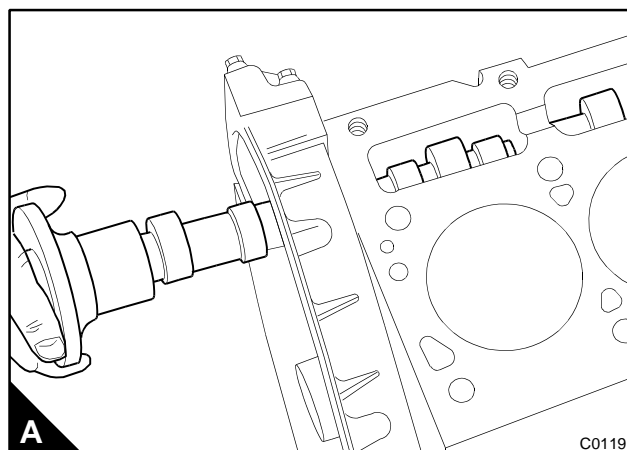
To remove

- 1 Drain the coolant system.
- 2 Remove the alternator together with its mounting bracket and front support plate.
- 3 Remove the cylinder head, see Operation 3-8.
- 4 Remove the timing case cover see Operation 6-1.
- 5 Remove the fuel lift pump, see Operation 11-9.
- 6 Remove the camshaft (A).
- 7 Inspect the camshaft for wear and other damage, renew the camshaft, if necessary.

To fit

- 1 Lubricate the journals of the camshaft with clean engine lubricating oil.
- 2 Fit the camshaft into the cylinder block (A).
- 3 Fit the fuel lift pump, see Operation 11-9.
- 4 Fit the camshaft gear, see Operation 6-11.
- 5 Fit the cylinder head, see Operation 3-9.
- 6 Fit the timing case cover, see Operation 6-2.
- 7 Fit the alternator bracket and the alternator, see Operation 14-4
- 8 Fill the coolant system with coolant of the correct specification, see Operation 12-3.

Note: See "Coolant specification" in Chapter 5 of the User's handbook for details of the correct coolant to be used in the cooling system.



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7

Cylinder block assembly

General description

In production the cast iron cylinder block is made without cylinder liners, but where necessary the cylinders can be bored to receive partially finished liners. The original bores and the partially finished liners are honed with silicon carbide tools to a controlled finish, to ensure a long life and low oil consumption.

In early engines the four camshaft journals rotate in plain bores. In some applications a bush is fitted in the cylinder block for the front camshaft journal, the other journals run directly in the cylinder block.

Cylinder block

To dismantle**Operation 7-1**

Note: If the cylinder block is to be renewed, it may be necessary to fit new pistons and small end bushes, see Chapter 4, Piston and connecting rod assembly. This will occur if the correct piston height above the cylinder block face cannot be maintained with the original piston and connecting rod assemblies see Operation 4-6. If all or most of the original pistons and connecting rod assemblies cannot be used, it may be cost effective to fit a short engine.

Warnings!

- *Discard the used canister, lubricating oil and coolant in a safe place and in accordance with local regulations.*
- *Do not remove the filler cap of the cooling system while the engine is still hot and the system is under pressure because dangerous hot coolant can be discharged.*

- 1 Drain the cooling system.
- 2 Drain the lubricating oil system.
- 3 Remove the engine from the vehicle or machine.
- 4 Remove the alternator drive belt, see Operation 14-3, the alternator and it's mounting brackets, see Operation 14-4.
- 5 Remove the fan, see Operation 12-8.
- 6 Remove the coolant pump, see Operation 12-4.
- 7 If fitted, remove the turbocharger, see Operation 9-1.
- 8 Remove the fuel filter, see Operation 11-2 or Operation 11-3.
- 9 Remove the atomisers, see Operation 11-5 or Operation 11-7.
- 10 Remove the fuel injection pump, see Operation 11-14, Operation 11-16 or Operation 11-20.
- 11 Remove the fuel lift pump, see Operation 11-9.
- 12 Remove the lubricating oil filter, see Operation 10-2.
- 13 Remove the cassette oil cooler assembly, see Operation 10-3. Remove the lubricating oil sump, see Operation 10-4 or Operation 10-6.
- 14 Remove the lubricating oil pump, see Operation 10-10.
- 15 Remove the starter motor, see Operation 14-6.
- 16 Remove the cylinder head assembly, see Operation 3-8.
- 17 Remove the timing case and the timing gears, see Operation 6-13.
- 18 Remove the piston and connecting rod assemblies, see Operation 4-4.
- 19 Remove the camshaft, see Operation 6-15.
- 20 Remove the flywheel, see Operation 13-1
- 21 Remove the flywheel housing, see Operation 13-3.
- 22 Remove the rear oil seal assembly, see Operation 5-2, and the crankshaft, see Operation 5-10.
- 23 Inspect the cylinder block, see Operation 7-3.

To assemble

Operation 7-2

Special requirements

Consumable products			
Description	Part number	Description	Part number
POWERPART Threadlock and Nutlock	21820118	POWERPART Silicon RTV Sealing and Jointing Compound	1861108

- 1 Clean the new cylinder block thoroughly. Ensure that all the oil passages are clean and free from debris.
- 2 If a new cylinder block is to be fitted, remove the threaded plugs from the old cylinder block and clean the threads. Seal the threads with POWERPART Threadlock and Nutlock, or a similar sealant, and fit the threaded plugs into the new cylinder block.
- 3 Fit the crankshaft, see Operation 5-11, and the rear oil seal assembly, see Operation 5-2.
- 4 Fit the piston and connecting rod assemblies, see Operation 4-5.
- 5 Fit the flywheel housing, see Operation 13-3 and the flywheel Operation 13-1.
- 6 Fit camshaft, see Operation 6-15.
- 7 Fit the lubricating oil pump, see Operation 10-11.
- 8 Fit the timing case and the timing gears, see Operation 6-14.
- 9 Fit the cylinder head assembly, see Operation 3-9.
- 10 Fit the starter motor, see Operation 14-6.
- 11 Fit the fuel lift pump, see Operation 11-9.
- 12 If necessary, fit the turbocharger, see Operation 9-2.
- 13 If necessary fit the cassette oil cooler, see Operation 10-3.
- 14 Fit the lubricating oil filter, see Operation 10-2.
- 15 Fit the lubricating oil sump, see Operation 10-5 or Operation 10-7.
- 16 Fit the fuel filter, see Operation 11-2 or Operation 11-3.
- 17 Fit the atomisers, see Operation 11-6 or Operation 11-8
- 18 Fit the fuel injection pump, see Operation 11-15, Operation 11-17 or Operation 11-21.
- 19 Fit the coolant pump, see Operation 12-5.
- 20 Fit the fan, see Operation 12-8.
- 21 Fit the alternator and its mounting brackets, see Operation 14-4, and the alternator drive belt, see Operation 14-3.
- 22 Install the engine into the vehicle or machine.
- 23 Connect electrical cables, control wires and hoses.
- 24 Fill the cooling system, see Operation 12-3.
- 25 Fill the lubricating oil sump to the correct level with an approved lubricating oil.
- 26 Connect the battery.
- 27 Eliminate air from the fuel system, see Operation 11-19 for Delphi fuel injection pumps or Operation 11-22 for Stanadyne fuel injection pumps.
- 28 Start the engine and check for fuel, lubricating oil and coolant leaks. Allow the engine to reach the normal temperature of operation before it is stopped.

To inspect

Operation 7-3

- 1 Clean the passages for the coolant and for the 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 piston height above the top face of the cylinder block.
- 4 Check the condition of the cylinder bores.

To ensure the best performance during the life of the engine it is important that worn or damaged cylinder bores have service liners fitted.

The condition of a cylinder bore is decided by:

- The amount and location of any polished areas
- Wear
- Damage to the cylinder wall.

To check the condition of a cylinder bore

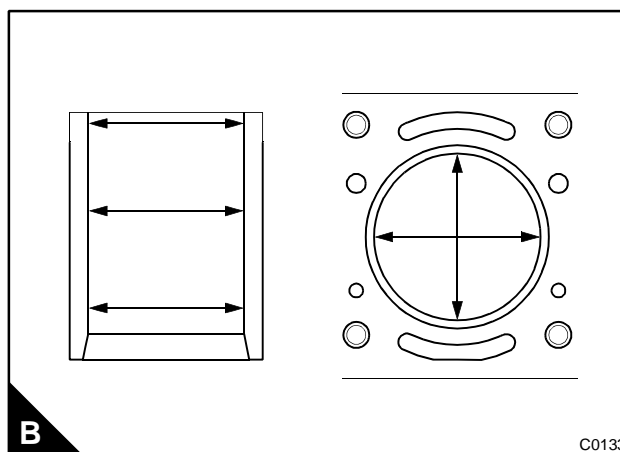
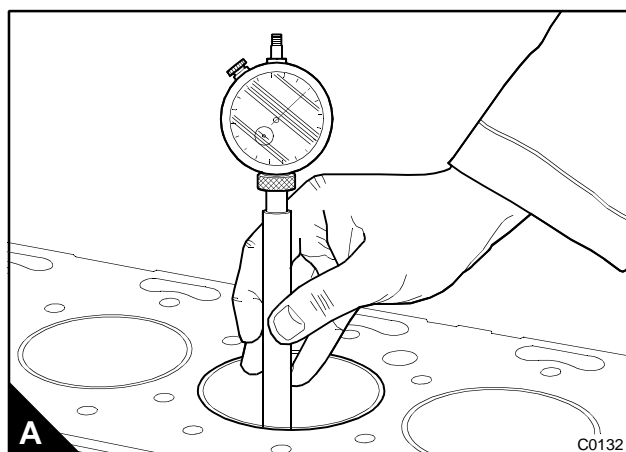
Caution: If the surface of the bores are glazed, the engine may have high oil consumption with very little wear of the bores.

- 1 Inspect the cylinder bores for cracks and deep scratches.
- 2 Check the cylinder bores for areas where the honed finish has been polished away. Check especially the area around the top of the bore just below the carbon ring. In this area, thrust from the top piston ring is at its maximum.
- 3 Check the cylinder bores (A) for wear and other damage.

The cylinder bores should be checked at the top, centre and bottom both along and across the engine (B). The maximum permissible wear is 0,18 mm (0.007 in). If one or more cylinder bores are below standard then the cylinder(s) need to be bored to 97,108/97,133 mm (3.823/3.824) and fitted with partially finished liners.

Specialist training and equipment is needed to machine the cylinder bore(s).

For further information contact your nearest Perkins Distributor.



Cylinder liner

To fit

Operation 7-4**Special requirements**

Special tools		Consumable products	
Description	Part number	Description	Part number
Depth gauge, liner flange	21825496	POWERPART Retainer (oil tolerant)	1861108
Dial gauge (for use with depth gauge)	21825617	Loctite 640	-
Heavy duty hydraulic press without damper	-	Loctite safety cleaner	21820128
Stepped adaptor	27610024		

To ensure the best performance during the life of the engine it is important that worn or damaged cylinder bores are reconditioned. The cylinders are bored and honed to 97,108/97,133 mm (3.823/3.824) to form parent bores for partially finished service liners. The liner is an interference fit in the parent bore and an hydraulic press rated 0 - 24 tonne (0 - 23.62 ton) is used to press the liners into the cylinder block.

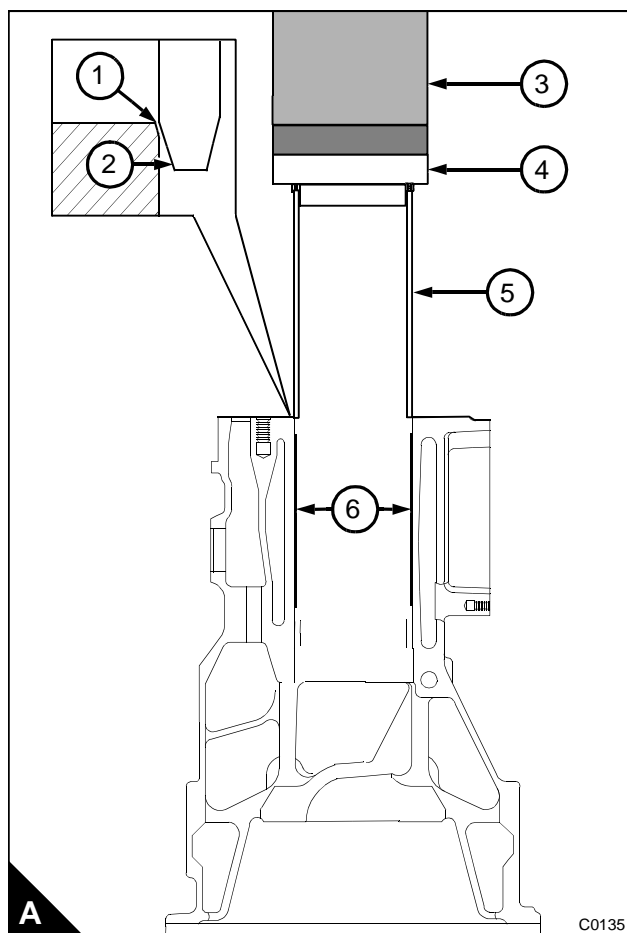
Cautions:

- *Specialist training and equipment is needed to machine the finish of a partially finished liner. For further information contact your nearest Perkins Distributor.*
- *New piston rings must be fitted if a service liner is fitted.*

Continued

To fit a partially finished liner

- 1 Dismantle the cylinder block, see Operation 7-1.
- 2 Inspect the cylinder block, see Operation 7-3.
- 3 Bore and hone the cylinders to form parent bores and machine a chamfer (A1) on the top inner edge of the cylinders to the dimensions given in the relevant Data and dimensions for "Cylinder liner specifications" on page 22.
- 4 Remove all loose debris and clean the parent bore thoroughly with Loctite Safety Cleaner or a similar product; use it in accordance with the manufacturer's instructions.
- 5 Apply Loctite 640 to the complete parent bore except for a 25 mm (1.00 in) band around the top and the bottom of the bore (A6).
- 6 Clean the new cylinder liner with Loctite Safety Cleaner and dry with a lint-free cloth.
- 7 Put the cylinder block on a flat surface below the hydraulic press (A3). Engage the new liner (A5) into the parent bore with the external chamfer (A2) towards the bottom. Put the (0.010 mm) stepped adaptor, Part number 27610024, (A4) into the top of the liner (A5). Ensure that the liner is vertical.

*Continued*

8 Lower the hydraulic press (B2) until it contacts the top of the stepped adaptor (B3). Press in the liner slowly, until the stepped adaptor contacts the face of the cylinder block and the top of the liner is level with the face of the block.

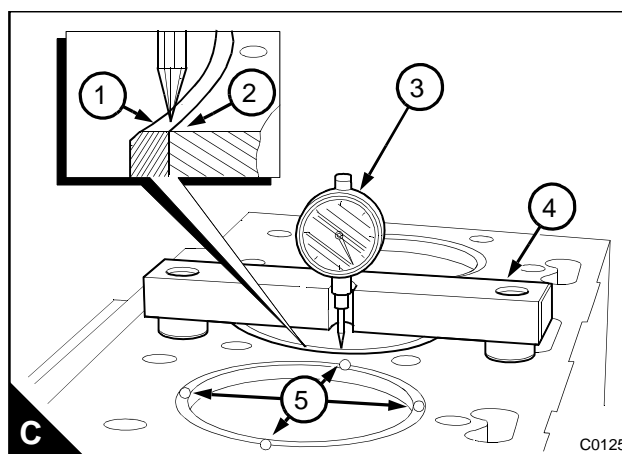
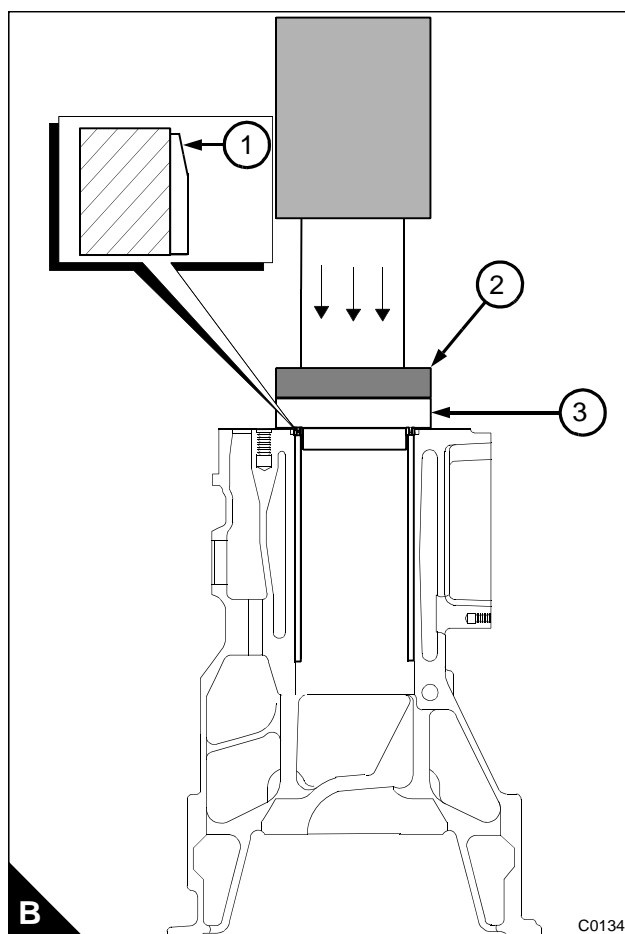
9 Assemble the liner height gauge, Part numbers, 21825496, (C3) and 21825617, (C4). Put the gauge onto the face of the cylinder block (C2) and set the dial to zero.

Caution: The liner height must be measured immediately, before the loctite 640 has time to set; the loctite will set fully set in 15 minutes.

10 Place the point of the liner height gauge on the top edge of the liner (C1) and measure the liner height at four points 90° apart (C5). The reading should be within 0,075 mm (0.003 in) below to 0,05 mm (0.002 in) above the face of the cylinder block. If the liner height is too high, the liner may be pressed in further if the loctite 640 has not set.

Caution: Specialist training and equipment is needed to machine the finish of a partially finished liner. For further information contact your nearest Perkins Distributor.

Partially finished cylinder liners must be bored and then diamond honed, silicon carbide base honed and silicon carbide plateau honed to the finished size to conform to the dimensions given in "Cylinder liner specifications" on page 22. Machine a 16° chamfer (B1) from the top inner diameter of the liner to a depth of 1,20 mm (0.047 in). after the bore has been machined.



Continued

11 Fit new piston rings.

Cautions:

- *After a new cylinder liner has been fitted, these recommendations are advised for the first 240 km (150 miles) or 5 hours of operation:*
- *Do not operate the engine at full load.*
- *Do not operate the engine at high speed.*
- *Do not allow the engine to run at low idle speed for long periods.*

12 Clean the new cylinder block thoroughly. Ensure that all the oil passages are clean and free from debris and that all excess loctite 640 is removed from the bottom of the liner. Assemble the cylinder block as in Operation 7-2.

To inspect

Operation 7-5

To ensure the best performance during the life of the engine it is important that worn or damaged cylinder liners are identified. The service liner is not renewed as the parent bore and cylinder block will be damaged when the liner is withdrawn.

The condition of a cylinder liner is decided by:

- The amount and location of any polished areas.
- Wear.
- Damage to the liner wall.

Notes:

- The liner is an acceptable standard if:
- The honed finish can still be clearly seen.
- The engine performance and oil consumption is acceptable.

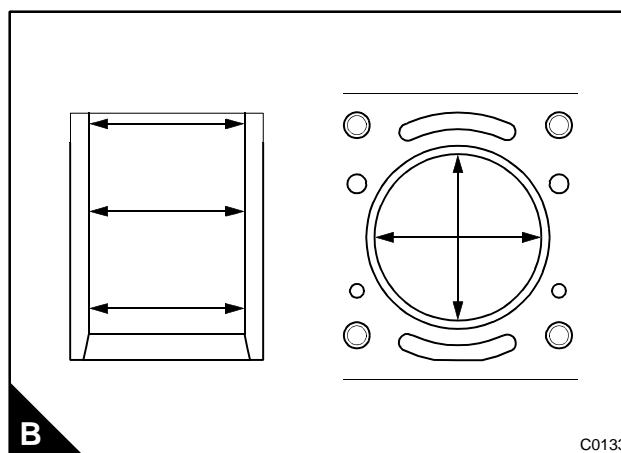
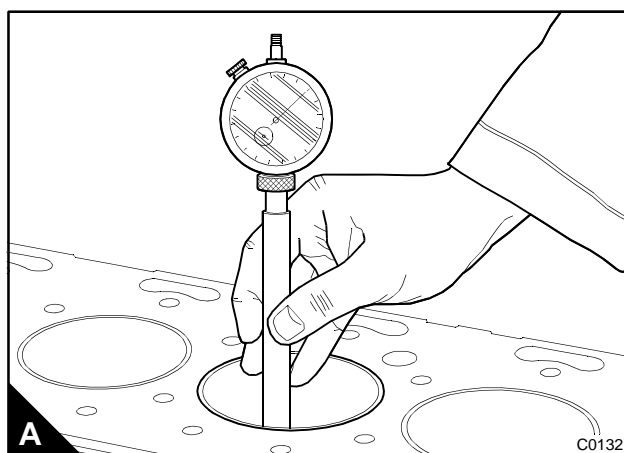
To check the condition of a cylinder liner**Cautions:**

- *New piston rings must be fitted when the cylinder liner is fitted.*
- *If the surface of the liners are glazed, an engine can have high oil consumption with very little wear of the liner bores.*
- *The cylinder block can only be bored once because the liners if fitted, cannot be withdrawn without damage to the parent bores and the cylinder block.*
- *If the liner is damaged or worn the cylinder block must be renewed or a short engine fitted.*

1 Inspect the liner surface for cracks and deep scratches.

2 Check the liner wall for areas where the honed finish has been polished away. Check especially the area around the top of the liner bore just below the carbon ring. In this area, thrust from the top piston ring is at its maximum.

3 Check the liner bores for wear (A) and other damage. The liner bores should be checked at the top, centre and bottom both along and across the engine (B). The maximum permissible wear is 0,18 mm (0.007 in). If one or more liner bores is below standard then the block must be discarded and a new block or short engine fitted.



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8

Engine timing

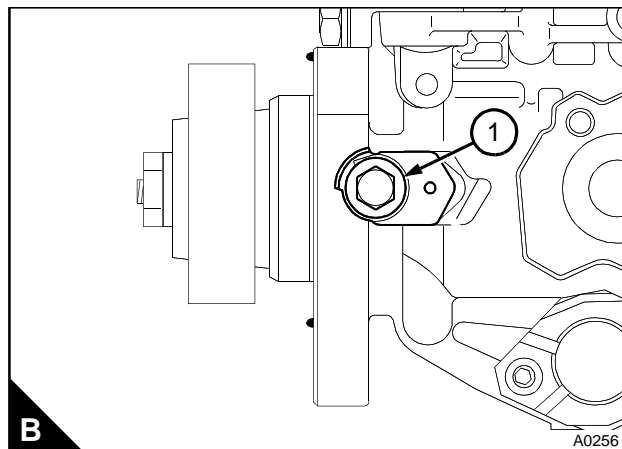
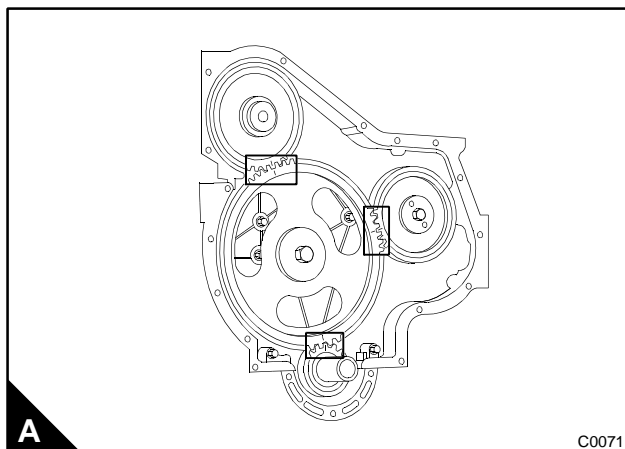
General description

The timing gears are stamped with timing marks (A) to ensure that they are assembled correctly. The stamped teeth of the crankshaft, camshaft and fuel pump gears will be aligned with the idler gear when number 1 piston is at top dead centre (TDC) on the compression stroke. The marked teeth of the idler gear may not necessarily be aligned in this position, because of the different speeds at which the gears rotate.

TDC on number 1 cylinder can be found by the alignment of holes in the backplate and the flywheel.

The two types of fuel injection pump available are both timed at TDC on the compression stroke of number 1 cylinder. There is no timing mark on the rear face of the timing case, but there is a mark on the flange of the fuel injection pump.

Both fuel injection pumps have a lock screw (B1) that locks the shaft. When the lock is applied before the pump is removed, it is not necessary to time the pump to the engine if the crankshaft has not been rotated.



Engine timing

To set the engine to top dead centre (TDC)

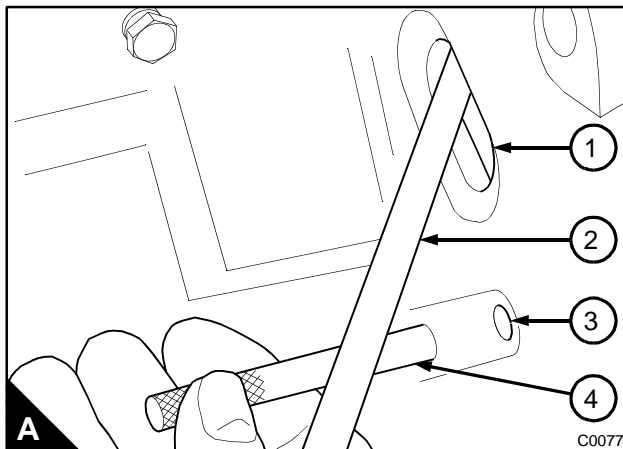
Operation 8-1

Special requirements

Special tools	
Description	Part number
Locking pin for the crankshaft	21836001

TDC on number 1 cylinder on the compression stroke can be found by the alignment of a hole in the flywheel with a hole in the backplate.

- 1 Remove the rocker cover, see Operation 3-1.
- 2 Loosen by two or three turns the setscrews that retain the atomiser clamps or release the gland nuts if threaded atomisers are fitted.
- 3 Rotate the crankshaft clockwise, when seen from the front, until the inlet valve, the first valve, has just closed. There is a slot (A1) in the left side of the backplate, seen from the rear, to give access to the starter ring. A suitable lever (A2) can be used through the slot to rotate the flywheel.
- 4 Insert the locking pin (A4) into the hole (A3) below the slot in the backplate. Continue to rotate the crankshaft clockwise slowly until the pin enters a hole in the flywheel. The engine is now set at TDC number 1 cylinder, compression stroke.
- 5 Remove the pin from the flywheel and the backplate.
- 6 Fit the rocker cover, see Operation 3-1.



To check the valve timing

Operation 8-2

- 1** Check and, if necessary, adjust the valve tip clearances, see Operation 3-6.
- 2** Set number 1 cylinder to TDC on the compression stroke.
- 3** Make a mark on the crankshaft pulley. Fit a suitable pointer to the timing case cover to align with the mark on the pulley.
- 4** Turn the crankshaft, clockwise from the front, until the exhaust valve of number 3 cylinder is fully open.
- 5** Set the valve tip clearance of number 1 cylinder inlet valve to 0,631 mm (0.025 in).
- 6** Turn the crankshaft, clockwise from the front, until the push rod for number 1 cylinder inlet valve just tightens. In this position, check if the mark on the crankshaft pulley is within $2\frac{1}{2}^{\circ}$ of the pointer.
 $2\frac{1}{2}^{\circ}$ is 3,5 mm (0.14 in) at the circumference of the standard pulley, that has a diameter of 163,2 mm (6.43 in).
- 7** If the timing is more than $2\frac{1}{2}^{\circ}$ out of position, the timing gears are probably not in correct mesh.
- 8** One tooth on the camshaft gear is equivalent to 20.5 mm (0.81 in) of pulley circumference for a pulley of 163,2 mm (6.43 in) diameter.
- 9** Turn the crankshaft, clockwise from the front, until the inlet valve of the rear cylinder is fully open. Set the valve tip clearance of the inlet valve of number 1 cylinder to 0,20 mm (0.008 in).
- 10** Fit the rocker cover, see Operation 3-1.
- 11** Remove the temporary pointer from the timing case and the timing mark from the pulley.

To check the locking angle of the fuel injection pump timing

Operation 8-3

Special requirements

Special tools			
Description	Part number	Description	Part number
Universal timing tool	21825610	Drive adaptor	21825513

Caution: This procedure must be followed carefully if:

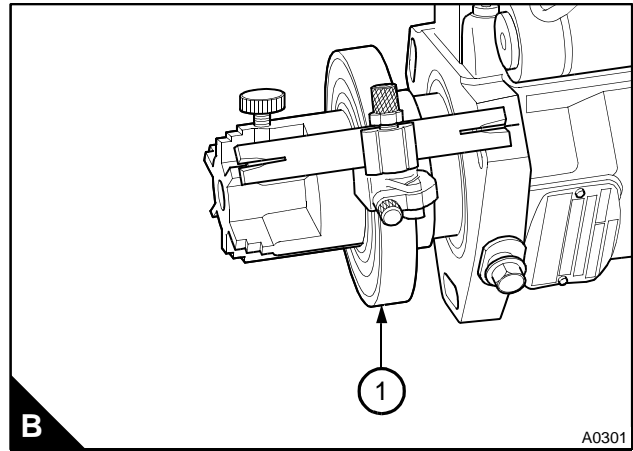
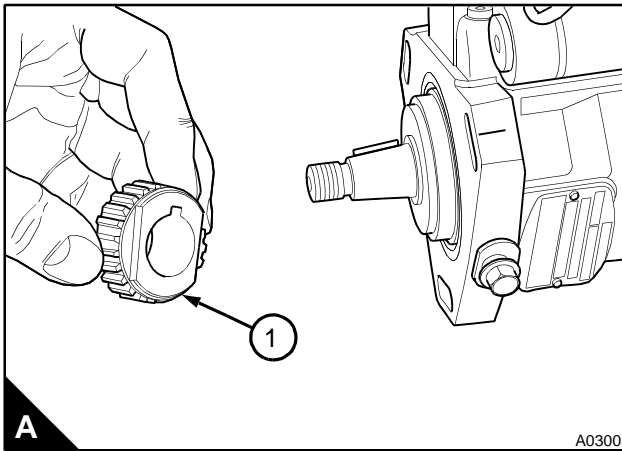
- The engine performance is not correct
- The locking screw is released after the pump is removed from the engine.

Note: The fuel pump code letters for the 900 Series locked pumps are either AN or BN.

1 Remove the fuel injection pump from the engine, see Operation 11-14.

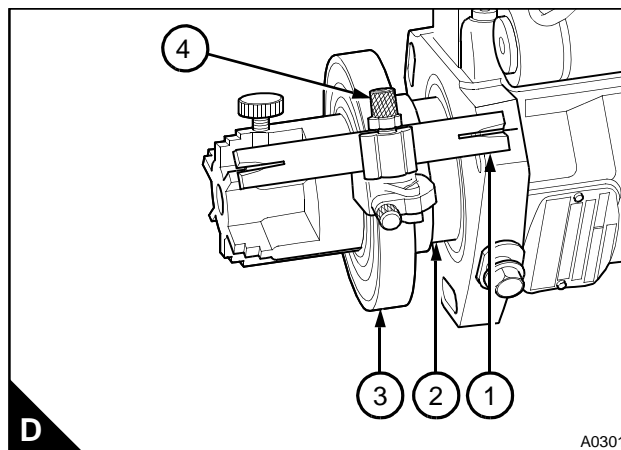
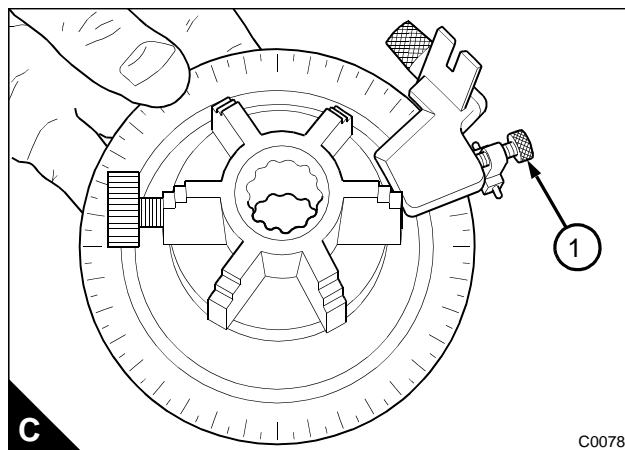
Caution: When the pump is held, do not apply pressure to the alloy components.

2 Hold the pump securely in a vice. Fit the adaptor (A1) for the timing tool (B1) to the drive shaft of the pump. Use the nut for the drive gear to retain the adaptor, tighten the nut finger tight.



Continued

- 3 Loosen the locking screw (C1) on the timing tool and set the tool to 88° for pump code letters AN and BN. Tighten the locking screw. These angles are locking angles.
- 4 Fit the timing tool together with the spacer (D2), to the adaptor on the pump.
- 5 Release the locking screw (D4) and slide the pointer (D1) forward until it is over the centre of the pump flange then tighten the locking screw. Check that the mark on the pump flange is in the centre of the slot in the pointer.
- 6 If the mark is not correct, remove the timing tool and the adaptor. Remove the pump to the nearest Perkins distributor to have the pump checked. If the mark is correct, remove the timing tool and the adaptor from the pump.
- 7 Fit the fuel injection pump, see Operation 11-15.



To check the timing of pin-timed fuel injection pumps

Operation 8-4

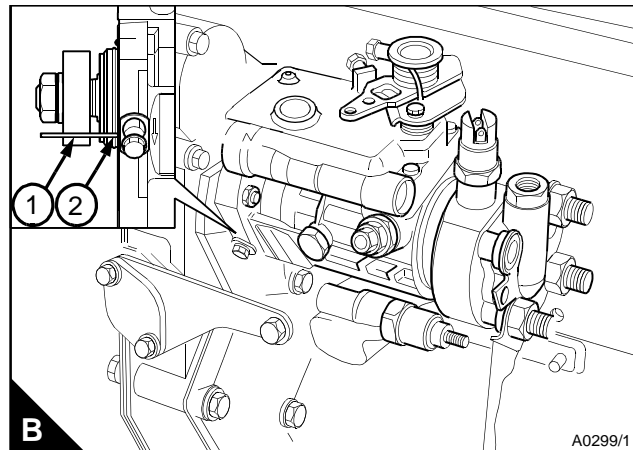
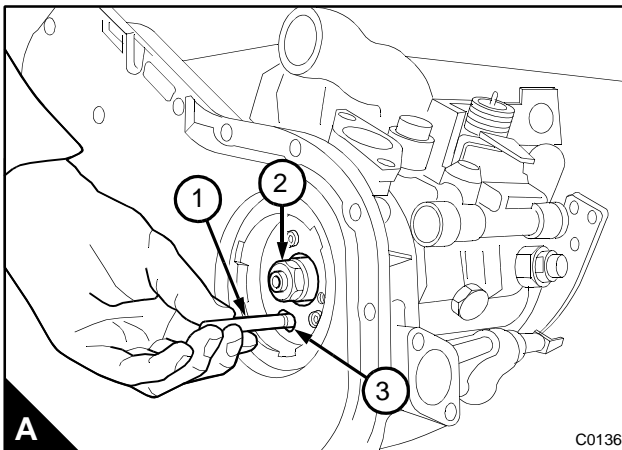
Special requirements

Special tools			
Description	Part number	Description	Part number
Timing pins for Delphi and Stanadyne fuel injection pumps	27610033	Locking pin for the crankshaft	21836001

Caution: Do not remove the nut (A2) from the shaft of the fuel injection pump. The fuel pump hub is fitted to the shaft in the factory to ensure that the fuel pump is in the correct position for timing. If the hub is removed, the hub will need to be accurately fitted to the pump by use of special equipment available to Perkins distributors.

- 1 Remove the cover for the fuel injection pump gear.
- 2 Set the piston of number 1 cylinder to TDC on the compression stroke, see Operation 8-1.
- 3 Insert the timing pin (A1) through the slot (A3) in the fuel pump gear and the hole in the hub (B1). Push the pin fully into the recess (B2) in the body of the fuel pump. If the pin can be fully inserted then the pump timing is correct. There should be no resistance when the pin is inserted.
- 4 If the timing pin cannot be pushed into the pump body, check that the engine is correctly set at TDC on the number 1 cylinder compression stroke, see Operation 8-1.
- 5 If the engine is set correctly at TDC but the pin does not fit into the hole, the fuel pump must be removed and set by a specialist.
- 6 If the engine is correctly set, remove the timing pin and fit the gear cover of the fuel injection pump back onto the timing case.

Caution: Remove the pin from the flywheel and the backplate.



9

Aspiration system

General description

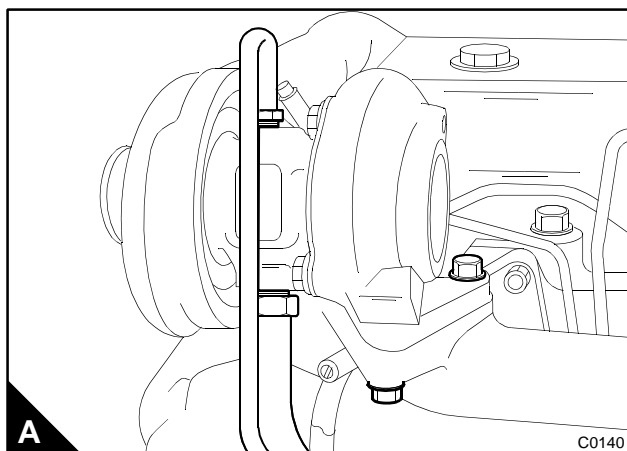
Warning! Turbochargers operate at high speeds and at high temperatures. Keep fingers, tools and debris away from the inlet and outlet ports of the turbocharger. Do not touch hot surfaces.

The Schwitzer S1B turbocharger (A), is fitted between the exhaust and the induction manifolds and is driven by exhaust gases. Air is supplied to the engine at more than atmospheric pressure. The turbocharger is lubricated by oil from the filter head. The oil passes through the bearing housing of the turbocharger and returns to the lubricating oil sump.

Some engines have the turbochargers mounted towards the front of the engine or centrally according to the application it is fitted to.

Always use the manufacturer's 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.



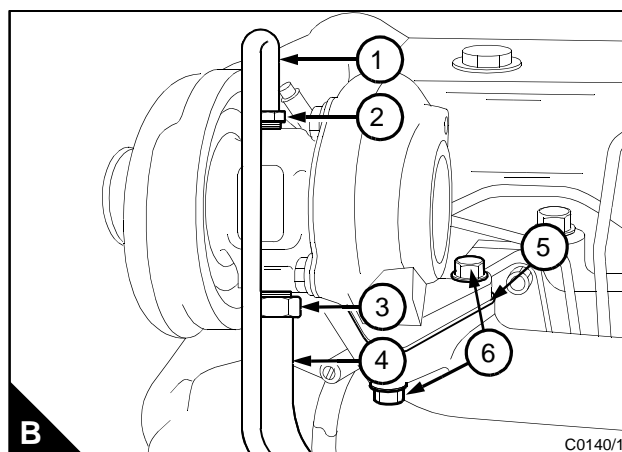
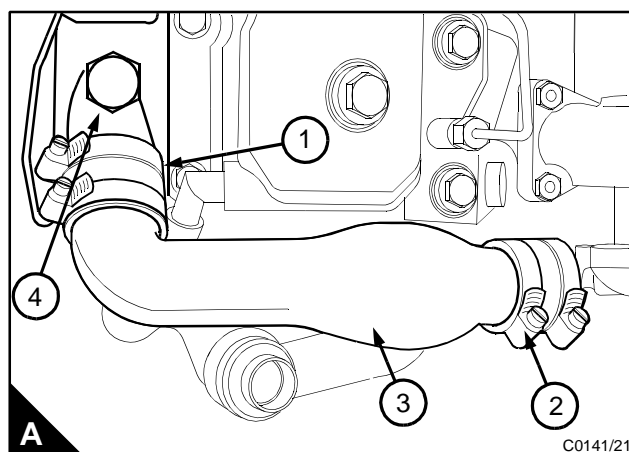
Turbocharger

To remove

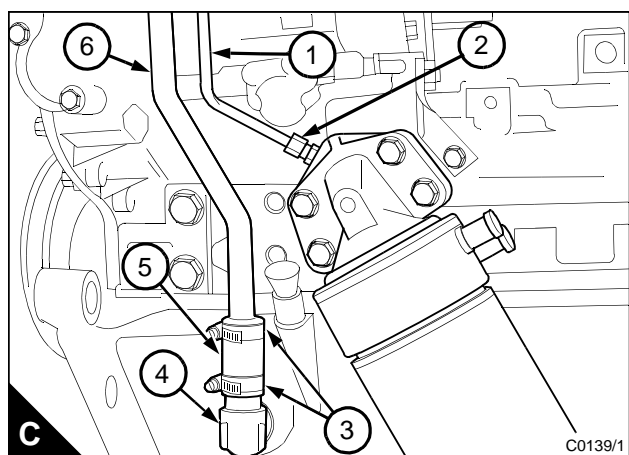
Operation 9-1

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

- 1 Thoroughly clean the turbocharger with a non caustic cleaner.
- 2 Remove the air cleaner hose at the compressor inlet.
- 3 Release the hose clips (A1) between the crossover pipe (A3) and the induction manifold (A4). Push the hose on to the crossover pipe.
- 4 Release the hose clips (A2) between the turbocharger compressor outlet and the crossover pipe. Remove the crossover pipe, together with the hose and the hose clips.



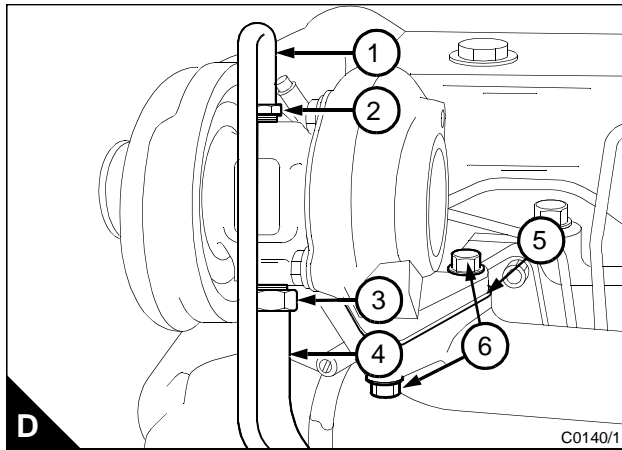
- 5 Release the union connection (B2) on the oil supply pipe (B1) at the top of the bearing housing. On the lower section of the oil supply pipe (C1); use a spanner to hold the union adaptor at the oil filter head adaptor and release the union nut (C2). Remove the oil supply pipe.
- 6 Release the union nut (B3) of the oil drain pipe (B4) at the bottom of the bearing housing of the turbocharger.
- 7 Release the hose clip(s) (C3) between the oil drain pipe and the sump elbow (C4). Push the hose (C5) up the oil drain pipe (C6) and remove the oil drain pipe from the elbow.



Continued

8 Release the nuts (D6) at the turbocharger to exhaust manifold flange and remove the turbocharger and the joint (D5). Cover the open ports in the manifolds, the turbocharger and the pipes to ensure that dirt or debris will not enter.

9 Check the crossover pipe hoses and the oil drain hose for cracks or other damage and renew them, if necessary.

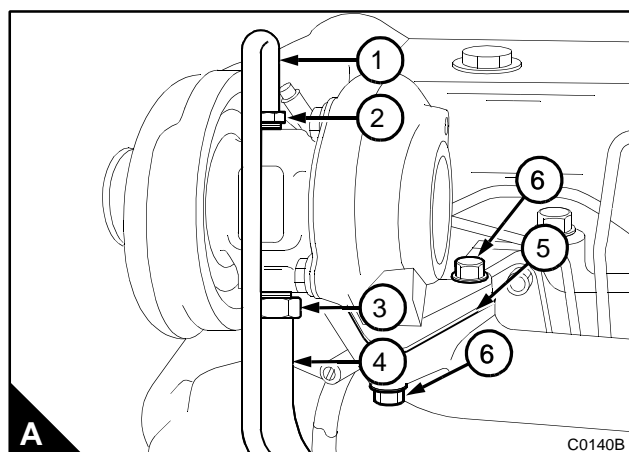


To fit

Operation 9-2**Special requirements**

Consumable products	
Description	Part number
POWERPART Threadlock (pipe)	21820117 or 21820118

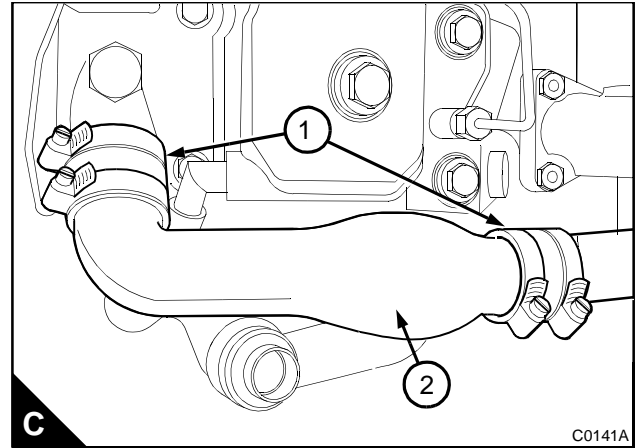
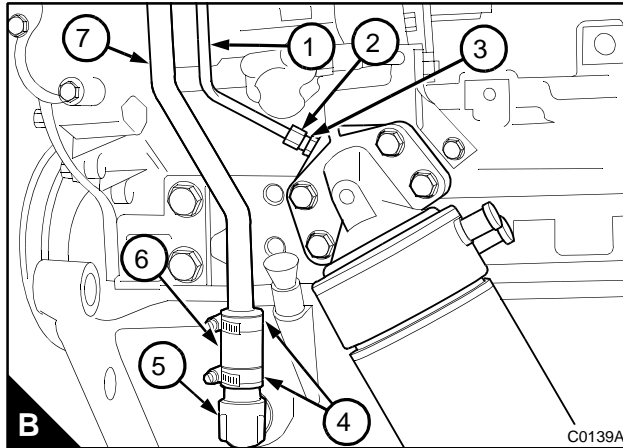
- 1 Remove the covers from the pipes and manifolds.
- 2 Check that the turbocharger inlet and outlet are clean and free from restriction. Check that the turbocharger shaft rotates freely. Also check that the openings in the manifolds and the exhaust pipe are clean and free from restriction.
- 3 Fit a new joint (A5) to the exhaust manifold.
- 4 Lower the turbocharger into position on the exhaust manifold studs and fit the nuts (A6) above and below the exhaust flange. Tighten the nuts to 22 Nm (16 lbf ft) 2,2 kgf m.
- 5 Put a suitable container under the turbocharger to contain the oil from the oil drain outlet of the turbocharger.
- 6 Fill the bearing housing of the turbocharger through the oil supply port with clean engine lubricating oil. Turn the compressor wheel until oil comes out of the oil drain outlet. Clean the thread of the union connection (A2) of the oil supply pipe (A1) and apply POWERPART Threadlock (pipe).

*Continued*

7 Fit the oil supply pipe to the bearing housing and tighten the union connection. On the lower section of the oil supply pipe (B1), ensure that dirt does not enter the oil filter head/adaptor plate or the union adaptor. Clean the threads of the union nut and apply a thread sealant to the union adaptor (B3). Use a spanner to hold the adaptor and tighten the union nut (B2).

8 Fit the air cleaner hose to the compressor inlet.

9 Fit the crossover pipe (C2) to the compressor outlet and tighten the clips (C1).

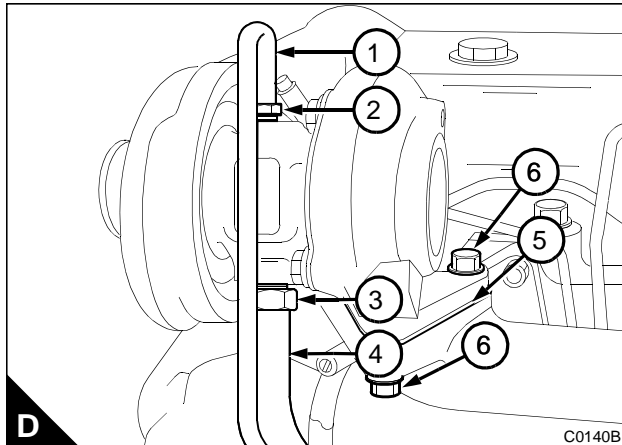


10 Remove the container from under the oil drain outlet. Fit the oil drain pipe to the oil drain outlet at the bottom of the bearing housing and tighten the union nut (D3). Put the oil container under the oil drain pipe.

11 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. Where fitted, connect the electrical stop control.

12 Push the hose (B6) on to the sump elbow (B5) and tighten the clips (B4).

13 Remove the container and discard the lubricating oil in a safe place in accordance with local regulations.



Turbocharger faults

Problems and possible causes

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

If the inside of the induction manifold is wet, check that there is not a fuel leak from the fuelled starting aid, if there is one fitted, see Operation 14-9.

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
Black smoke	1, 4, 5, 6, 7, 8, 9, 10, 11, 18, 20, 21, 22, 25, 26, 27, 28, 34
Blue smoke	1, 2, 4, 6, 8, 9, 17, 19, 20, 21, 22, 30, 31, 32, 34
High lubricating oil consumption	2, 8, 15, 17, 19, 20, 28, 29, 31, 32, 34
Too much lubricating oil at turbine end	2, 7, 8, 17, 19, 20, 22, 28, 30, 31, 32
Too much lubricating oil at 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 impeller	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, 21, 22, 23, 24, 29, 32, 33, 37, 38
Worn bearings, bearing bores, journals	6, 7, 8, 12, 13, 14, 15, 16, 23, 24, 29, 33, 37, 38
Noise from 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 bearing housing	2, 11, 13, 14, 15, 17, 18, 24, 29, 33, 37, 38

List of possible causes

- 1 Element of the air filter dirty.
- 2 Restricted crankcase breather.
- 3 Element of the air filter not fitted, 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 has cracks, is loose, or has flange distortion.
- 10 Exhaust manifold has cracks, is loose, or has flange distortion.
- 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 too low/high.
- 35 Spare.
- 36 Spare.
- 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.

Closed breather system

To renew the engine breather valve

Operation 9-3

The engine breather assembly is fitted to the top left hand side of the timing case. It consists of two parts; the adaptor (A3), that is fitted to the timing case by two setscrews; and the breather valve (A2), that is fitted to the top of the adaptor. The breather is a sealed unit that contains a valve and a gauze filter. Crankcase gases pass through a flexible hose that is fitted between the connection (A5) and the pipe between the air filter and the induction manifold. Some engines are fitted with a new type of adaptor that has two lugs (B1) to hold the breather flange (B2) securely.

Cautions:

- It is important that the area around the vent holes (A1) is kept clean and the vent hole is not restricted.
- Ensure that the pipe, when fitted, does not contact other components as this may cause the failure of the pipe.
- Do not add lubricating oil to the engine through the engine breather adaptor.

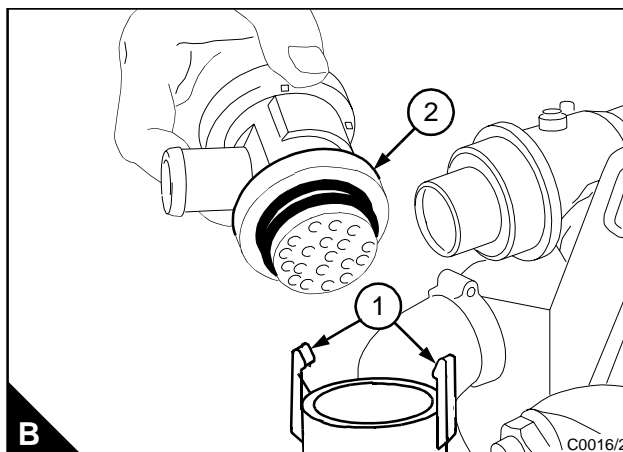
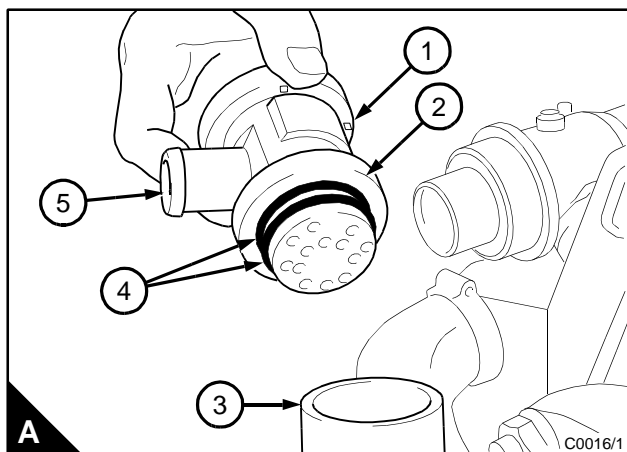
- 1 Release the hose clips that retain the engine breather pipe and remove the pipe from the connection (A5).
- 2 Pull the breather valve out from the adaptor.

Note: If a new type adaptor is fitted, push the lugs away from the flange (B2) to release the breather flange and withdraw the breather valve

- 3 Lubricate the 'O' rings (A4) on the new breather valve with clean engine oil and push the breather valve into the adaptor.

Note: If a new type adaptor is fitted, push the breather into the adaptor until the flange (B2) is locked under the lugs (B1)

- 4 Fit the breather pipe to the connection (A5) and tighten the hose clips.



Open breather system

General information

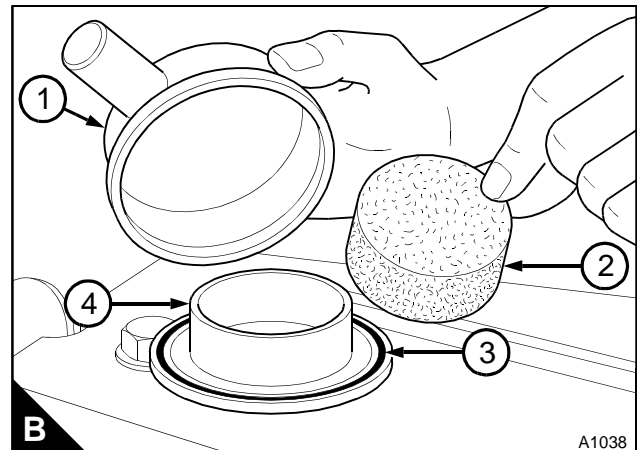
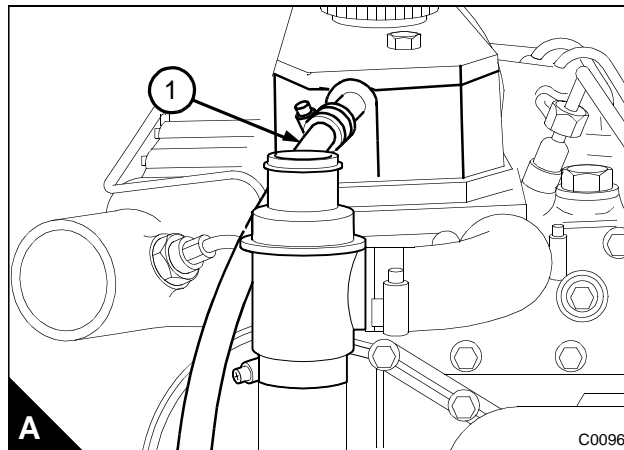
Operation 9-4

Basic open breather

The basic open breather fitted to the 900 Series engine is a reinforced flexible hose fitted to a connection (A1) at the front of the rocker cover. This will allow any crankcase pressure to pass directly from the engine.

Breather assembly

A later version is a breather assembly, made of plastic that is fitted into the rocker cover; there is a reinforced flexible hose fitted to the cap. A metal gauze strainer (B2) is fitted to remove any oil and return it to the rocker cover.

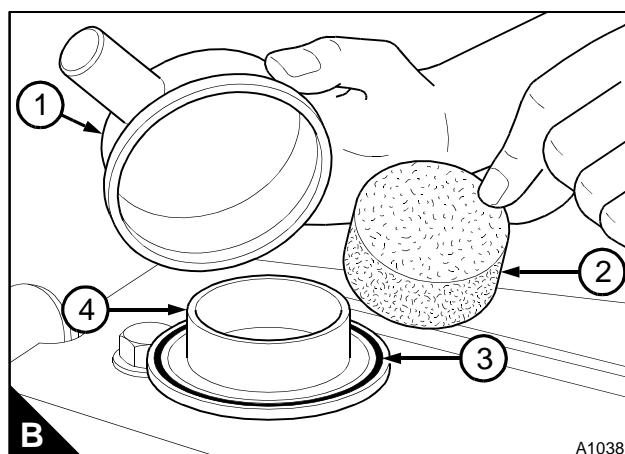
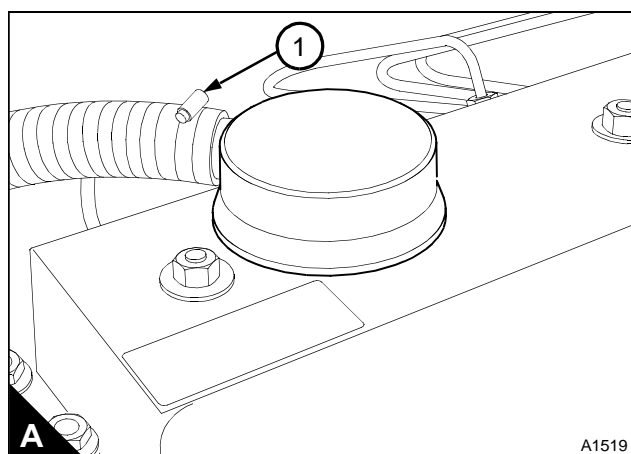


To clean

Operation 9-5

Note: It is not necessary to remove the body of the breather from the rocker cover to obtain access to the gauze.

- 1 Release the hose clip (A1) from the breather cover. Use a suitable lever between the outlet nozzle and the rocker cover to remove the breather cover (B1) from the body of the breather (B4). Ensure that the breather cover and the rocker cover are not damaged.
- 2 Use a cloth made damp with a proprietary cleaning fluid to clean the body of the breather.
- 3 Renew the "O" ring seal (B3), part number 2415H493.
- 4 Check that the inside of the breather pipe is clean. If the pipe is not clean, remove the pipe and wash it with kerosene. Dry the pipe with low-pressure air. Fit the pipe.
- 5 Wash the steel gauze (B2) with kerosene and dry it with low-pressure air or renew the gauze if it is broken.
- 6 Fit the cover (B1) to the breather body, ensure that it is fitted securely.



To renew

Operation 9-6

To renew the complete breather assembly, the body of the breather must be removed from the rocker cover.

Notes:

- The breather is fastened to the rocker cover by a thread on the bottom of the breather body.
- To remove the breather assembly a special "C" spanner will have to be made, see Operation 9-7

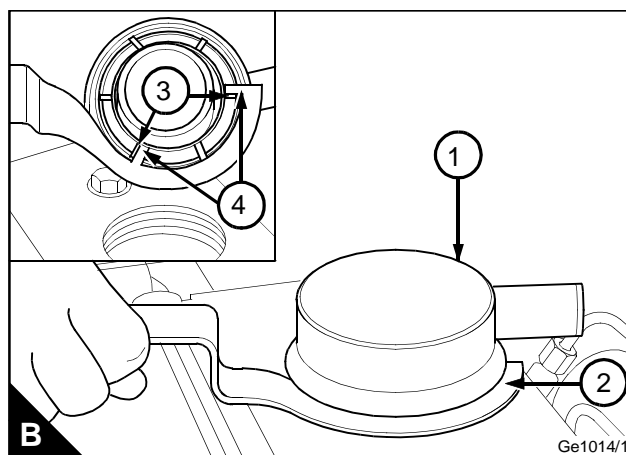
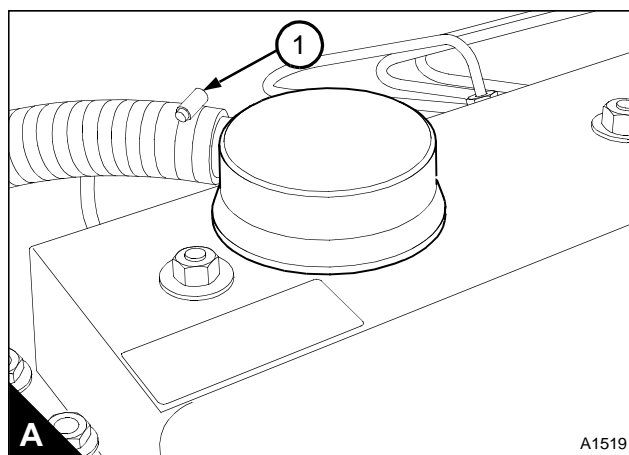
1 Release the hose clip (A1) and remove the hose from the breather cover.

2 Fit a "C" spanner (B2) to the lugs (B3) at the bottom of the breather body and turn the spanner counter clockwise to release and discard the breather assembly.

3 Clean the threads in the rocker cover and on the new breather assembly.

4 Fit the new breather by hand and tighten it into the rocker cover with the "C" Spanner.

5 Fit the breather pipe and tighten the hose clip.



Breather separator

To renew the engine oil separator

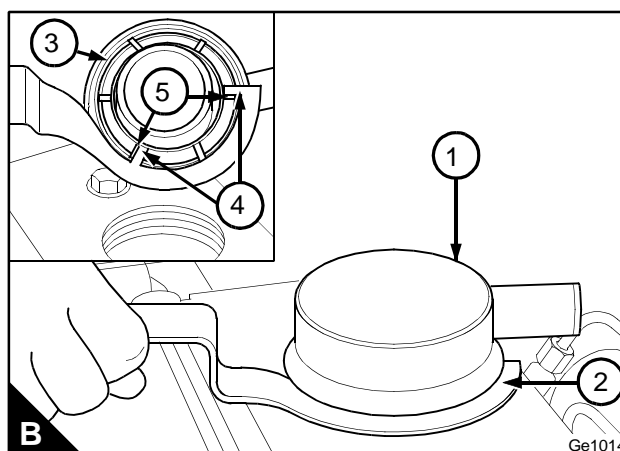
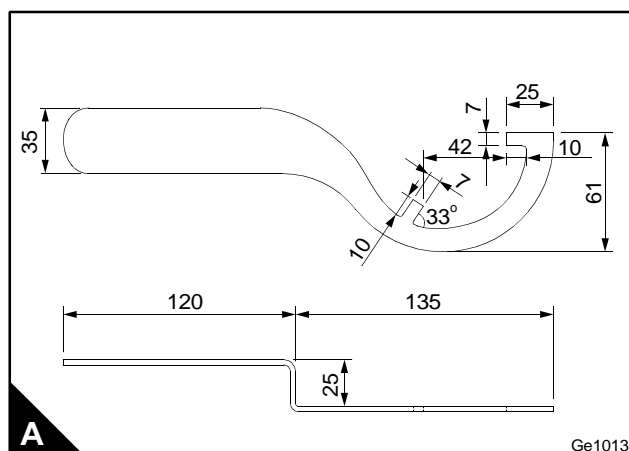
Operation 9-7

Cautions:

- Do not try to remove the cap of the oil separator as it will break. The gauze should not be cleaned.
- Renew the whole oil separator at every engine overhaul or 8000 hours.

The latest version of the open breather assembly, has an oil separator (B) that is fitted into a threaded hole in the rocker cover. The oil separator has a hard plastic cap (B1) that can withstand higher temperatures.

- 1** To remove the oil separator from the rocker cover, it will be necessary to make a tool (A) from 3,1 mm (0.125 in) mild steel plate; all dimensions are in millimetres.
- 2** Release the hose clip and remove the hose from the oil separator cover.
- 3** Use the pegs (B4) on the tool (B2) to contact the lugs (B5) of the oil separator. Rotate the tool counter-clockwise to release the oil separator.
- 4** Ensure that the 'O' ring (B3) is fitted correctly and fit the new oil separator into the rocker cover until it is finger tight. Tighten the oil separator a further 90° with the tool. Fit the hose and tighten the hose clip.



10

Lubrication system

General description

Note: Refer to the "Lubrication system flow diagram" on page 140 for illustration references.

Pressure lubrication is supplied by a rotor type pump which is driven through an idler gear from the crankshaft gear. The pump has an inner rotor and an outer rotor that are off-centre to each other. The inner rotor has three lobes that mesh with the four lobes of the outer rotor. When the pump rotates, the space between the lobes of the outer rotor that are in mesh, increases to cause a suction or decreases to cause a pressure increase. Lubricating oil (A1) from the sump passes through a strainer and pipe to the suction side of the pump.

The lubricating oil, at increased pressure (A2) passes from the outlet of the pump to the relief valve, that is fitted into the oil pump body. As engine speed increases the output of the oil pump increases, and more oil flows into the system. The increase in flow causes an increase in pressure in the system. When the oil pressure on the plunger of the relief valve is greater than the spring pressure, the valve will open. When the valve opens, surplus oil is returned to the sump. This action will reduce the oil pressure and the valve will close.

Lubricating oil (A2) from the relief valve, passes through a pipe to the full flow oil filter. The oil filter is fitted to the left side of the engine.

On turbocharged engines the oil passes from the filter head and through an oil cooler before it enters the oil filter canister.

Engines fitted with a turbocharger have an external lubrication circuit (A5). Lubricating oil passes from a channel drilled between the oil filter outlet and the pressure rail, through an external oil supply pipe to the inlet of the turbocharger. The oil lubricates the shaft and bearings and is gravity drained from the turbocharger through an external oil drain pipe back to the sump.

The lubricating oil passes from the filter to the pressure rail that is drilled the complete length of the left side of the cylinder block.

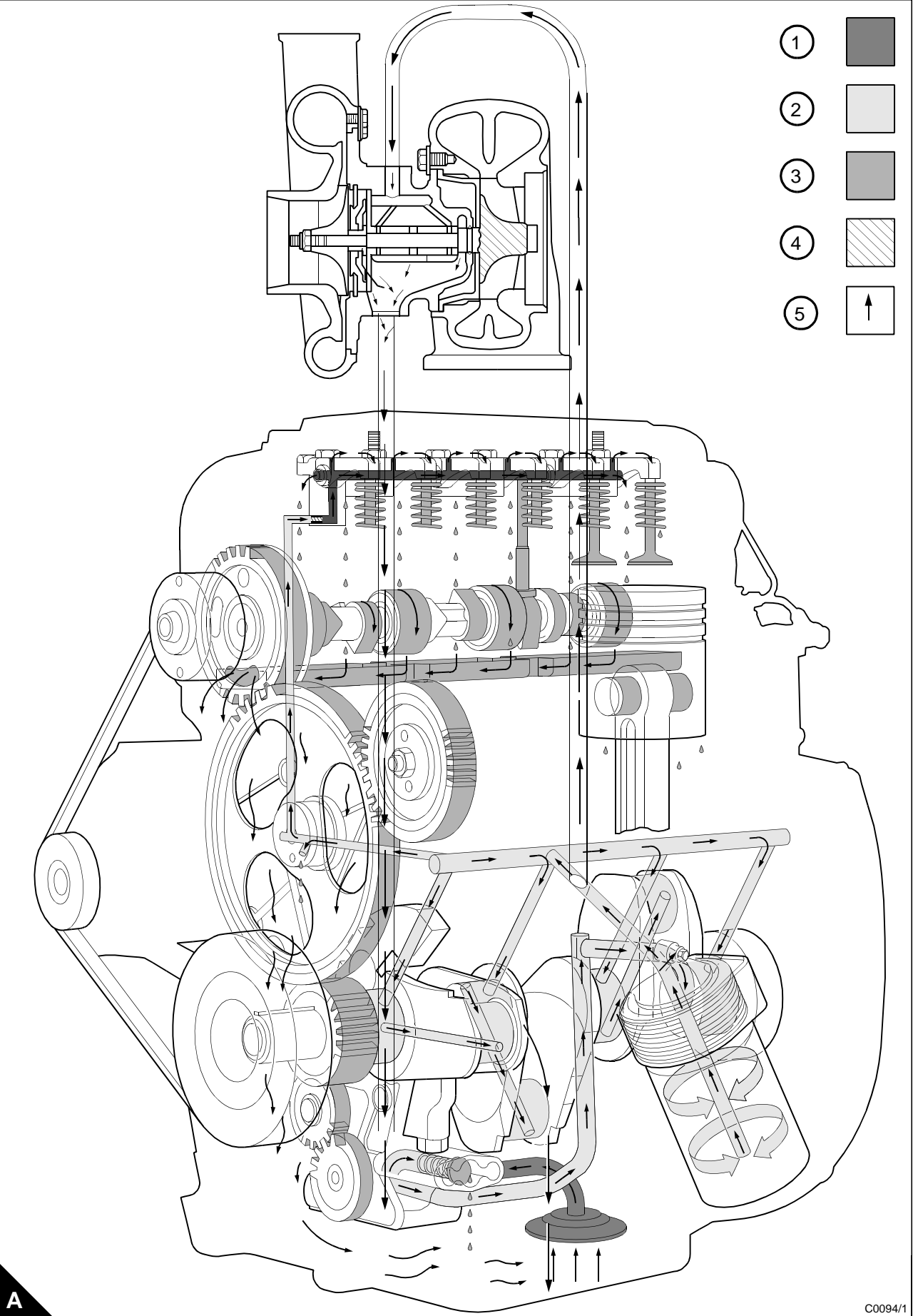
Lubricating oil passes from the pressure rail, through passages in the main journals of the crankshaft, to the main bearings. Lubricating oil also passes through passages in the crankshaft to the big end bearings. The small end bearings, the pistons and the cylinder bores are lubricated by splash and oil mist (A3).

Lubricating oil passes from the pressure rail through a hole drilled across the front of the cylinder block, that connects with a vertical passage to the front of the cylinder head. The hub of the idler gear is lubricated by oil from the pressure rail and the timing gears are splash lubricated.

Oil passes through a passage from the front of the cylinder head to a restriction in the first pedestal of the rocker shaft. The restriction reduces the oil pressure (A4), to lubricate the rocker assembly. The oil passes through the rocker shaft to the bore of each of the rocker levers and leaves the bores through holes in the top of the rocker levers. Oil passes along channels in the top of the rocker levers to the valve stems, the valve springs and the tappets, which are lubricated by splash and oil mist.

Lubricating oil from the rocker shaft drains from the cylinder head into an oil reservoir below the camshaft. The camshaft and its journals are lubricated by splash. Excess oil which passes from the reservoir into the timing case lubricates the gears. Lubricating oil from the timing case returns to the sump.

Lubrication system flow diagram



Filter canister

To renew

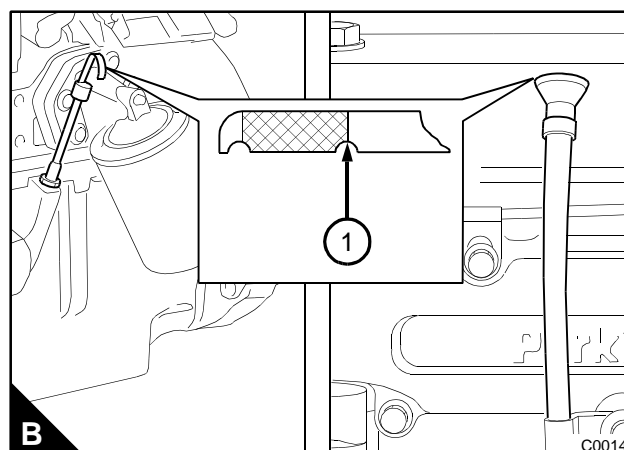
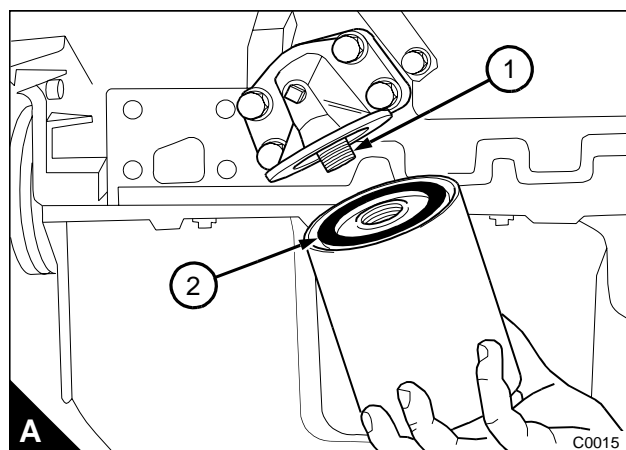
Operation 10-1

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

Cautions:

- Do not fill the sump past the "**Max**" mark (B1) on the dipstick or damage could occur to the engine.
- The canister contains a valve and special tube to ensure that lubricating oil does not drain from the filter. Therefore, ensure that the correct Perkins POWERPART canister is used.

- 1 Put a tray under the filter to retain spilt lubricating oil. Clean thoroughly the outside surfaces of the filter assembly.
- 2 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.
- 3 Clean inside the filter head.
- 4 Add clean engine lubricating oil to the new canister. Allow the oil enough time to pass through the filter element.
- 5 Lubricate the seal (A2) on top of the canister with clean engine lubricating oil.
- 6 Fit the new canister and tighten it by hand until the seal contacts the filter head. Tighten the canister a further $\frac{1}{2}$ to $\frac{3}{4}$ of a turn by hand only. Do not use a strap wrench.
- 7 Ensure that there is lubricating oil in the sump. 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.
- 8 Start the engine and check for leakage from the filter. Stop the engine. After 15 minutes check the oil level on the dipstick and, if necessary, put more lubricating oil into the sump.



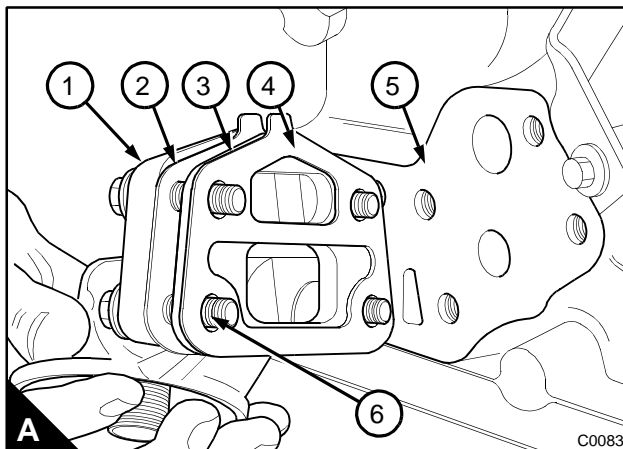
Filter head

To remove and to fit

Operation 10-2**Special requirements**

Consumable products	
Description	Part number
POWERPART Threadlock (pipe)	21820117 or 21820118

- 1 Put a tray under the filter head to contain spilt lubricating oil.
- 2 Remove the filter canister, see Operation 10-1.
- 3 Release the four setscrews (A6) and remove the filter head (A1) and the spacer (A3) from the cylinder block (A5). Discard the two joints (A2) and (A4).
- 4 Some engines do not have a spacer fitted. When a spacer is not fitted there is only one joint between the filter head and the cylinder block.
- 5 Thoroughly clean the joint face of the filter head, the spacer and the flange face of the cylinder block. Fit the filter head, the spacer and the two new joints. Apply POWERPART threadlock to the first three threads of the setscrews and tighten the setscrews to 44 Nm (32 lbf ft) 4,5 kgf m.
- 6 Fit new filter canister(s), see Operation 10-1.



Canister type lubricating oil cooler

To remove and to fit

Operation 10-3

Note: Canister lubricating oil coolers are a type of plate oil cooler and are fitted either direct to the oil filter head and have a cover at the base, or between the oil filter head and the oil filter. If the engine has low oil pressure, remove the lubricating oil cooler and clean it before further checks for possible causes of the low oil pressure.

To remove

- 1 Drain the cooling system.
- 2 Release the hose clips of the coolant pipes at the oil cooler (A3). Release the threaded adaptor (A5) from the lubricating oil cooler and pull the oil cooler (A6) from the hose connections and the filter head (A1).

To fit

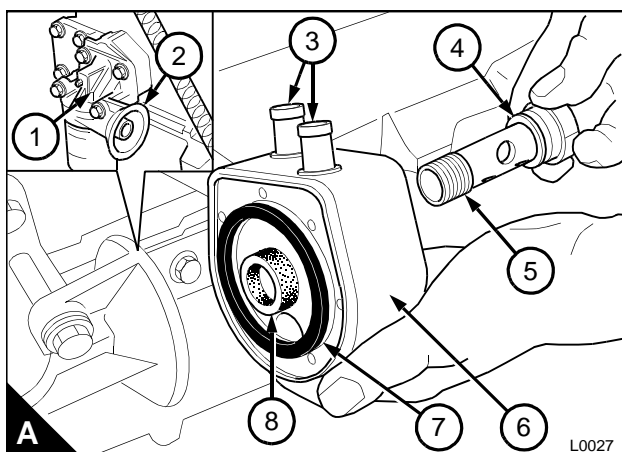
- 1 Clean the joint face of the filter head (A2).
- 2 Check the washer (A4) and the seals (A7 and A8) for damage. Renew the washer and the seals if they are damaged or worn. Lightly lubricate the seals with clean lubricating oil.
- 3 Push the hose connections for the coolant pipes onto the lubricating oil cooler. Hold the oil cooler in position against the filter head and fit the threaded adaptor. Tighten the threaded adaptor to 57 Nm (42 lbf ft) 5,8 kgf m. Ensure that the hose connections are fitted correctly and tighten the hose clips.
- 4 Fill the cooling system.
- 5 If the oil filter is an attachment to the oil cooler, renew the filter. Check and correct the oil level in the sump.
- 6 Operate the engine and check for leakage of coolant or oil. Correct any faults.
- 7 Check and correct the oil level in the sump.

Service period

The recommended service period for this type of oil cooler is 2000 hours.

To service the oil cooler

- 1 Remove the oil cooler from the engine.
- 2 Clean thoroughly the outside of the cooler plates with a proprietary cleaning fluid. Clean thoroughly the inside of the cooler plates with clean water.
- 3 Fit the oil cooler to the engine.



Sump

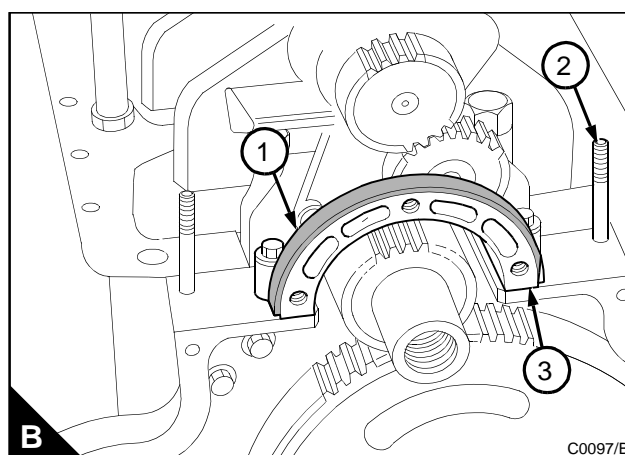
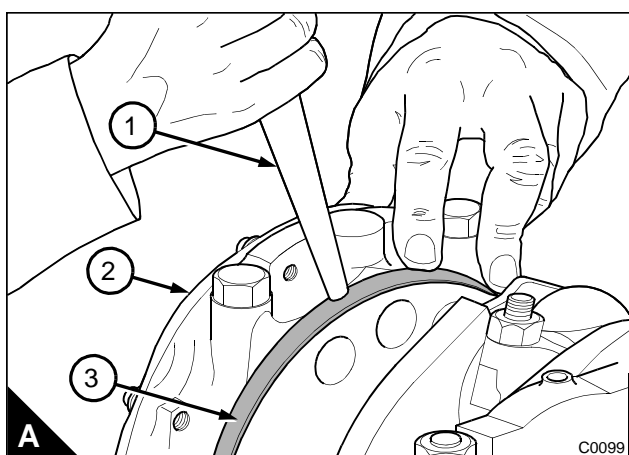
To remove

Operation 10-4

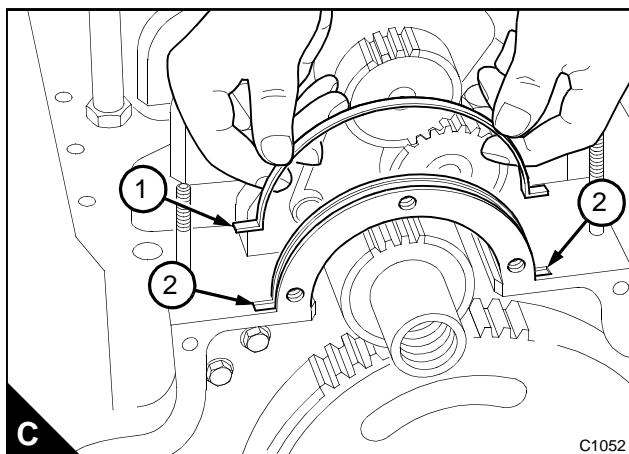
Warnings!

- Discard the used lubricating oil in a safe place and in accordance with local regulations.
- The cast iron sump is heavy, ensure that there is enough support for the sump, or obtain assistance when it is removed or fitted.

- 1 Run the engine until it is warm.
- 2 Stop the engine, remove the sump drain plug and its "O" ring and drain the oil. If necessary, remove the dipstick and the dipstick tube.
- 3 Provide a support for the sump. Remove the setscrews and the two nuts which fasten the sump to the cylinder block and to the timing case. Lower the sump and remove the joint.
- 4 Remove the cork seal (A3) from the cap of the rear main bearing (A2).



- 5 Remove the cork seal (B1), from the bridge piece (B3) of the timing case.
- 6 If the engine is fitted with a one-piece timing case that includes the bridge piece, remove the blue rubber seal (C1) from the bridge (C2)



To fit

Operation 10-5

Special requirements

Consumable products	
Description	Part number
POWERPART Silicone sealing and jointing compound	21820117 or 21820118

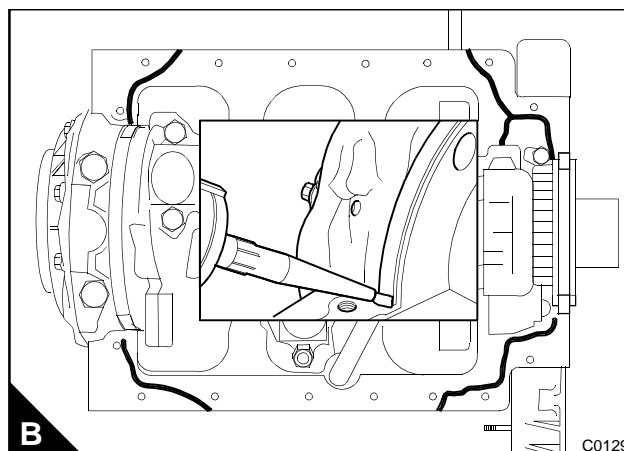
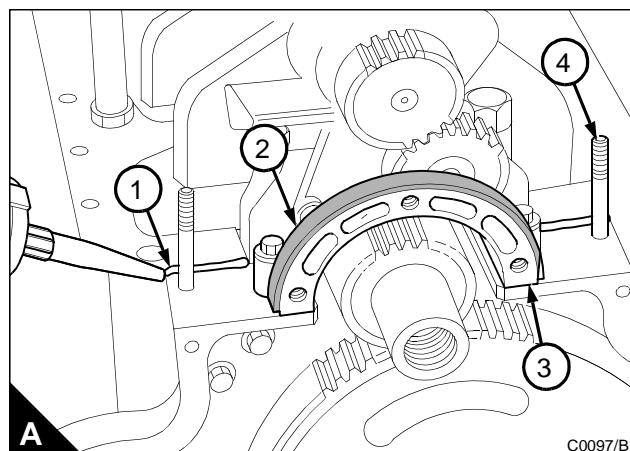
1 Wash the sump with an approved cleaning fluid, ensure that all of the cleaning fluid is removed. Thoroughly clean the flange faces of the sump and the cylinder block. Thoroughly clean the groove for the cork seal in the cap of the rear main bearing. Thoroughly clean the groove for the cork seal in the bridge piece of the timing case.

Caution: The cork seals supplied are the correct length and must not be reduced.

2 Apply a bead of POWERPART Silicone sealing and jointing compound (A1) along the junction between the timing case and the cylinder block.

3 Apply a 3 mm bead of POWERPART Silicone rubber to the surface of the block in the four positions shown in (B).

4 Fit a new cork seal (A2) into the groove of the bridge piece of the timing case.

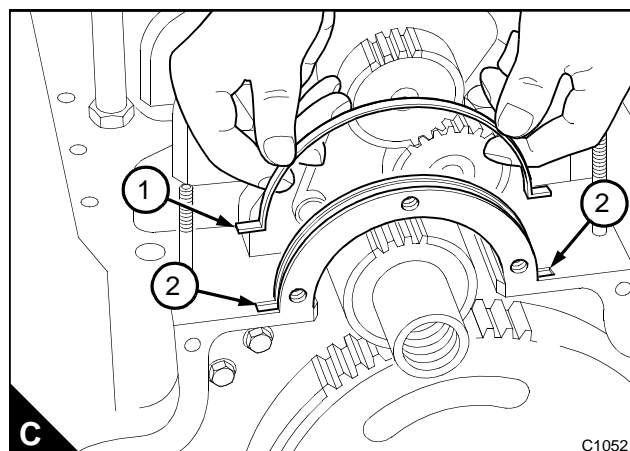


5 If the engine is fitted with a timing case that includes a bridge piece, put the new blue rubber (C1) seal into the groove (C2).

Note: The new blue seal will appear to be too long, but will fit correctly when the sump is fitted.

6 Put the new left and right joints into position on the timing case studs (A4) and align the joints with the setscrew holes. Apply light pressure to ensure that the joints do not move.

7 If a timing case with a blue rubber seal is fitted, ensure that the front lhs and rhs joints fit over the seal at (C2)

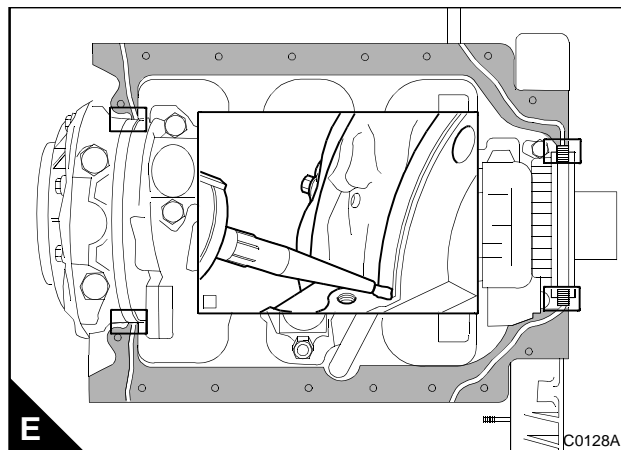
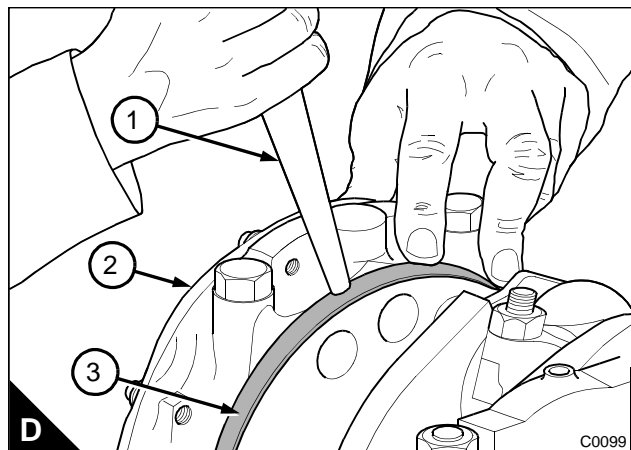


Continued

8 Fit a new cork seal (D3) into the groove in the cap of the rear main bearing. Begin at one end of the groove and press the seal into the groove gradually and evenly with a suitable tool (D1) until the seal is fitted fully into the groove and touches the joint

9 Apply a bead of POWERPART Silicone sealing and jointing compound on the surface of the joint, at the junction of the cork seals.

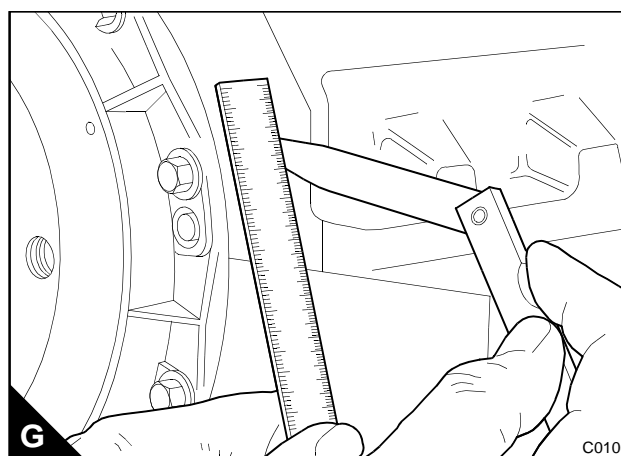
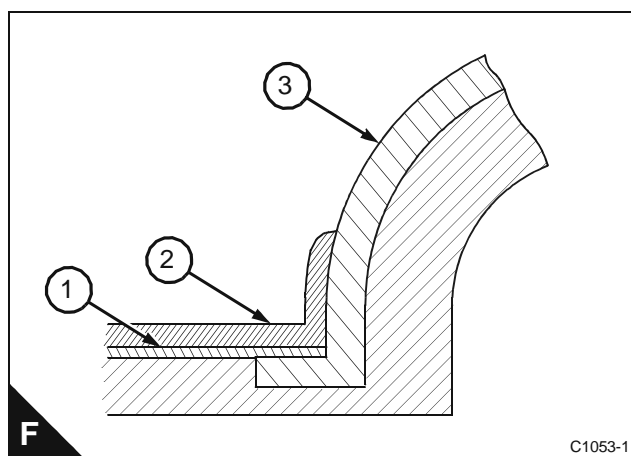
10 Apply a 3 mm bead of POWERPART Silicone sealing and jointing compound on the surface of the sump joints from the cork seals to the edge of the cylinder block as shown in (E).



11 If a blue rubber seal is used, ensure that a 3 mm bead of silicon sealant (F2) is applied to the surface of the joint (F1). The sealant must not extend further than 15 mm up the side of the blue rubber seal (F3).

12 Carefully fit the sump onto the cylinder block. Fit a setscrew on each side of the sump to ensure that it is in the correct position. Loosely fit the remainder of the setscrews and the nuts.

Caution: If a cast iron sump is fitted it is important that the rear face of the sump and the cylinder block are aligned to within 0,1 mm (0.004 in). Check the alignment with a feeler gauge and a straight edge (G). If necessary, a soft face hammer can be used to adjust the position of the sump before the fasteners are fully tightened. Two fasteners at each end should be tightened by hand.



Continued

13 Tighten all the fasteners to 22 Nm (16 lbf ft) 2,2 kgf m. Fit the drain plug (H1) together with a new rubber "O" ring and tighten the plug to 34 Nm (25 lbf ft) 3,5 kgf m. Where necessary, fit the dipstick tube and the dipstick.

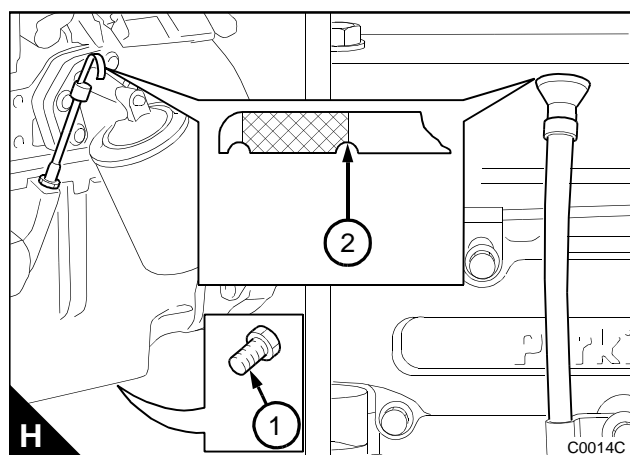
Cautions:

- Do not fill the sump past the mark (H2) on the dipstick or damage could occur to the engine
- If the lubrication system has been drained, ensure that the rocker gear and camshaft reservoir are lubricated before starting the engine.

14 If the engine has a filler in the rocker cover, enough time should be allowed for the oil to cover the rocker gear and fill the camshaft reservoir before the level is checked on the dipstick. Fill the sump to the mark (H2) on the dipstick with an approved lubricating oil.

15 If the engine has a filler on the timing case; remove the rocker cover and pour one litre of an approved lubricating oil over the rocker gear and allow to drain into the camshaft reservoir and sump. Fit the rocker cover and fill the sump to the mark (H2) on the dipstick through the filler on the timing case.

16 Start the engine and check for leakage. Stop the engine. After 15 minutes check the oil level on the dipstick and, if necessary put more lubricating oil into the sump.



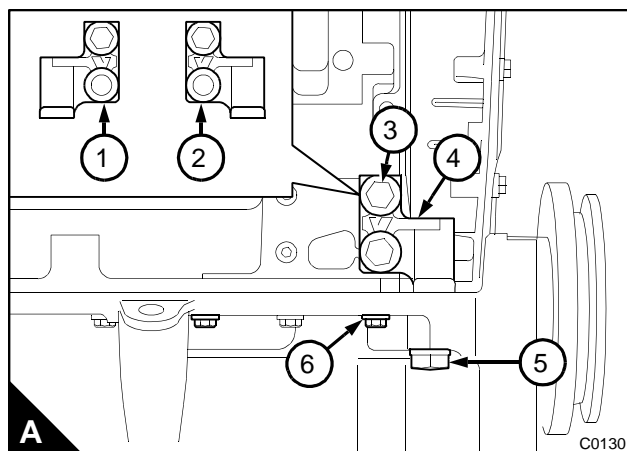
To remove a sump retained by clamps

Operation 10-6

Warnings!

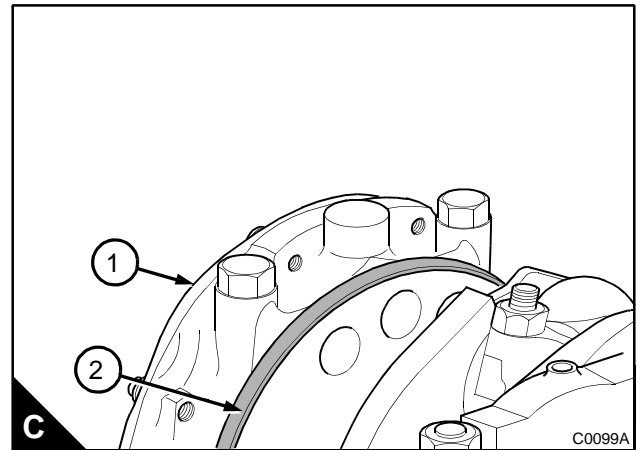
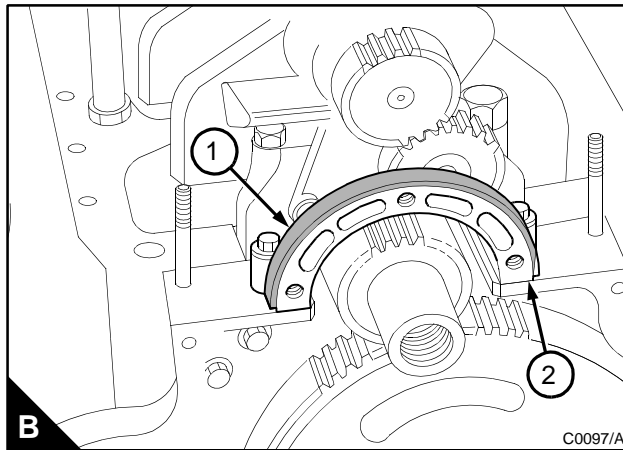
- *Discard the used lubricating oil in a safe place and in accordance with local regulations.*
- *The cast iron sump is heavy, ensure that there is enough support for the sump, or obtain assistance when it is removed or fitted.*

- 1 Operate the engine until it is warm.
- 2 Stop the engine, remove the sump drain plug and its "O" ring and drain the oil. If necessary, remove the dipstick and the dipstick tube.
- 3 Provide a support for the sump. Remove the M16 setscrew and washer (A5). Release the two M12 setscrews (A3) and remove the right-hand support clamp (A2) from the cylinder block and sump.
- 4 Remove the left-hand clamp (A1) as in step 3.
- 5 Remove the setscrews and the washers (A6) from the left side and from the right side of the sump.
- 6 Remove the remainder of the setscrews and the two nuts that fasten the sump to the cylinder block and to the timing case.
- 7 Lower the sump and remove the joints.

*Continued*

8 Remove the cork seal (B1) from the bridge piece (B2) of the timing case. Remove the cork seal (C2) from the cap of the rear main bearing (C1).

9 Thoroughly clean the flange faces of the cylinder block. Thoroughly clean the groove for the cork seal in the cap of the rear main bearing. Thoroughly clean the groove for the cork seal in the bridge piece of the timing case.



To fit a sump retained by clamps

Operation 10-7

Special requirements

Consumable products	
Description	Part number
POWERPART Silicone sealing and jointing compound	21820117 or 21820118

1 Apply a 3 mm bead of POWERPART Silicone sealing and jointing compound (A1) at the point where the timing case contacts the cylinder block.

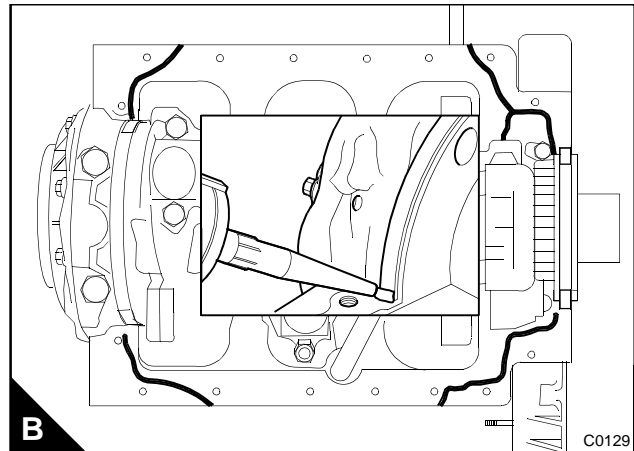
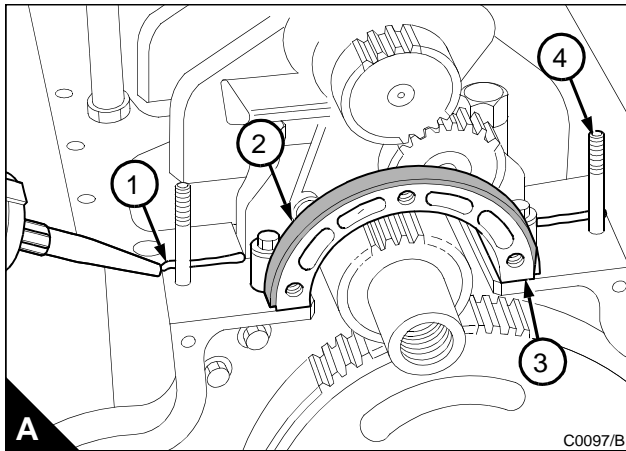
2 Apply a 3 mm bead of POWERPART Silicone sealing and jointing compound to the surface of the block in the four positions shown (B).

Caution: The sump joints must be fitted dry except where shown in this procedure.

3 Put the new left and right joints into position on the timing case studs (A4) and align the joints with the setscrew holes. Apply light pressure to ensure that the joints do not move.

Caution: The cork seals supplied are the correct length and must not be reduced.

4 Fit a new cork seal (A2) into the groove of the bridge piece of the timing case

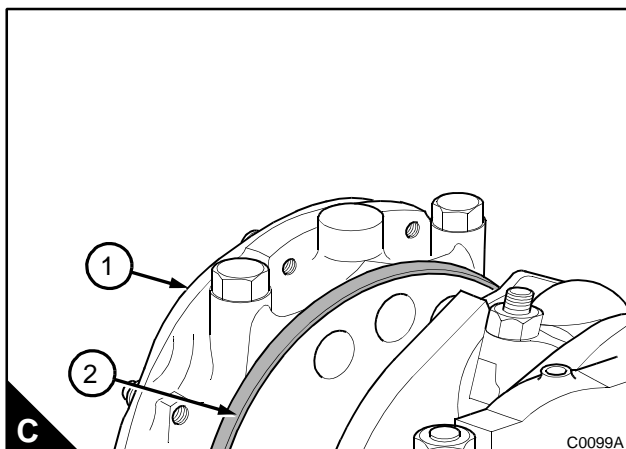


5 If the engine is fitted with a timing case that includes a bridge piece, put the blue rubber seal (C1) into the groove (C2).

Note: The new blue seal will appear to be too long, but will fit correctly when the sump is fitted.

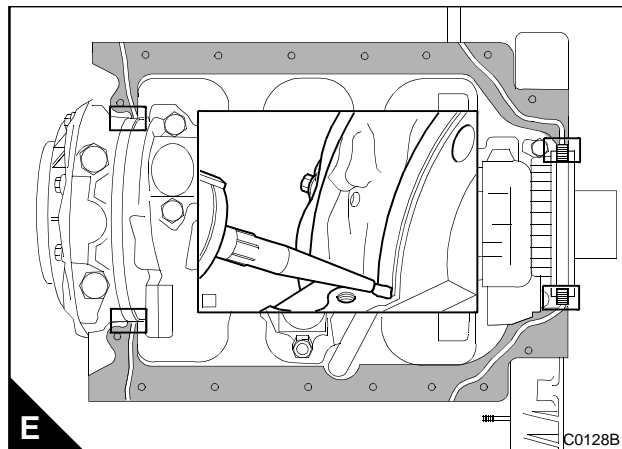
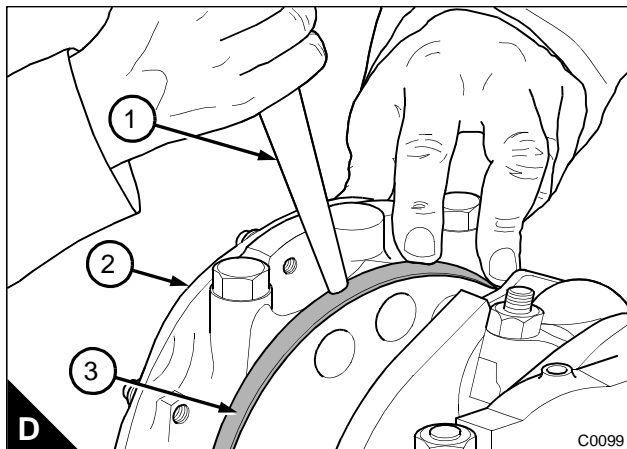
6 Put the new left and right hand joints into position on the timing case studs (A4) and align the joints with the setscrew. Apply light pressure to ensure that the joints do not move.

7 If a timing case with a blue rubber seal is fitted, ensure that the front lhs and rhs of the joints fit over the seal at (C2).



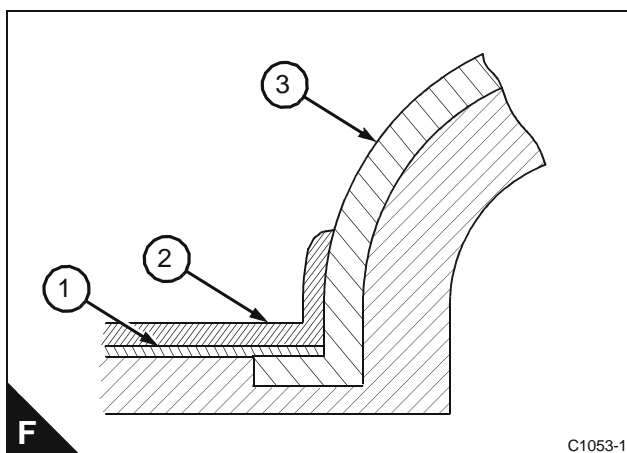
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8 Fit a new cork seal (D3) into the groove in the cap of the rear main bearing . Ensure that the edge of the cork seal is in contact with the left-hand sump joint and press the seal into the groove gradually and evenly with a suitable tool (D1) until the seal is fitted fully into the groove and contacts the right-hand joint.



9 Apply a 3 mm bead of POWERPART Silicone sealing and jointing compound on the surface of the sump joints from the cork seals to the edge of the cylinder block as shown (E).

10 If a blue rubber seal is used, ensure that a 3 mm bead of silicon sealant (F2) is applied to the surface of the joint (F1). The sealant must not extend further than 15 mm up the side of the blue rubber seal (F3).



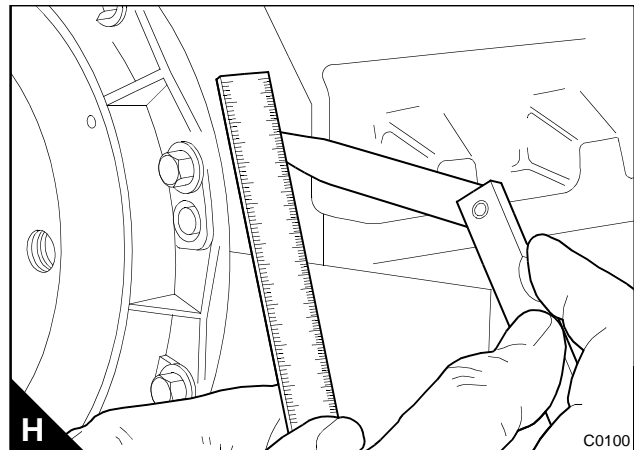
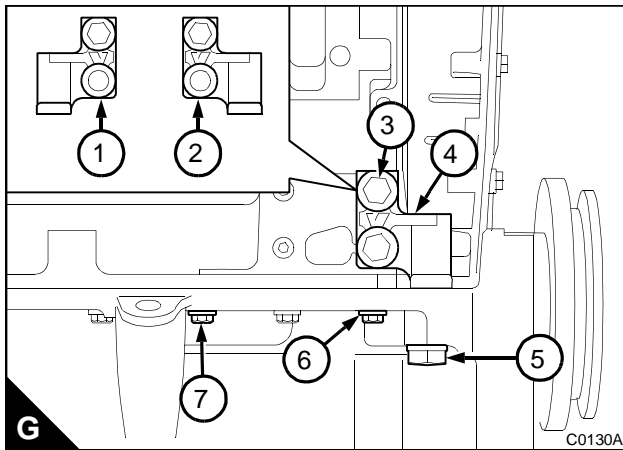
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11 Carefully fit the sump onto the timing case studs and fit a setscrew on each side of the sump to ensure that it is in the correct position. Loosely fit the remainder of the setscrews and the nuts. Ensure that the two long M8 setscrews are put into the holes at the rear of the sump.

Caution: Washers must be fitted to the M8 setscrews (G6) on both sides of the engine to ensure that the setscrews do not contact the sump clamps (G4) when they are fitted.

Fit a plain washer to the M8 setscrew (G6) in the position shown.

Caution: It is important that the rear face of the sump and the cylinder block are aligned to within 0,1 mm (0.004 in). Check the alignment with a feeler gauge and a straight edge (H). If necessary, a soft face hammer can be used to adjust the position of the sump before the fasteners are fully tightened. Two fasteners at each end should be tightened by hand.



12 Hold the left-hand clamp (G1) in position. Fit, finger tight, the two long (40 mm) M12 setscrews (G3) into the clamp. Fit, finger tight, the M16 setscrew and plain washer (G5).

Note: Some sump brackets are retained by black Phosphated M16 setscrews, Part number 2315F233. These are tightened to 370 Nm (273 lbf ft) 38,7 kgf m.

13 Hold the right-hand clamp (G2) in position. Fit, finger tight, the two short (35 mm) M12 setscrews (G3) into the clamp. Fit, finger tight, the M16 setscrew and plain washer (G5).

Caution: Do not exceed the torque for the M8 flange faced nuts at the front of the sump as this will damage the threads.

14 Tighten all the M8 setscrews for the sump to 30 Nm (22 lbf ft) 3,0 kgf m. Tighten the two flange faced nuts at the front of the sump to 25 Nm (18 lbf ft) 2,5 kgf m.

15 Tighten the left-hand clamp M12 setscrews (G3) to 5-10 Nm (2-4 lbf ft) 0,7-1,4 kgf m

16 Tighten the right-hand clamp M12 setscrews (G3) to 5-10 Nm (2-4 lbf ft) 0,7-1,4 kgf m.

17 Tighten the left and right clamp M16 setscrews (G5) to 170 Nm (125.4 lbf ft) 17,3 kgf m.

18 Wait 15 minutes and tighten again all the sump fasteners to 30 Nm (22 lbf ft) 3,0 kgf m.

19 Tighten the M12 setscrews (G3) for the left and right clamp to 78 Nm (57.5 lbf ft) 8,0 kgf m.

20 Remove any excess sealant where the cylinder block contacts the sump.

Continued

21 Fit the drain plug (J1) together with a new rubber "O" ring and tighten the plug to 34 Nm (25 lbf ft) 3,5 kgf m. Where necessary, fit the dipstick tube and the dipstick.

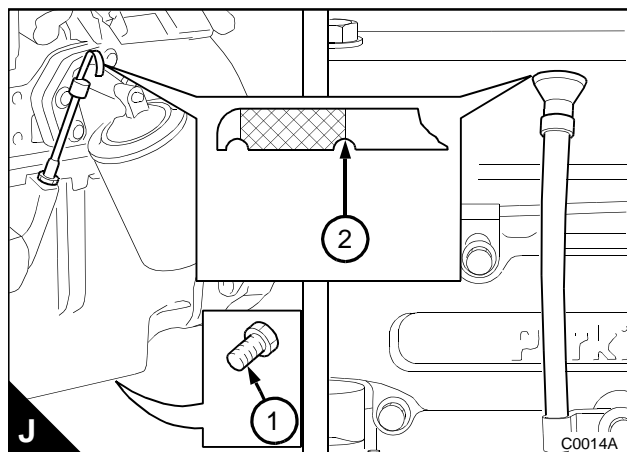
Cautions:

- Do not fill the sump past the mark (J2) on the dipstick or damage could occur to the engine.
- If the lubrication system has been drained, ensure that the rocker gear and camshaft reservoir are lubricated before starting the engine.

22 If the engine has a filler in the rocker cover, enough time should be allowed for the oil to cover the rocker gear and fill the camshaft reservoir before the level is checked on the dipstick. Fill the sump to the mark (J2) on the dipstick with an approved lubricating oil.

23 If the engine has a filler on the timing case; remove the rocker cover and pour one litre of an approved lubricating oil over the rocker gear and allow to drain into the camshaft reservoir and sump. Fit the rocker cover and fill the sump to the mark (J2) on the dipstick through the filler on the timing case.

24 Start the engine and check for leakage. Stop the engine. After 15 minutes check the oil level on the dipstick and, if necessary put more lubricating oil into the sump.



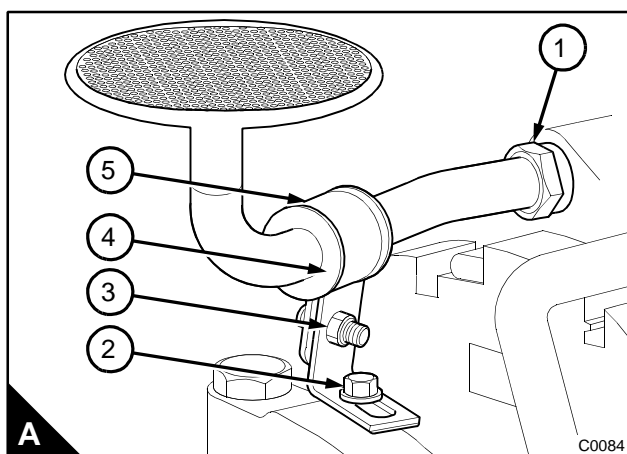
Oil strainer and suction pipe assembly

To remove and to fit

Operation 10-8

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

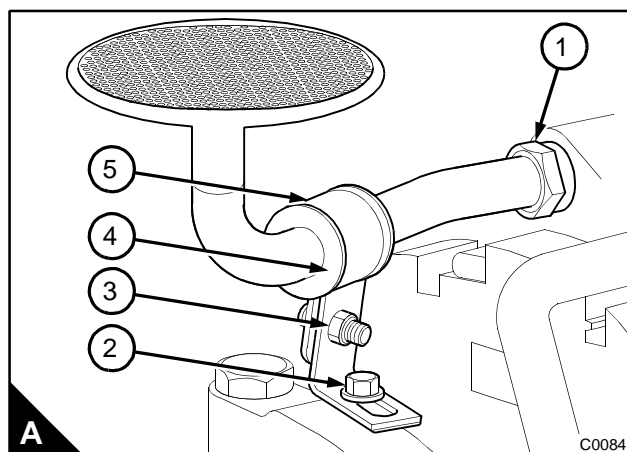
- 1 Remove the sump, see Operation 10-4 or Operation 10-6.
- 2 Release the union nut (A1) of the suction pipe.
- 3 Release the setscrew (A2) that holds the clamp to the bearing cap. Remove the suction pipe and strainer.
- 4 Loosely assemble the clamp of the suction pipe to the correct bearing cap. Fit the suction pipe to the oil pump. Ensure that the strainer inlet is towards the bottom of the sump. Tighten the union nut. Tighten the setscrew of the suction pipe clamp. Ensure that there is no stress on the suction pipe.
- 5 Fit the sump, see Operation 10-5 or Operation 10-7, and fill it with an approved oil to the "MAX" mark on the dipstick.



To inspect and to correct

Operation 10-9

- 1 Wash the assembly in an approved cleaning fluid and dry it thoroughly.
- 2 Check the pipe, the strainer and the welded joints for cracks and other damage. Check that the mounting clamp is secure.
- 3 If the damaged component cannot be welded correctly, renew the assembly.
- 4 If the neoprene bush (A4) is damaged release the nut (A3), open the clamp (A5) and renew the bush.



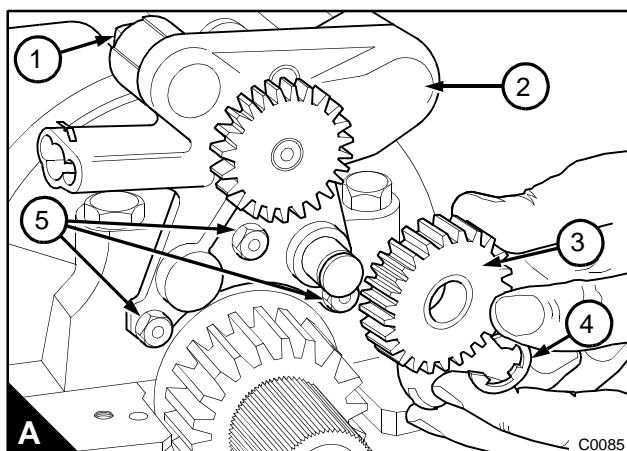
Lubricating oil pump

To remove

Operation 10-10

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

- 1 Remove the drive belt, see Operation 14-3.
- 2 Remove the crankshaft pulley, see Operation 5-1.
- 3 Drain the lubricating oil and remove the lubricating oil sump, see Operation 10-4 or Operation 10-6.
- 4 Remove the suction pipe and strainer, see Operation 10-8.
- 5 Remove the delivery pipe (A1) of the oil pump.
- 6 Remove the timing case cover, see Operation 6-1.
- 7 Remove the bridge piece of the timing case, see Operation 6-13.
- 8 Release the circlip (A4) that retains the idler gear (A3) of the oil pump and remove the idler gear. The lubricating oil pump gear must not be removed as this can reduce the interference fit of the gear. A pump that is worn cannot be corrected as separate parts are not available.
- 9 Release the setscrews (A5) and remove the oil pump (A2).

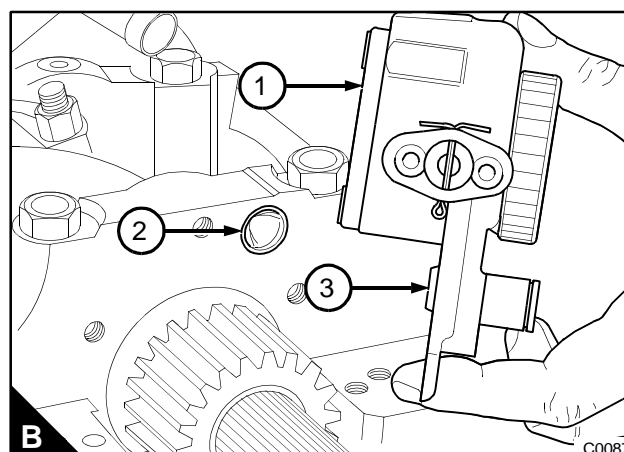
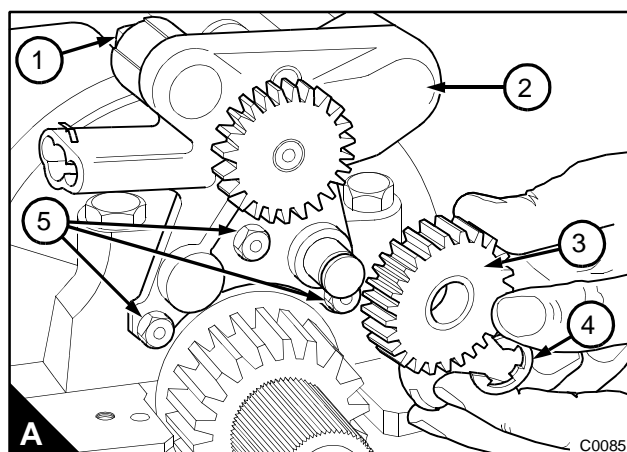


To fit

Operation 10-11

1 Check that the backplate (B1) of the oil pump is secure. Fill the oil pump with clean engine lubricating oil. Ensure that the recess (B2) for the idler shaft (B3) is clean. Fit the oil pump to the main bearing cap and tighten the setscrews (A5) to 22 Nm (16 lbf ft) 2,2 kgf m. Loosely fit the delivery pipe (A1).

2 Check the idler gear (A2) and the bush (A3) for wear and other damage. If the gear and/or the bush are damaged, they can be renewed as an assembly or the bush can be renewed as a single item. Check the shaft for the idler gear for wear or other damage. If the shaft is worn or damaged, refer "To renew the idler shaft of the oil pump" on page 158.

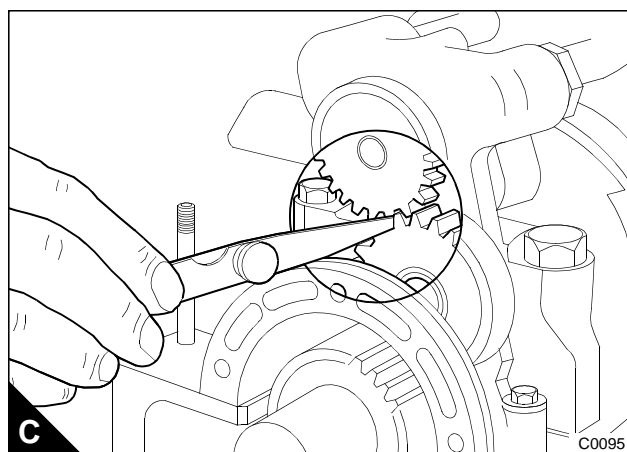


3 Lubricate the bush (A3) with clean engine lubricating oil and fit the idler gear (A2) and the circlip (A4). Check that there is a minimum of 0,102 mm (0.004 in) backlash (C) between the oil pump gear and the idler gear.

Check that there is a minimum of 0,076 mm (0.003 in) backlash between the oil pump idler gear and the crankshaft gear.

4 Fit the suction pipe and strainer, see Operation 10-8.

5 Connect the delivery pipe to the cylinder block and tighten the connections at the pump and at the cylinder block.



Continued

- 6 Fit the bridge piece for the timing case, see Operation 6-14.
- 7 Fit the timing case cover, see Operation 6-2.
- 8 Fit the crankshaft pulley, see Operation 5-1, and the drive belt, see Operation 14-3.
- 9 Fit the lubricating oil sump, see Operation 10-5 or Operation 10-7. Fill the sump to the "MAX" mark on the dipstick with an approved lubricating oil.

To renew the idler shaft of the oil pump

- 1 Support the front of the oil pump body. Put a suitable adaptor on the idler shaft and press the idler shaft out of the oil pump from the rear of the pump body.
- 2 Ensure that the idler shaft and the hole in the oil pump are clean. Support the rear of the oil pump and ensure that the pump will not move when the idler shaft is pressed in. Apply POWERPART retainer to the hole of the idler shaft.
- 3 Enter the chamfer of the idler shaft into the hole, ensure that the idler shaft is square to the oil pump. Press in the shaft until the dimension from the top of the idler shaft to the boss on the front of the oil pump body is 18,80/18,87 mm (0.7401/0.7429 in). Remove the surplus POWERPART retainer.

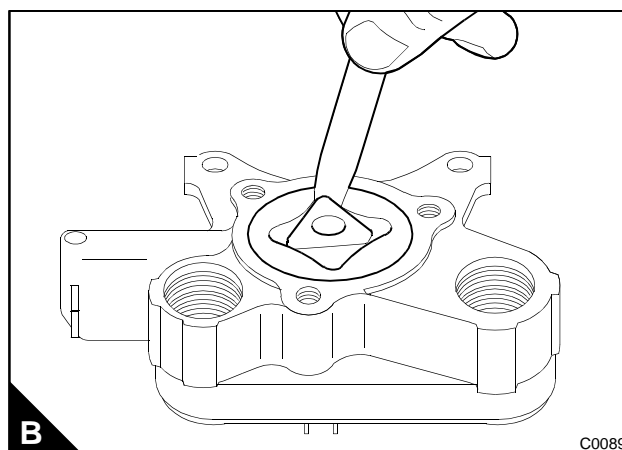
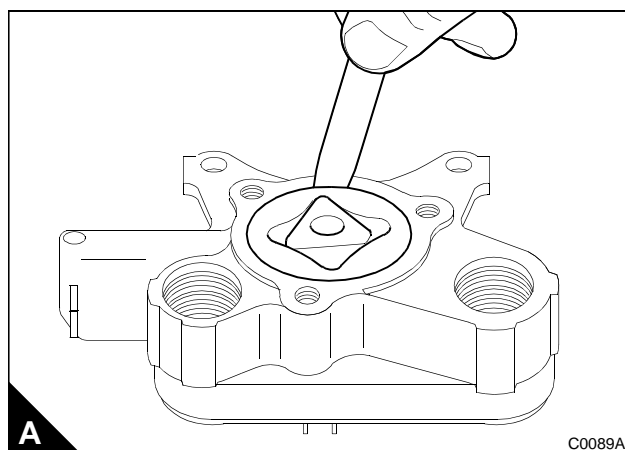
Note: The idler shaft will protrude a little from the rear of the oil pump body.

To inspect

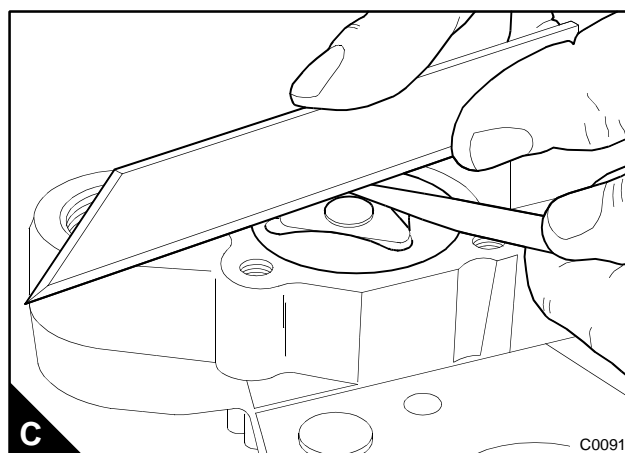
Operation 10-12

If any part is worn enough to have an effect on the performance of the oil pump, the complete oil pump must be renewed.

- 1 Release the three Allen screws and remove the cover of the oil pump.
- 2 Remove the outer rotor and clean thoroughly all the parts. Check for cracks and any other damage.
- 3 Fit the outer rotor and check the outer rotor to body clearance with a feeler gauge (A).
- 4 Check the inner rotor to outer rotor clearance (B).



- 5 Check the rotor end-float with a straight edge and a feeler gauge (C). For all the above clearances, refer to the relevant Data and dimensions for the "Lubrication system" on page 24.
- 6 Clean the top face of the oil pump and the bottom face of the cover and fit the cover.



Relief valve

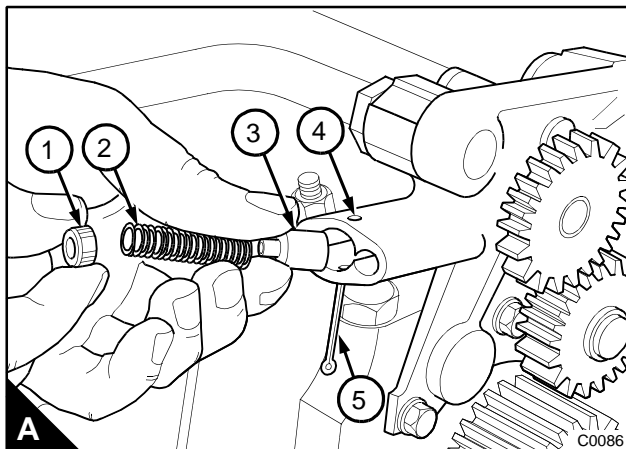
The relief valve (A) is fitted in the lubricating oil pump body and prevents too much pressure in the lubricating oil system.

As engine speed increases the output of the oil pump increases, and more oil flows into the system. The increase in flow causes an increase in pressure in the system. When the oil pressure on the plunger of the relief valve is greater than the spring pressure, the valve will open. When the valve opens, surplus oil is returned to the sump. This action will reduce the oil pressure and the valve will close. Oil that passes the relief valve reaches the oil filter.

To dismantle and to assemble

Operation 10-13

- 1 Apply pressure to the end plate (A1) of the spring assembly, release and discard the split pin (A5). Carefully release the pressure to remove the end plate and the spring (A2) from the valve body (A4). Remove the plunger (A3) from the bore of the body.
- 2 Ensure that all the components are cleaned and then lubricated lightly with clean engine lubricating oil.
- 3 Fit the plunger into the bore with its hollow end to the inside. Fit the spring and the end cap into the bore with the ends of the spring fitted around the bosses of the plunger and the end plate. Apply pressure to the end plate and fit a new split pin into its hole.



To inspect

Operation 10-14

Do not try to change the operation pressure of the relief valve. If necessary, fit new components.

- 1 Check the spring for wear and other damage and, if possible, check the load necessary to compress the spring to its fitted length, refer to the relevant Data and dimensions for the "Lubrication system" on page 24.
- 2 Check the plunger for wear and other damage and ensure that it slides easily in the bore of the relief valve.
- 3 Check the body and the end plate for wear and other damage.
- 4 Renew worn or damaged components.

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11

Fuel system

General description

Delphi fuel injection pumps

Two types of Delphi DP200 Series fuel injection pumps are fitted to naturally aspirated engines and turbocharged engines. Early engines are fitted with locked pumps and turbocharged engines and some naturally aspirated engines are fitted with pin-timed pumps. The two types of pump are not interchangeable.

Both types of pump have an electrically operated cold start advance unit (A5) that retards the timing for normal operation. A self-vent feature and a stop solenoid (A3) is included.

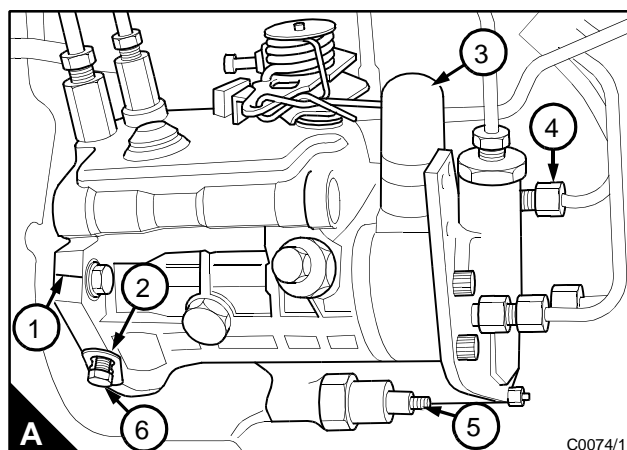
A data plate is fitted to the bracket of the fuel injection pump. The data plate information is shown below:

- Perkins part number
- Fuel pump serial number
- Manufacturers model number

The maximum no-load speed is shown on the emissions data plate fitted to the left side of the cylinder block.

Cautions:

- *The fuel injection equipment must only be checked and adjusted by personnel who have had the correct training.*
- *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.*
- *Do not clean an engine while it runs. If cold cleaning fluids are applied to a hot engine, certain components on the engine may be damaged.*
- *If there is a failure in the electrical circuit for the cold start advance, the engine will run continuously with the timing in the fully advanced position and damage the engine.*



Continued

The locked pumps (B) have a locking screw (B6) and a spacer (B2). The locking screw prevents the rotation of the drive shaft after the pump is removed from the engine. This allows the pump to be removed and fitted without the need to time the pump to the engine.

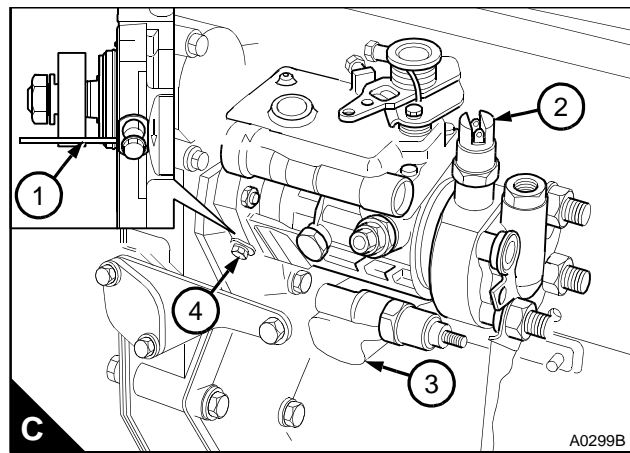
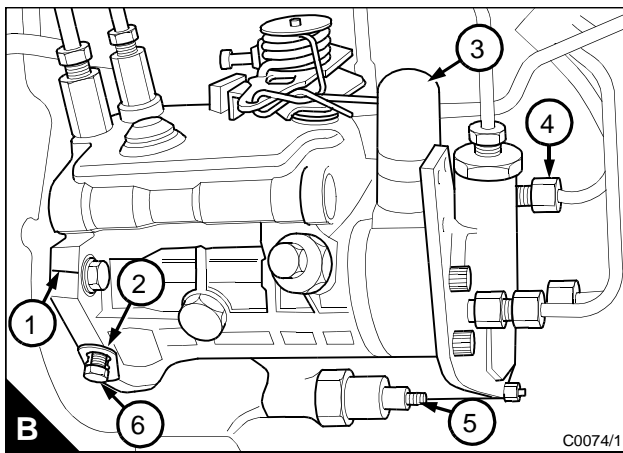
Caution: Do not try to rotate the drive shaft of the fuel pump when it is locked with the locking screw. If the drive shaft is rotated, it will be damaged.

Engines with these pumps do not have a timing mark on the timing case, but there is a timing mark (B1) on the pump flange. If the engine performance indicates that the timing of the fuel pump may be incorrect, the pump must be removed and the mark on the pump checked, see Operation 8-3.

A new pump will be supplied locked at the correct angle for the engine. It is important that the complete engine number is given to the distributor when a new pump is needed.

An "O" ring is fitted in the pump flange. This "O" ring is fitted instead of a joint between the pump flange and the timing case.

The high-pressure outlet for number 1 cylinder is shown at (B4).



The pin-timed pump (C) conform to emissions legislation and have tamper proof engine timing and adjustment screws.

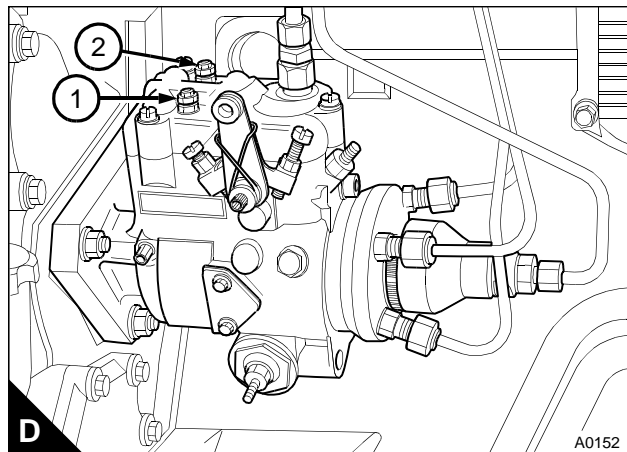
The pump has a hole in the flange through which the pin (C1) is inserted to lock the shaft to the body of the pump. This pump has a locking screw (C4) that locks the shaft. It is important that the lock screw is released and the pump shaft is free to turn when the pump is fitted to the engine. An electrically operated cold start device (C3) which retards the timing for normal operation and a stop solenoid (C2) are fitted. The pump includes a self-vent feature.

Continued

Stanadyne fuel injection pump

The engines used on generator sets are fitted with the pin-timed Stanadyne fuel injection pump (D). The electrical stop solenoid on these fuel pumps is fitted inside the governor housing. The earth connection (D1) and the electrical supply connection (D2) are on top of the governor housing.

Caution: The low speed idle adjustment screw and the maximum no-load speed adjustment screw are sealed with tamper proof screws in the factory. The adjustment must only be reset by persons authorised by Perkins Engines company limited.



Atomisers

The atomisers, which are of the VCO (valve covered orifice) type, have nozzles with five holes. the atomisers inject fuel in a very fine spray into the combustion chamber in the top of each piston. Each atomiser is fastened to the cylinder head, either by a clamp or a gland nut. The atomisers are set in the factory, but they must be checked in accordance with the preventive maintenance schedules. The pressure at which atomisers operate can be adjusted by a change of shims fitted above the spring.

For details of the atomiser setting pressures for the engine, refer to "Atomiser service settings" on page 26.

Fuel system

Air is removed from the fuel pump through a leak-off pipe that returns fuel to the fuel tank, together with the atomiser leak-off fuel. The pump is lubricated and cooled by the movement of fuel through the injection pump. The pump has a mechanical governor to control the engine speed.

The pump has an electrical stop and an electrically operated cold start advance unit fitted.

Fuel from the tank leaves the pre-filter and then passes to the diaphragm type lift pump, which is driven by an eccentric on the camshaft. Fuel leaves the lift pump under pressure and passes through a full flow filter to the fuel injection pump.

The fuel injection pump increases the fuel pressure and supplies high-pressure fuel through small bore pipes to the atomisers at the correct time and sequence. The atomisers inject fuel as a very fine spray into the combustion chambers. Combustion occurs in a bowl in the piston crown.

A fuel leak-off rail is fitted to the top of each clamp type atomiser or the side of gland nut type atomisers. Excess fuel, used to lubricate the internal parts of the atomiser, is returned to the fuel tank.

Fuel filter

Fuel filter types

Operation 11-1

There are two types of fuel filter used:

- The element type, where the filter element is held between the filter head and a bottom cover. To renew refer to Operation 11-2.
- The quick release type, where the filter canister is fastened to the filter head by a clamp ring. To renew refer to Operation 11-3.

To renew the element type filter

Operation 11-2

Cautions:

- *It is important that only the genuine Perkins fuel filter element is used. The use of a wrong element can damage the fuel injection pump.*
- *Do not allow dirt to enter the fuel system. Before a connection is disconnected, clean thoroughly the area around the connection. After a component has been disconnected, fit a suitable cover to all open connections.*

1 Clean the outside surfaces of the fuel filter assembly. If a drain tap is fitted to the filter bowl, drain the fuel from the filter.

2 Hold the bottom cover of the filter element and release the setscrew (A1), that is fitted through the filter head above the centre of the element.

3 Lower the bottom cover (A6) of the filter.

4 Remove the element (A4) and discard it.

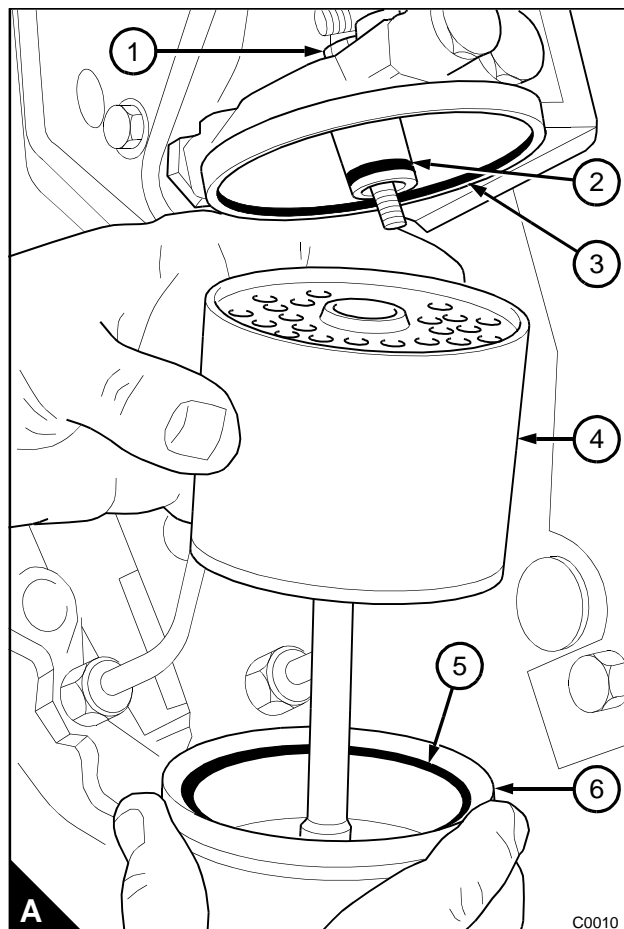
Warning! Discard the used canister and fuel in a safe place and in accordance with local regulations.

5 Clean the inside surfaces of the filter head and the cover.

6 Renew the seals (A3 and A5) and the 'O' ring (A2) and lightly lubricate them with clean fuel. The larger seal is fitted to the filter head and the smaller seal is fitted to the bottom cover.

7 Put the bottom cover under the new element and hold the element squarely to the filter head. Ensure that the element is fitted in the centre against the 'O' ring in the filter head. With the assembly in this position, engage and tighten the setscrew.

8 Eliminate the air from the fuel filter, see Operation 11-19.



To renew the quick release type filter

Operation 11-3

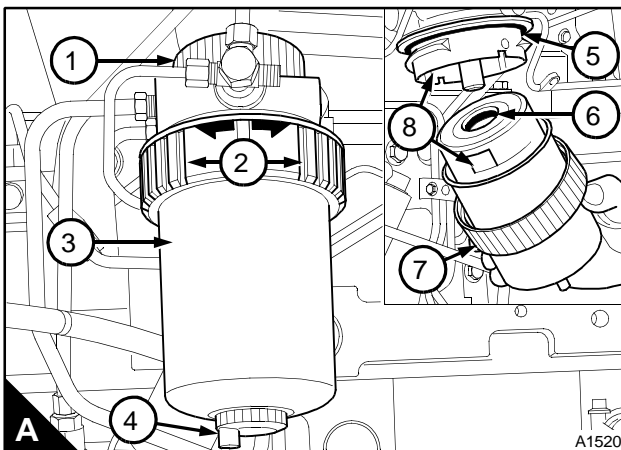
Cautions:

- It is important that only the genuine Perkins fuel filter canister is used. The use of a wrong canister can damage the fuel injection pump.
- Do not allow dirt to enter the fuel system. Before a connection is disconnected, clean thoroughly the area around the connection. After a component has been disconnected, fit a suitable cover to all open connections.

- 1 Thoroughly clean the outside surfaces of the filter assembly.
- 2 Loosen the drain device (A4), if one is fitted, at the bottom of the canister and allow the water/fuel to drain into a suitable container.

Note: If the filter does not have a drain device fitted release the cap (A1) on top of the filter head. Remove the nylon insert to lower the level of the fuel in the filter canister. This will prevent fuel spill when the clamp ring (A2) is released.

- 3 Unscrew the sediment bowl at the bottom of the canister, if one is fitted.
- 4 Support the filter canister and rotate the clamp ring (A2) to the left, see the direction arrow, and remove the clamp ring.
- 5 Remove the canister from the filter head by a direct pull downwards, and discard the old canister (A3). Keep the clamp ring.
- 6 Ensure the filter head is clean and that the seals (A5) and (A6) are in good condition, or renew them. Align the spline (A8) with the groove in the filter head and push the new canister fully into the filter head.
- 7 Support the canister, fit the clamp ring (A7) and rotate it to the right, see the direction arrow, to fasten the canister to the filter head.
- 8 If a sediment bowl is fitted, remove the bowl and thoroughly clean the cover of the bowl.
- 9 Check the two 'O' ring seals of the sediment bowl for damage and renew if necessary.
- 10 Clean the threads of the sediment bowl and fit the bowl to the canister and tighten by hand only.
- 11 If it was removed, fit the nylon insert used to lower the level of the fuel in the filter canister and fasten the cap.
- 12 Eliminate the air from the fuel system, see Operation 11-22.



Atomisers

Atomiser faults

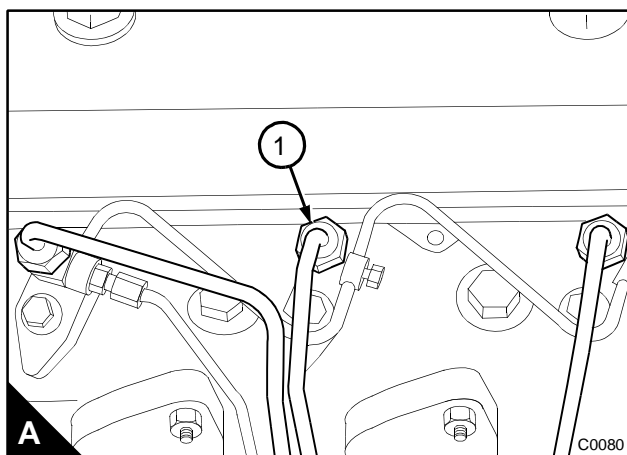
Operation 11-4

There are two types of atomisers used on the 900 Series engine. Early engines use a clamp to retain each atomiser. Later engines use atomisers where the body of the atomiser is held in position with a gland nut.

Warnings!

- *If your skin comes into contact with high-pressure fuel, obtain medical assistance immediately.*
- *Keep away from moving parts during engine operation. Some moving parts cannot be seen clearly while the engine runs.*

In order to find which atomiser is defective, operate the engine at a fast idle speed. Loosen and tighten the union nut (A1) of the high-pressure fuel pipe at each atomiser. Do not loosen the union nut more than half a turn. When the union nut of the defective atomiser is loosened, it has little or no effect on the engine speed.

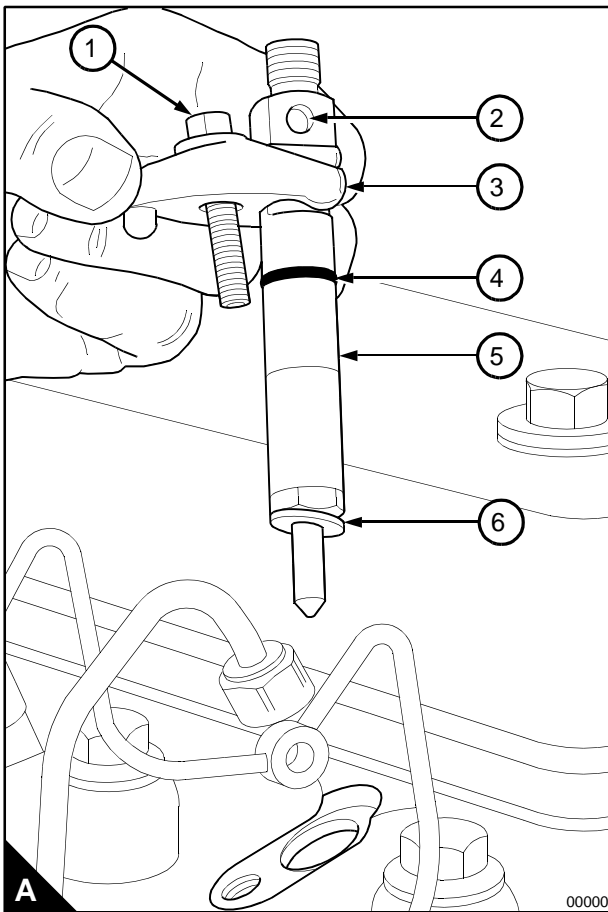


To remove atomisers retained by a clamp

Operation 11-5

Caution: Do not allow dirt to enter the fuel system. Before a connection is disconnected, clean the area around the connection. After a component has been disconnected, fit a suitable cover to all open connections.

- 1 Remove the fuel leak-off pipe from the connection (A2)
- 2 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.
- 3 Release the clamp setscrew (A1) of the atomiser. Remove the clamp (A3). Remove the atomiser (A5) and its seat washer (A6).
- 4 Check the clamp for damage and, if necessary, renew the clamp. Renew the atomiser seat washer and the dust seal (A4).



To fit atomisers retained by a clamp

Operation 11-6

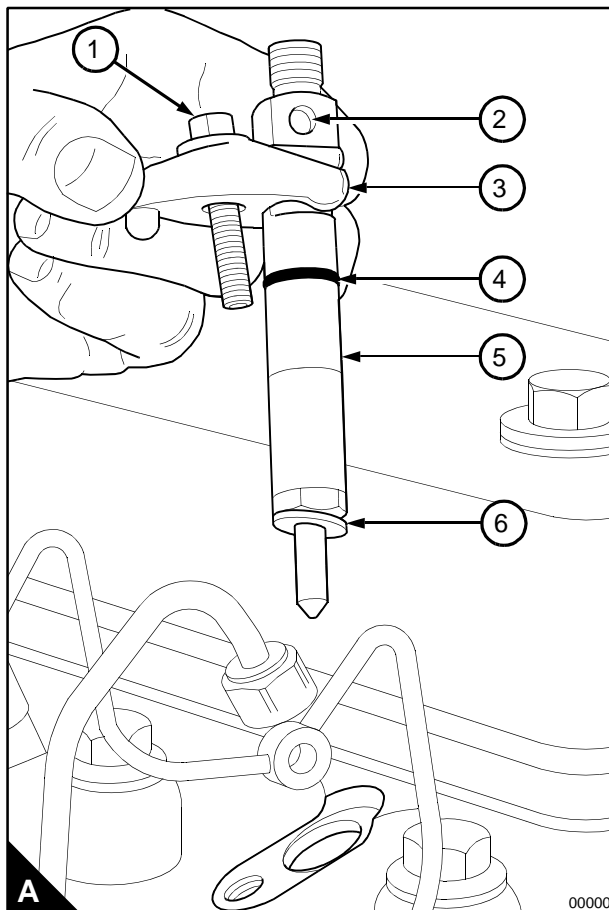
1 Put the new atomiser and seat washer into position with the leak-off connection (A2) towards the rear of the engine. Ensure that the atomiser is not tilted and fit the clamp with the arms of the clamp fitted squarely on the shoulders of the atomiser. Tighten the clamp setscrew to 22 Nm (16 lbf ft) 2,2 kgf m.

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

2 Fit the high-pressure fuel pipe and tighten the union nuts to 27 Nm (20 lbf ft) 2,8 kgf m. If necessary, fit the pipe clamps.

3 Renew the sealing washers and fit the leak-off pipe. Tighten the banjo bolts to 9,5 Nm (7,0 lbf ft) 1,0 kgf m.

4 Operate the engine and check for leakage of fuel and air.

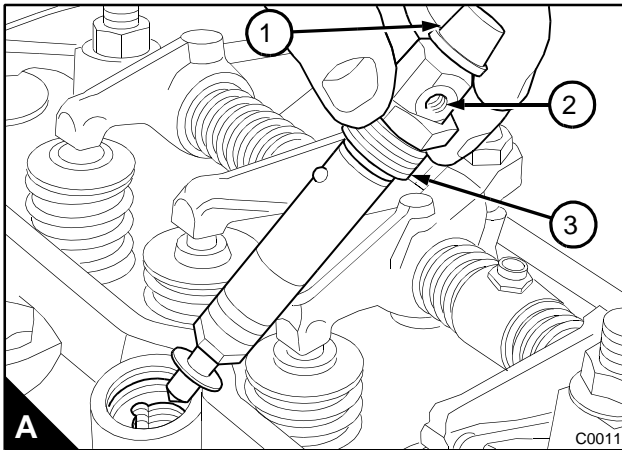


To remove atomisers retained by a gland nut

Operation 11-7

Caution: Do not allow dirt to enter the fuel system. Before a connection is disconnected, clean thoroughly the area around the connection. After a component has been disconnected, fit a suitable cover to all open connections.

- 1 Remove the fuel leak-off pipe from the connection (A2).
- 2 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. Fit a plastic cap (A1) to cover the fuel inlet connection.
- 3 Release the gland nut (A3) and remove the atomiser and its seat washer from the recess in the cylinder head.



To fit atomisers retained by a gland nut

Operation 11-8

Special requirements

Consumable products	
Description	Part number
POWERPART atomiser thread sealant	21820117 or 21820118

1 Thoroughly clean the threads of the gland nut (A3) and the cylinder head.

Caution: Do not allow any thread sealant to get below the gland nut threads.

2 Ensure that the wire clip (A4) is in position. Put a 2 mm (0.08 in) bead of POWERPART atomiser thread sealant onto the first two threads of the gland nut. The bead should extend approximately 6 mm (0.24 in) around each of the threads. Ensure that the sealant does not contact the body of the atomiser.

Caution: Remove and discard the original seat washer (A6). If the original seat washer remains in the recess for the atomiser, the nozzle protrusion will be incorrect when a new seat washer is added.

3 Put the new seat washer (A6) into the seat recess in the cylinder head.

4 Put the atomiser in position, ensure that the location ball (A7) is fitted in the groove (A5) correctly. Carefully engage the threads of the gland nut (A3) with the threads in the cylinder head.

Caution: Do not move the thread after it has been tightened, or the seal that is made when torque has been applied will be broken.

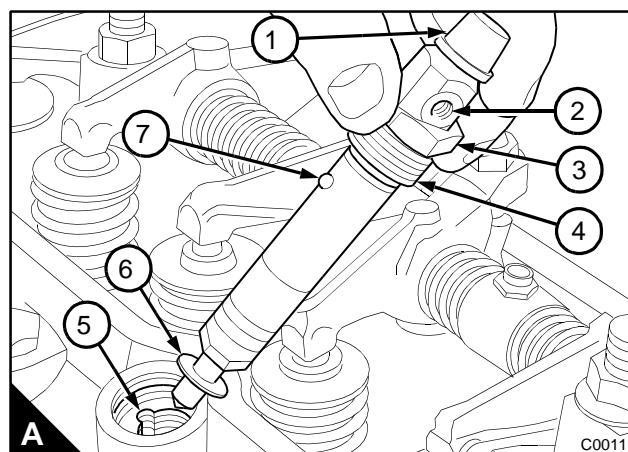
5 Tighten the nut gradually and evenly to 30 Nm (23 lbf ft) 3,0 kgf m. As the nut is tightened the atomiser will rotate clockwise as the ball moves in the slot, this is acceptable. Remove any excess thread sealant.

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

6 Remove the plastic cap (A1) and fit the high-pressure fuel pipe and tighten the union nuts to 27 Nm (20 lbf ft) 2,8 kgf m. If necessary, fit the pipe clamps.

7 Renew the sealing washers and fit the leak-off pipe to the leak off connection (A2). Tighten the banjo bolt to 9,5 Nm (7,0 lbf ft) 1,0 kgf m.

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



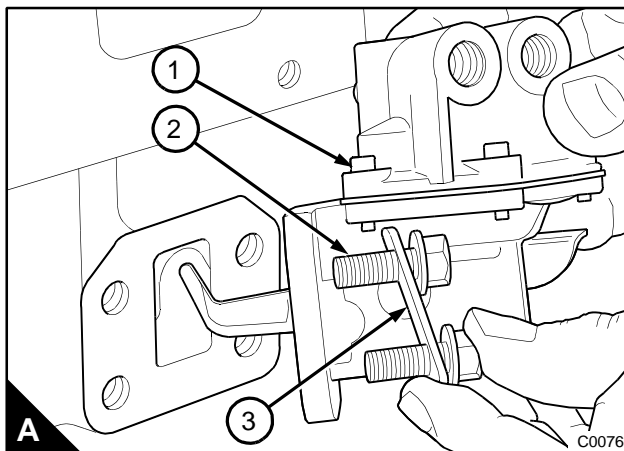
Fuel lift pump

To remove and to fit

Operation 11-9

- 1 Disconnect the fuel pipes from the fuel lift pump.
- 2 Release the setscrews (A2), remove the lock plates (A3) and remove the fuel lift pump (A1). The lift pump may be difficult to remove from the engine. If this occurs the crankshaft must be rotated until the camshaft eccentric, which operates the lift pump, is in a position that will free the rocker lever of the lift pump.
- 3 Ensure that the camshaft eccentric is in the minimum lift position before the lift pump is fitted. Clean the joint face of the lift pump and the cylinder block and fit the lift pump together with a new joint. Fit the lock plates and the setscrews and tighten them gradually and evenly to 22 Nm (16 lbf ft) 2,2 kgf m.
- 4 Connect the fuel pipes.
- 5 Release the vent screw on the fuel filter head and operate the priming lever of the fuel lift pump to eliminate any air between the lift pump and the fuel filter. Operate the lift pump until fuel, free of air, comes from the vent screw. Tighten the vent screw.
- 6 Operate the engine and check for any fuel or air leakage.

Note: Later fuel pumps are mounted on the engine without the locking plate (A3).



To dismantle

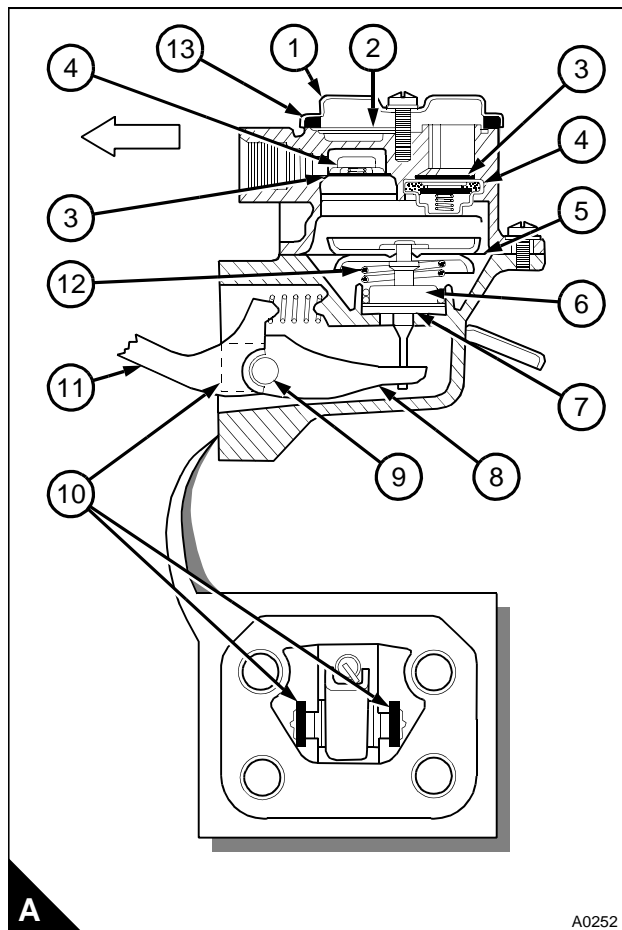
Operation 11-10

- 1 Clean the outside surfaces of the fuel lift pump.
- 2 Make a mark across the flanges of the two halves of the pump to ensure correct relationship when the pump is assembled.
- 3 Remove the cover (A1) and the gauze (A2). Release the setscrews and separate the two halves of the pump.
- 4 Turn the diaphragm assembly (A5) 90° to release the pull rod from the link arm (A8) and remove the diaphragm assembly. Remove the stem seal (A6), the spring seat washer (A7) and the spring (A12) from the pull rod. The diaphragm and pull rod assembly is renewed as an assembly and no service is possible on the diaphragm.
- 5 The valves (A4) are peened in and can be removed with a suitable lever. Some of the peened metal will have to be removed before the valves can be removed.
- 6 To remove the link arm:

Hold the rocker lever (A11) in a vice and hit the body of the lift pump with a soft face hammer to release the two retainers (A10). Be careful not to damage the joint face of the pump body.

Remove the rocker lever, the pin (A9), the link arm and the return spring.

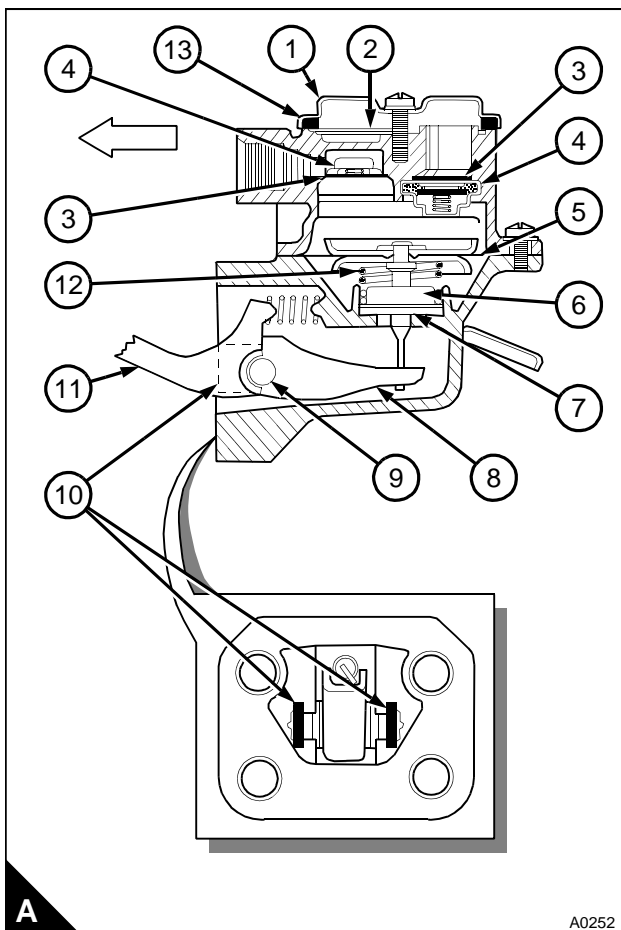
Check the components for wear and other damage.



To assemble

Operation 11-11

- 1 Thoroughly clean the valve housings. Fit new seat washers (A3) and push the new valves (A4) into position. As the valves are the same, but one valve is fitted in reverse of the other, it is possible to fit the valves upside down. To ensure that the valves are fitted correctly, fit them as shown in A. When the valves are correctly fitted, peen the edge of the valve housings in six places, evenly divided, to keep the valves in position.
- 2 Fit the rocker lever (A11), pin (A9) and link arm assembly (A8) into the bottom half of the lift pump. Fit the return spring; ensure that the ends of the spring are in their correct location.
- 3 With a light hammer and a suitable adaptor, fit two new retainers (A10) in their grooves in the casing until they fasten the pin. Peen the open ends of the grooves to fasten the retainers in position.
- 4 Fit the diaphragm spring (A12) into its location under the diaphragm (A5) and put the spring seat washer (A7) and a new stem seal (A6) into position on the pull rod. Ensure that the small diameter at the top of the seal is on the round section of the pull rod.
- 5 Put the diaphragm assembly in position over the lower half of the body with the blade of the pull rod aligned with the slot in the link arm. Press lightly down on the diaphragm until the notch in the pull rod is in the slot in the link arm and turn the diaphragm 90° in either direction. This action will engage and retain the pull rod in the slot of the link arm.
- 6 Push the rocker arm towards the pump body until the diaphragm is level with the body flange and fit the top half of the body in position with the marks on the flanges aligned. Keep the pressure on the rocker arm; fit the spring washers and the screws and tighten them evenly.
- 7 Fit the gauze filter (A2) and the cover (A1), ensure that the rubber seal (A13) is fitted correctly and tighten the screw.



To test

Operation 11-12

- 1** Disconnect the fuel outlet pipe from the fuel lift pump. Fit a 0-70 kPa (0-10 lbf/in²) 0-0,7 kgf/cm² pressure gauge to the outlet of the lift pump. Release the connection at the gauge and operate the priming lever of the lift pump to eliminate air from the pipe. When fuel, free of air, flows from the pipe tighten the connection. Ensure that there are no leaks at the connections between the pump and the gauge.
- 2** Operate the starter motor for 10 seconds with the engine stop control in the stop position or with the stop solenoid disconnected.
- 3** Note the maximum pressure indicated on the gauge. If the pressure indicated is less than the test pressure of 42/70 kPa (6/10 lbf/in²) 0,4/0,7 kgf/m², repair or renew the pump. Also check the rate at which the pressure reduces to half the maximum pressure obtained. If this is less than 30 seconds, repair or renew the pump.
- 4** Remove the gauge and connect the outlet pipe to the lift pump. Release the vent screw on the fuel filter head and operate the priming lever until fuel, free of air, flows from the vent screw. Tighten the vent screw.
- 5** Connect the engine stop solenoid.

Delphi fuel injection pumps

General description

Operation 11-13

Two types of DP200 pump are fitted to the naturally aspirated engines.

Early engines are fitted with locked pumps and the latest engines are fitted with pin-timed pumps. The two types of pump are not interchangeable.

Refer to "Delphi fuel injection pumps" on page 163 for general information.

To remove the Delphi locked pump

Operation 11-14

Special requirements

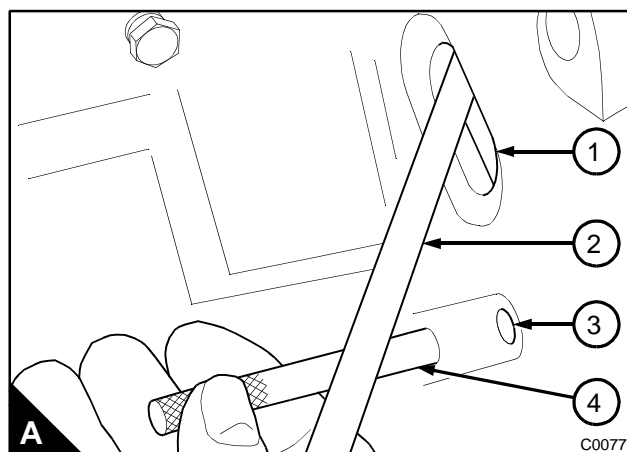
Special tools			
Description	Part number	Description	Part number
Locking pin for the crankshaft	21836001	Adaptors (for use with the gear puller)	21825568
Gear puller	21825565		

Cautions:

- The fuel injection pump is fitted with the engine set at top dead centre (TDC) on the compression stroke of number 1 cylinder. For this reason the crankshaft should be set at TDC before the fuel pump is removed. TDC for number 1 cylinder can be set by use of a locking pin (A4), that is used to lock the flywheel.
- Do not rotate the crankshaft when the fuel pump is not on the engine; the loose fuel pump gear may damage the timing case. If it is necessary to rotate the crankshaft, fit the fuel pump temporarily to ensure that the gear is in the correct position. If the fuel pump is fitted temporarily in order to rotate the crankshaft, the locking screw on the pump must be released.
- Do not rotate the crankshaft when the locking pin is fitted in the flywheel.

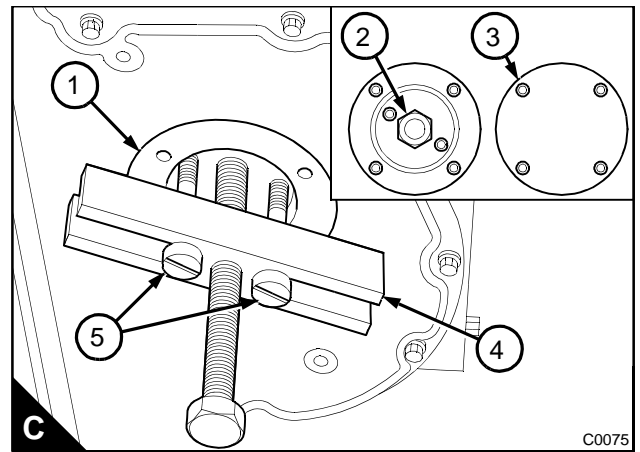
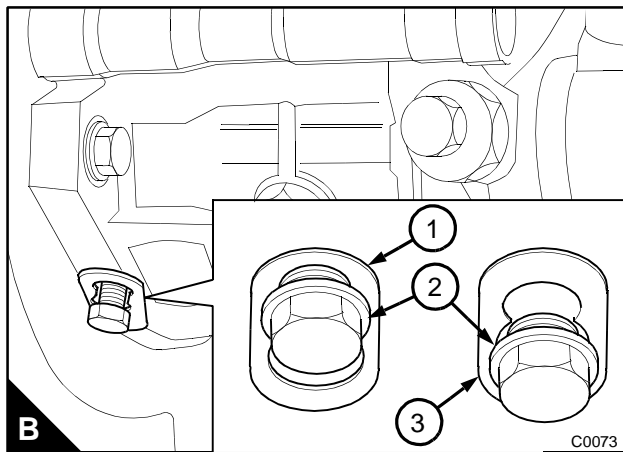
Note: The fuel pump can be removed from the engine and fitted again if:

- The crankshaft is not rotated.
- The drive shaft of the fuel pump is not rotated.
- If the crankshaft is rotated, number 1 cylinder must be set to TDC on the compression stroke, see Operation 8-1.
- If the shaft of the fuel injection pump is rotated, the pump must be timed, see Operation 8-3.



Continued

- 1 Set Number 1 cylinder of the engine to TDC on the compression stroke, see Operation 8-1
- 2 Remove the high pressure and low pressure fuel pipes. Disconnect the connections for the cold start advance unit and the electrical stop solenoid from the fuel pump.
- 3 Release the locking screw (B2) and adjust the spacer (B3) to enable the locking screw to be tightened on the drive shaft of the fuel pump. Tighten the locking screw to 12 Nm (9 lbf ft) 1,2 kgf m. Check that the spacer is free to move. The drive shaft of the fuel pump is now locked.
- 4 Loosen the nuts on the pump flange.
- 5 Release the setscrews and remove the gear cover (C3) from the timing case cover. Release the nut (C2) that retains the drive gear of the pump one to two turns.
- 6 Fit the gear puller (C4), and adaptors (C5) and loosen the gear on the drive shaft of the pump. Remove the puller, nut and spring washer.
- 7 Remove the nuts from the flange of the fuel pump and remove the pump.



To fit the Delphi locked pump

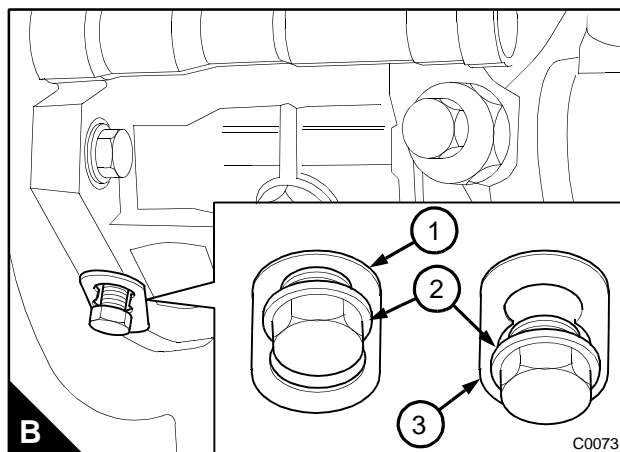
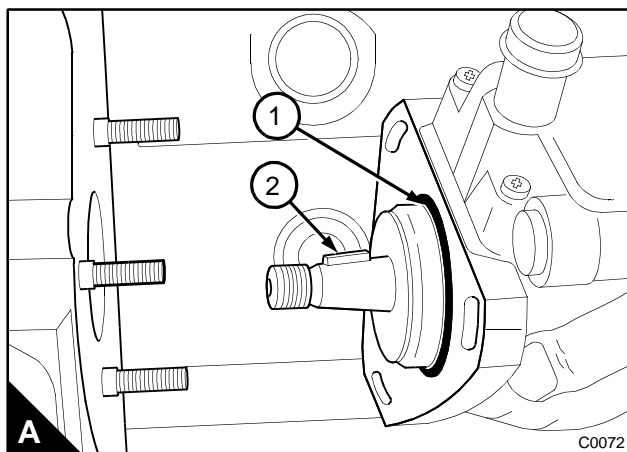
Operation 11-15

Special requirements

Special tools			
Description	Part number	Description	Part number
Locking pin for the crankshaft	21836001	Adaptors (for use with the gear puller)	21825568
Gear puller	21825565		

- 1 Inspect the "O" ring (A1) and, if necessary, fit a new "O" ring.
- 2 Lightly lubricate the "O" ring with clean engine lubricating oil and put the pump into position on the timing case. Ensure that the key (A2) is engaged correctly in the keyway of the drive gear.
- 3 Fit the spring washer and the nut to retain the drive gear. Tighten the nut to approximately 15 Nm (11 lbf ft) 1,5 kgf m.
- 4 Hold the top of the pump toward the engine to remove the backlash and fit the nuts to the pump flange. Tighten them to 22 Nm (16 lbf ft) 2,2 kgf m.
- 5 Release the locking screw (B2) on the fuel pump and adjust the spacer to enable the locking screw to be tightened on the slot of the spacer (B1). Tighten the locking screw on the fuel pump to 12 Nm (9 lbf ft) 1,2 kgf m. Check that the spacer cannot move. The drive shaft of the fuel pump is now free to move.
- 6 Fully tighten the nut for the drive gear to 80Nm(59lbf ft) 8,2 kgf m. Fit the gear cover.
- 7 Fit the fuel pipes, the gland nut atomisers (if fitted), the cables and the electrical connections to the pump.
- 8 Eliminate air from the fuel system, see Operation 11-19.
- 9 Fit the rocker cover, see Operation 3-1.
- 10 Remove the locking pin from the flywheel.
- 11 Operate the engine and check for leakage. With the engine at the normal temperature of operation, check that the idle speed and the maximum no-load speed are correct, see Operation 11-18.

Caution: If the low speed idle adjustment screw or the maximum no-load speed adjustment screw are sealed with locking wire or a plastic tamper proof cap, then the adjustment must be reset by personnel approved by Perkins Engines Company Limited.



To remove the Delphi pin-timed pump

Operation 11-16

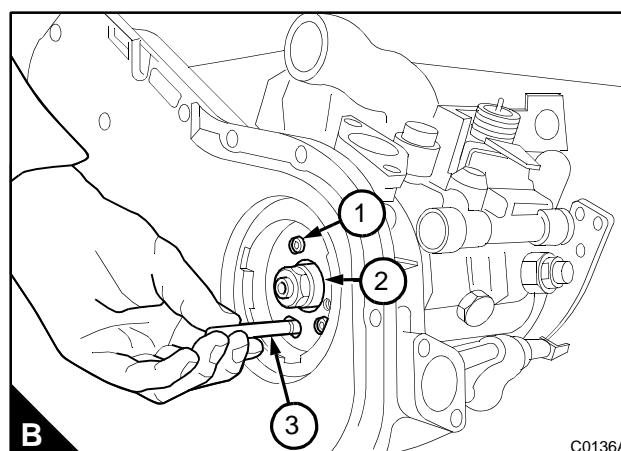
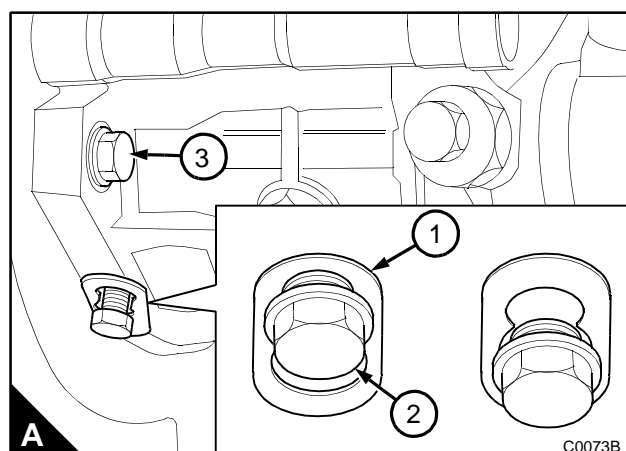
Special requirements

Special tools			
Description	Part number	Description	Part number
Timing pin - Delphi fuel injection pumps	27610033	Locking pin for the crankshaft	21836001

Cautions:

- Disconnect the battery before the fuel injection pump is removed from the engine.
- A new fuel injection pump may be supplied with the pump shaft in the locked position. The drive shaft of the pump must not be turned without the spacer (A1) in position under the locking screw (A2).
- Do not release the nut (B2) from the fuel injection pump. The fuel pump hub is fitted to the shaft in the factory to ensure that the fuel pump is in the correct position for timing. If the hub is removed, the hub will need to be accurately fitted to the pump by use of special equipment available to Perkins distributors.

Before the crankshaft is rotated or the pump is fitted, put the spacer into position under the locking screw (A2) to ensure that the pump drive shaft is released.



Continued

1 Set the engine to TDC with the number 1 cylinder on the compression stroke, see Operation 8-1.

Caution: Use a second spanner to prevent movement of the high-pressure outlet when the union nut for each high-pressure pipe is released.

2 Remove the pipes, the cables and the connections for the cold start advance unit and the electrical stop solenoid from the fuel pump.

Caution: Do not rotate the crankshaft when the pump is not on the engine; the loose fuel pump gear may damage the timing case. If it is necessary to rotate the crankshaft, fit the fuel pump temporarily to ensure that the gear is in the correct position. If the fuel pump is fitted temporarily in order to rotate the crankshaft, the locking screw (C2) must be released and a spacer (C1) fitted.

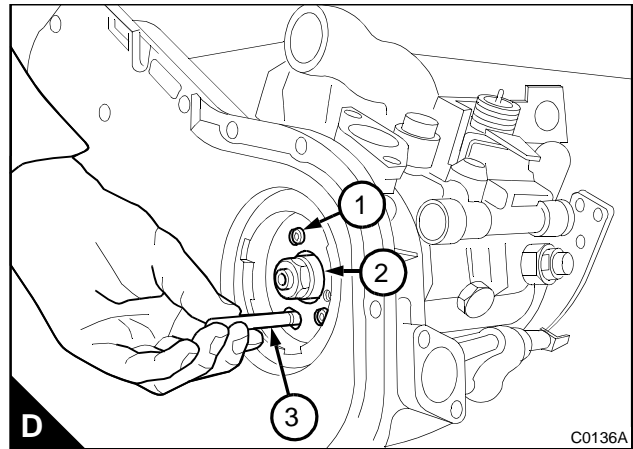
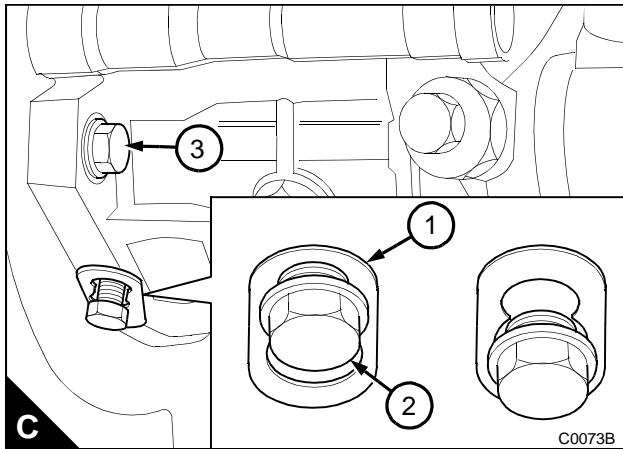
3 Remove the access cover for the fuel injection pump gear.

Caution: Put some lint-free cloth between the face of the fuel pump gear and the timing case to ensure that the gear to hub setscrews (D1) do not drop into the timing case. If this occurs the timing case cover must be removed.

4 Insert the timing pin (D3) through the injection pump gear, and hub into the recess in the pump. This will check that the number one cylinder is at TDC on the compression stroke.

5 Remove the four setscrews (D1) and release the fuel pump gear from the hub of the fuel injection pump.

6 Remove the nuts (C3) from the flange of the fuel pump and withdraw the pump and the timing pin from the fuel pump gear.



To fit the Delphi pin-timed pump

Operation 11-17

Special requirements

Special tools			
Description	Part number	Description	Part number
Timing pin - Delphi fuel injection pumps	27610033	Locking pin for the crankshaft	21836001

Cautions:

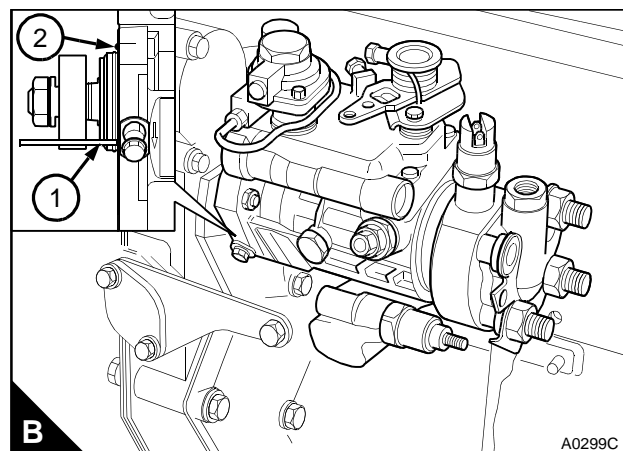
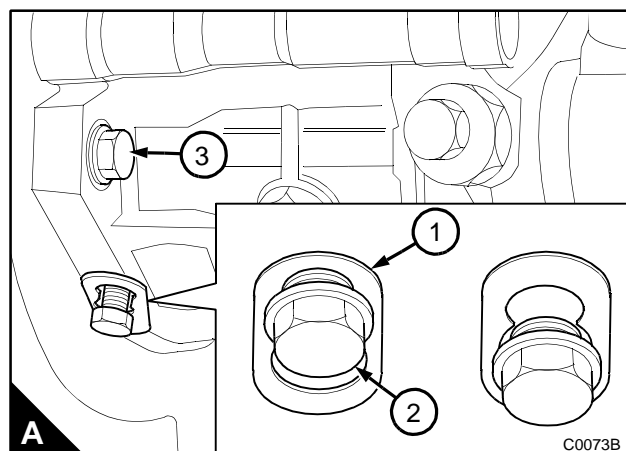
- The engine must be set to TDC number 1 cylinder, compression stroke before the pump is fitted. If the crankshaft needs to be rotated, the pump must be fitted temporarily, or the loose gear could damage the timing case.
- The drive shaft of the pump must not be rotated without the spacer (A1) in position under the locking screw (A2). If the drive shaft is rotated with the locking screw tightened on to the shaft, the drive shaft will be damaged.

1 Inspect the "O" ring (B2) in the pump flange and, if necessary, fit a new "O" ring. Lightly lubricate the "O" ring with clean engine lubricating oil.

2 Insert the 8 mm timing pin (B1) through the slot in the hub, into the pump housing location hole in the fuel injection pump body.

3 Put the fuel pump in position on the three studs in the timing case. At the same time ensure that the timing pin passes through the slot in the drive gear. Take care not to damage the timing pin. Push the pump to the end of its movement. Fit the flange nuts (A3) fully onto the rear face of the timing case.

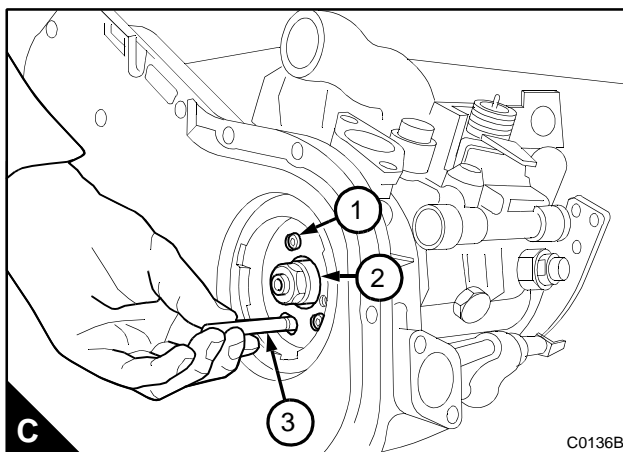
4 Tighten the flange nuts (A3) of the fuel pump to 22 Nm (16 lbf ft) 2,2 kgf m.



Continued

- 5 Put the fuel pump drive gear against the hub of the fuel pump. Fit the setscrews (C1) through the slots in the fuel pump gear into the hub of the fuel pump.
- 6 Apply pressure to the pump drive gear in an counter-clockwise direction to eliminate gear backlash. Fully tighten the setscrews to 28Nm (21 lbf ft) 2,9 kgf m. Remove the timing pin (C3) and fit the access cover for the fuel pump gear.
- 7 Remove the locking pin from the flywheel.
- 8 Fit the setscrew and nut of the support bracket. Ensure that force is not applied to the fuel pump when the support bracket is fitted.
- 9 Fit the high and low pressure pipes.
- 10 Fit the electrical connections to the cold start advance unit and to the electrical stop solenoid.
- 11 Eliminate air from the fuel system, see Operation 11-19.

Caution: Do not remove the nut (C2) from the shaft of the fuel injection pump. The fuel pump hub is fitted to the shaft in the factory to ensure that the fuel pump is in the correct position for timing. If the hub is removed, the hub will need to be accurately fitted to the pump by use of special equipment available to Perkins distributors.

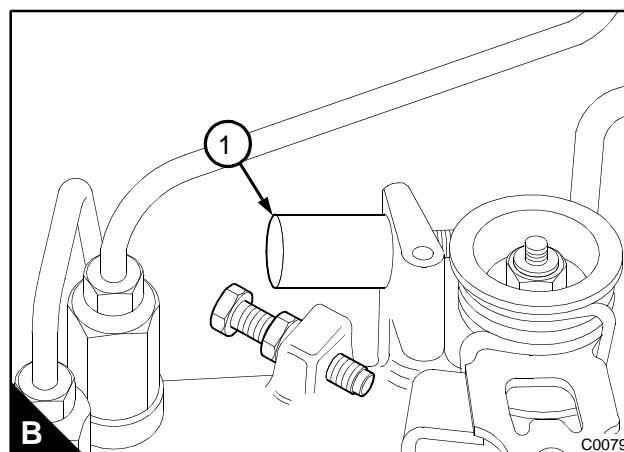
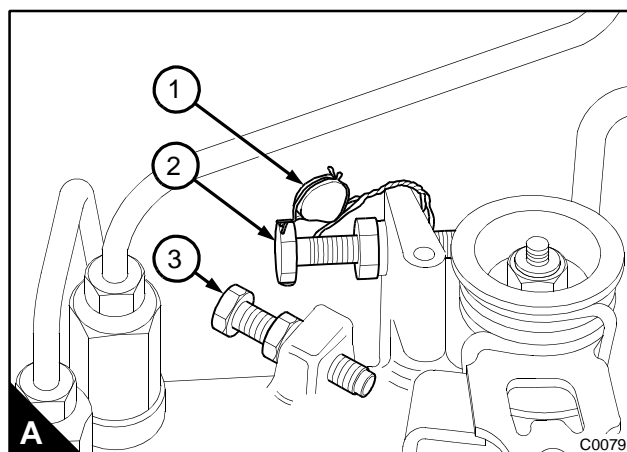


To adjust

Operation 11-18

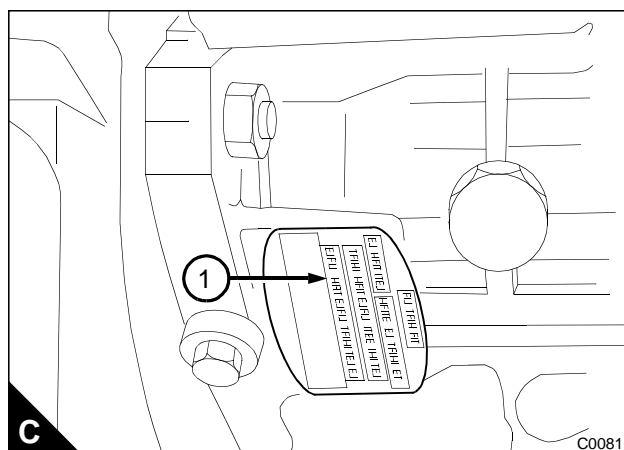
Caution: If the idle speed adjustment screw or the maximum no-load speed adjustment screw are sealed with locking wire (A1) or a plastic tamper proof cap (B1), then the adjustment must be reset by personnel authorised by Perkins Engines Company Limited.

- 1 Operate the engine until it reaches its normal temperature of operation and check the idle speed. If necessary, adjustment can be made by the adjustment screw (A3).
- 2 Release the lock nut and rotate the adjustment screw clockwise to increase the speed or counter-clockwise to decrease the speed. When the speed is correct, tighten the lock nut. Normally the correct speed is given in the manufacturer's handbook for the application. If it is not given, apply to your nearest Perkins distributor, or to Technical Services Department, Perkins Engines Company Limited, Peterborough, England.



Caution: The setting for the maximum no-load speed can change for different applications. Always check the fuel injection pump data plate (C) before an adjustment is made to the maximum no-load speed.

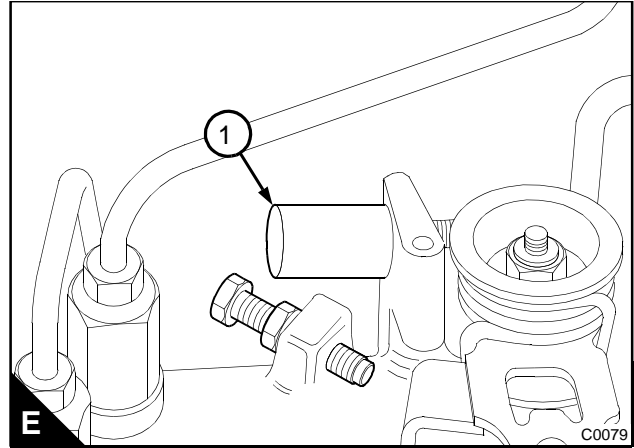
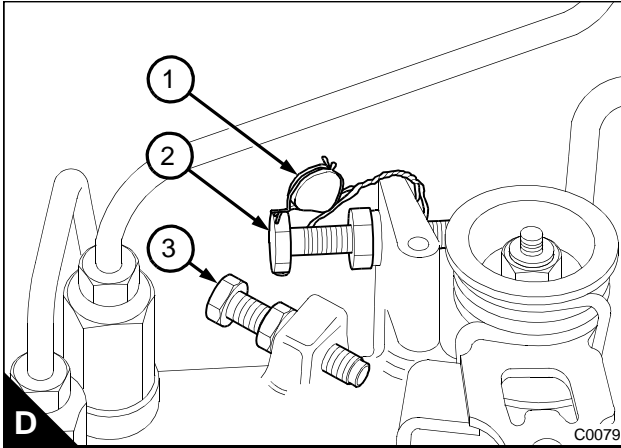
- 3 With the engine at its normal temperature of operation, check the maximum no-load speed.
 - 4 The maximum no-load speed is indicated by the last part of the setting code for the fuel injection pump. The setting code can be found on the data plate (C1) on the side of the fuel pump.
- A typical setting code is 2644-----AN/2/1890. In this example, the maximum no-load speed is 1890 rev/min. If necessary, this speed can be adjusted by the adjustment screw (A2).



Continued

5 Release the lock nut and rotate the adjustment screw counter-clockwise to increase, or clockwise to decrease, the speed. When the speed is correct, tighten the lock nut and seal the screw. The person who fits the pump must ensure that the adjustment screw is suitably sealed (D1) against interference after it has been set initially. On pin-timed pumps a plastic cap (E1) is fitted on the maximum speed adjustment screw after initial setting to prevent interference. This can only be reset by authorised Perkins personnel.

6 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.



To eliminate air from the fuel system

Operation 11-19

If air enters the fuel system, it must be removed before the engine can be started.

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.

In order to eliminate air from the fuel system, proceed as follows:

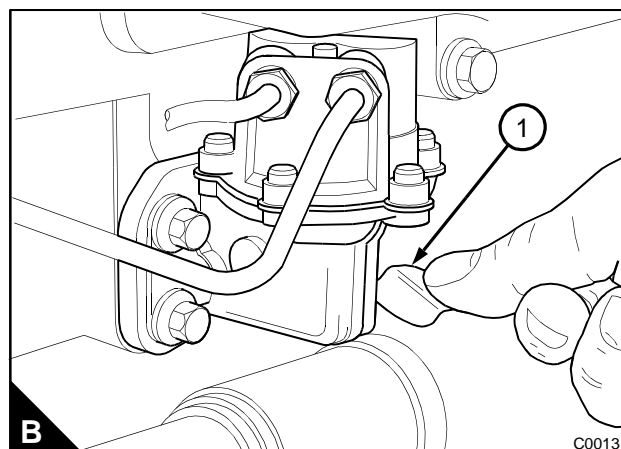
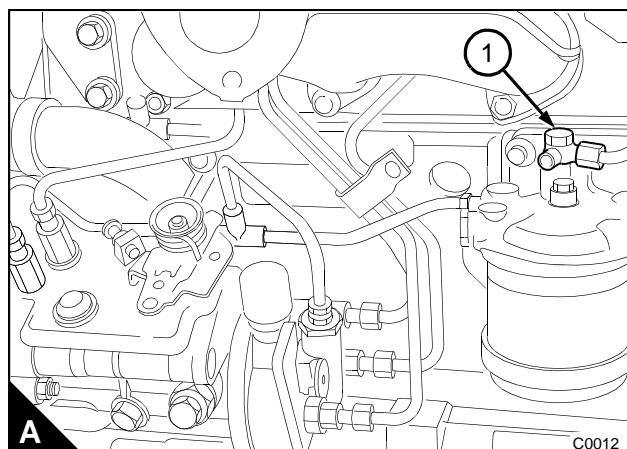
Vent screws are not fitted to the fuel injection pump. Air will usually be removed from the fuel pump automatically.

Caution: If the fuel system is empty or if the canister(s) of the fuel filter have been renewed, it will be necessary to eliminate air from the fuel system, especially the fuel injection pump.

1 Loosen the vent plug on the filter head of the pre-filter (if fitted). Operate the priming lever of the fuel lift pump (B) until fuel, free of air, comes from the banjo bolt. Tighten the banjo bolt.

Note: If the drive cam of the fuel lift pump is at the point of maximum lift, it will not be possible to operate the priming lever. In this situation, the crankshaft must be rotated one revolution.

2 Loosen the banjo bolt (A1) on the top of the filter head. Operate the priming lever of the fuel lift pump until fuel, free of air, comes from the banjo bolt. Tighten the banjo bolt.

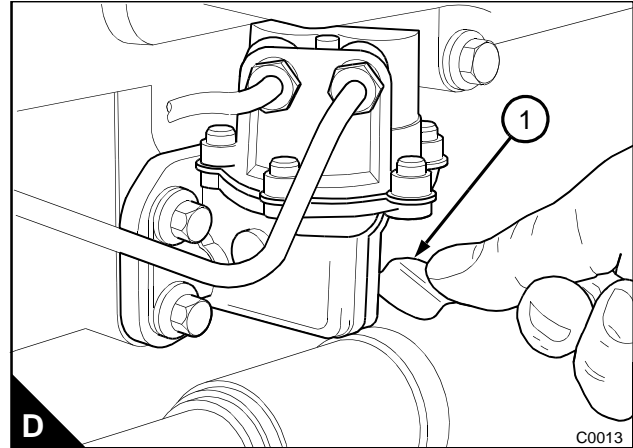
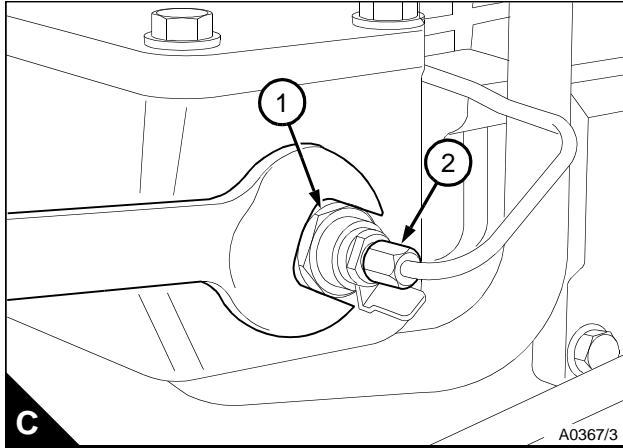


Continued

Caution: Use a spanner to prevent movement of the fuelled starting aid (C1) when the union nut (C2) is loosened or tightened.

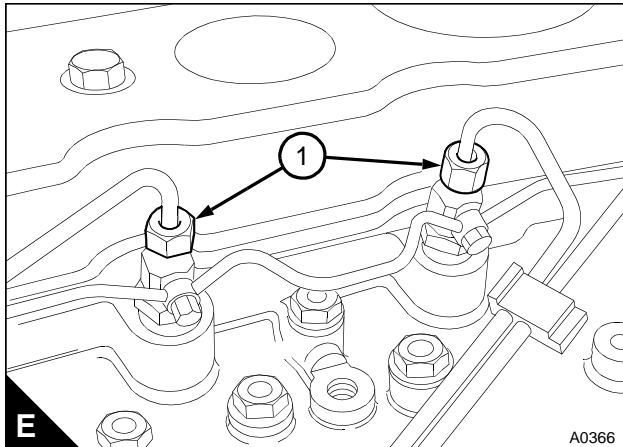
3 Loosen the union nut (C2) at the fuelled starting aid and operate the priming lever of the fuel lift pump (D1) until fuel, free of air, comes from the connection. Tighten the union nut at the starting aid.

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



4 Loosen the high-pressure connections at two of the atomisers (E1).

Caution: Damage to the fuel injection pump, battery and starter motor can occur if the starter motor is used excessively to eliminate air from the fuel system.



5 Put the electrical system switch to the "ON" position. Ensure that the manual stop control, if one is fitted, is in the "RUN" position. Operate the starter motor until fuel, free from air, comes from the high-pressure pipe connections. Tighten the high-pressure pipe connections to 22 Nm (16 lbf ft) 2,2 kgf m. Return the switch to the "OFF" position.

6 The engine is now ready to start.

Caution: Operate the engine at low idle speed for a minimum of five minutes immediately after air has been removed from the fuel system. This will ensure that the pump is free of air and prevent any damage to the pumps internal parts by metal to metal contact.

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.

Stanadyne fuel injection pump

General description

Caution: Do not release the nut (A2) from the fuel injection pump. Illustration (A) shows the nut in position when the fuel pump is fitted to the engine. The fuel pump hub is fitted to the shaft in the factory to ensure that the fuel pump is in the correct position for timing. If the nut is removed and the hub moves, the hub will need to be accurately fitted to the pump by use of specialist equipment before the pump can be fitted to the engine.

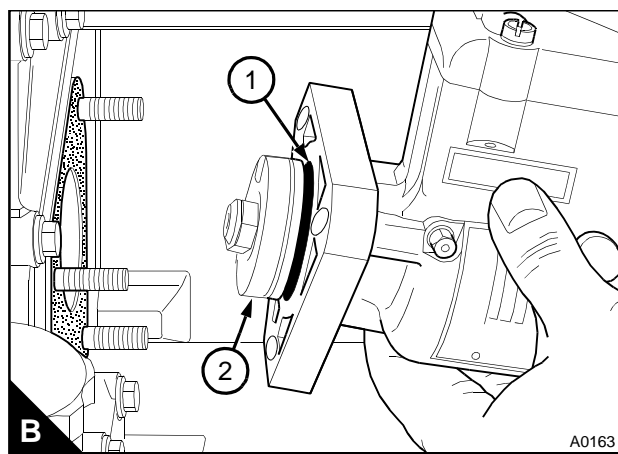
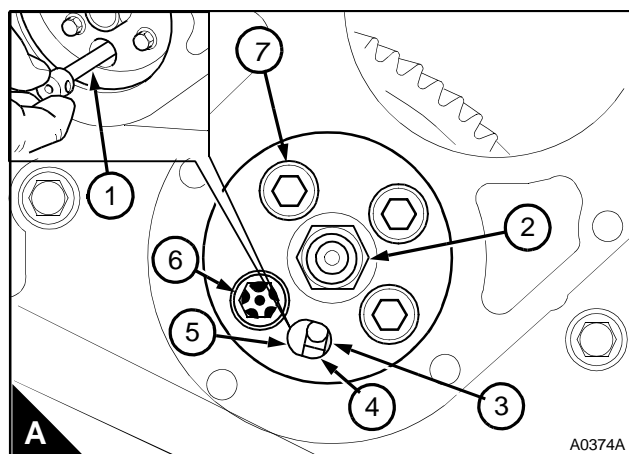
Note: If your engine has an emissions label, the pump will be supplied at a preset engine speed.

The manufacturer fits the hub (B2) to the drive shaft of the pump to ensure very accurate timing. Engines that have this arrangement have the drive gear fastened to the hub instead of to the shaft of the pump. The rubber seal (B1) has a square cross-section, if it is damaged it must be replaced.

To prevent adjustment to the engine timing, by rotation of the fuel pump, the mounting flange has holes instead of slots.

Accurate timing of the pump to the engine is by a pin (A1) used to align the fuel pump gear and the hub (A4), with a hole in the body (A3) of the fuel pump. The gear is passed over the pin and fastened to the hub with four fasteners (A6).

Note: On the latest engines, the fuel pump gear is now retained by one torx screw (A6) and three Allen screws (A7). The torque for all four fasteners is 27 Nm (20 lbf ft) 2,8 kgf m. A special tool to remove the torx screw is available at your Perkins distributor.



To remove

Operation 11-20

Special requirements

Special tools			
Description	Part number	Description	Part number
Timing pin - Stanadyne fuel injection pumps	27610033	Tool - Fuel pump drive gear retaining torx screw	27610122

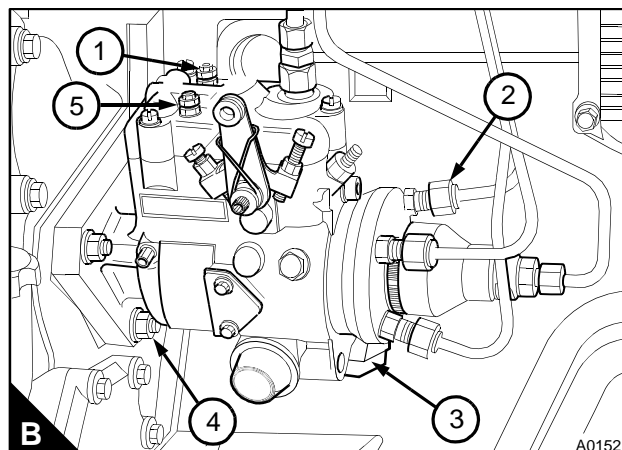
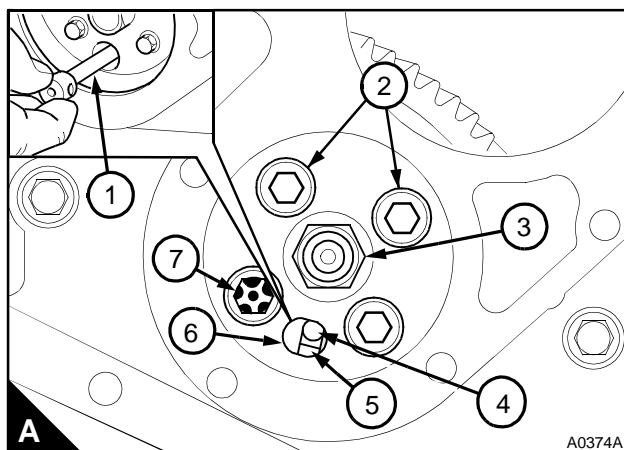
- 1 Disconnect the battery before the fuel injection pump is removed from the engine.
- 2 Set the engine to TDC with the number 1 cylinder on the compression stroke, see Operation 8-1
- 3 Remove the gear cover from the cover of the timing case.
- 4 Insert the timing pin (A1) through the hole (A6) in the fuel pump gear and the slot of the hub (A5). Push the pin fully into the hole (A4) in the body of the fuel pump. If the pin can be fully inserted then the pump timing is correct. There should be no resistance when the pin is inserted.

Cautions:

- Use a second spanner to prevent movement of the high-pressure outlet when the union nut (B2) for each high-pressure pipe is released.
 - Ensure that the position of the earth connection (B1) and the electrical supply connection (B5) for the electrical stop solenoid on top of the governor housing are connected correctly.
- 5 Remove the high and low pressure pipes. Disconnect the connections for the cold start advance unit (B3), and the electrical stop solenoid (B1)(B5) from the fuel pump. Disconnect the control rod

Caution: Put some lint-free cloth between the face of the fuel pump gear and the timing case to ensure that the gear to hub fasteners (A2)(A7) do not fall into the timing case. If this occurs the timing case cover must be removed.

- 6 Remove the torx screw (A7) and the three Allen screws (A2). Release the fuel pump gear from the hub of the fuel injection pump.
- 7 Remove the nuts (B4) from the flange of the fuel pump and remove the pump. Do not damage the timing pin when the pump is removed.



To fit

Operation 11-21

Special requirements

Special tools			
Description	Part number	Description	Part number
Timing pin - Stanadyne fuel injection pumps	27610033	Tool - Fuel pump drive gear retaining torx screw	27610122

Caution: The engine must be set to TDC number 1 cylinder, compression stroke before the pump is fitted. If the crankshaft needs to be rotated, the pump must be fitted temporarily, or the loose gear could damage the timing case.

1 Fit a new joint (A1) to the timing case. Fit a new "O" ring (A2) to the fuel pump. DB4 fuel pumps are fitted with a rubber seal that have a square section instead of a round section. When a rubber seal is fitted it is not necessary to fit a new joint.

2 Lightly lubricate the "O" ring with clean engine lubricating oil and put the pump into position on the timing case.

3 Put the fuel pump in position on the three studs of the timing case and fit the flange nuts.

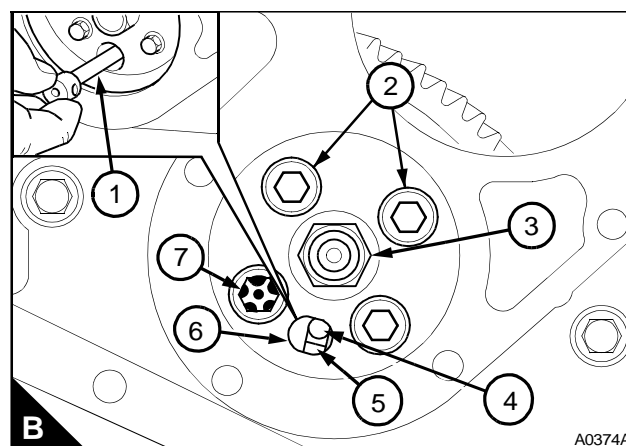
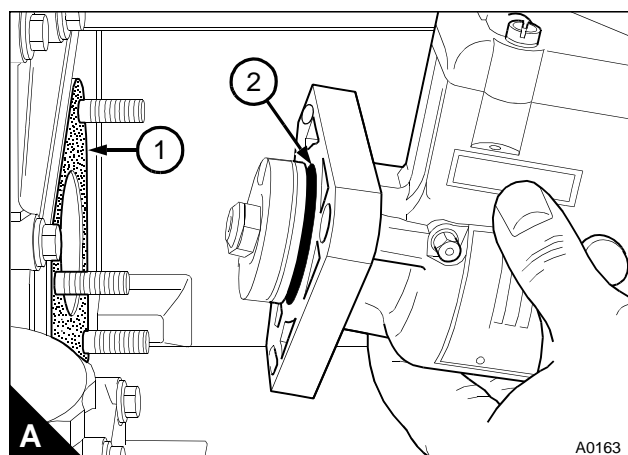
4 Tighten the flange nuts of the fuel pump to 19 Nm (14 lbf ft) 1,94 kgf m.

Caution: Do not remove the nut (B3) from the shaft of the fuel injection pump. The fuel pump hub is fitted to the shaft in the factory to ensure that the fuel pump is in the correct position for timing. If the hub is removed, the hub will need to be accurately fitted to the pump by use of special equipment available to Perkins distributors.

5 Put the fuel pump gear onto the hub of the fuel pump. The torx screw (B7) and the three Allen screws (B2) for the fuel pump gear should be in the centre of the slots to allow for the removal of the backlash. Tighten the setscrews finger tight.

Note: The fuel pump gear in the timing case will only fit in one position. The gear is fitted with the letters C and M at the front when in mesh.

6 Insert the timing pin (B1) through the hole (B6) of the fuel pump gear and the slot of the hub (B5) until it can be pushed fully into the hole (B4) in the body of the fuel pump. If the timing pin cannot be pushed into the pump body, check that the engine is correctly set at TDC on the number 1 cylinder, see Operation 8-1.



Continued

Caution: The fuel pump gear must be fitted to the engine before the crankshaft is rotated.

7 Carefully turn the gear counter-clockwise, by hand (C1), to remove the backlash between the idler gear and the fuel pump gear. Do not rotate the crankshaft or the fuel pump shaft. Tighten the setscrews for the fuel pump gear to 27 Nm (20 lbf ft) 2,8 kgf m.

8 Remove the timing pin.

9 Fit the gear cover to the cover of the timing case.

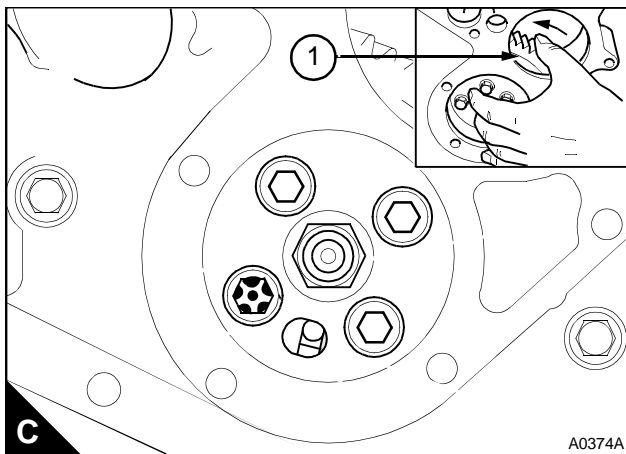
Caution: Do not tighten the union nuts of the high-pressure pipes more than the recommended torque tension. If there is a leakage from the union nut, ensure that the pipe is correctly aligned with the atomiser inlet. Do not tighten the atomiser union nut more, as this can cause a restriction at the end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

10 Fit all of the pipes. Connect the control rod of the fuel injection pump. Fit the cables and connection for the cold start advance unit and electrical stop solenoid to the pump. Ensure that a spanner is used to prevent movement of the pump outlets when the high-pressure pipes are fitted and tighten the union nuts to 27 Nm (20 lbf ft) 2,8 kgf m.

11 Eliminate air from the fuel system, see Operation 11-22.

12 Fit the cylinder head rocker cover.

13 Operate the engine and check for leakage with the engine at the normal temperature of operation.



To eliminate air from the fuel system

Operation 11-22

If air enters the fuel system, it must be removed before the engine can be started.

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.

In order to eliminate air from the fuel system, proceed as follows:

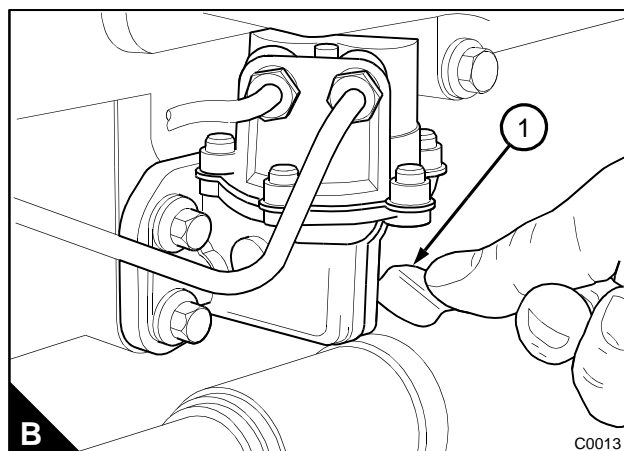
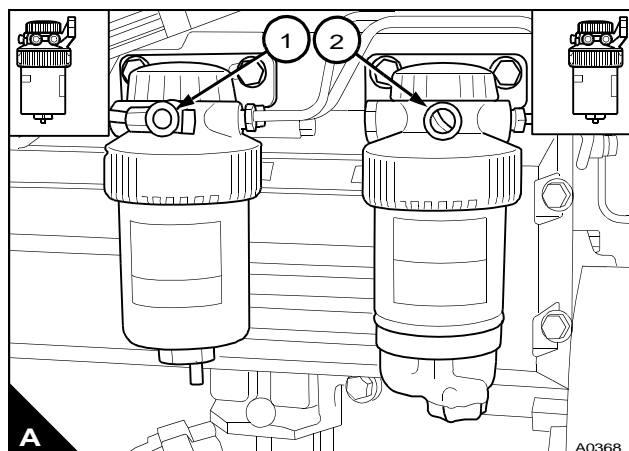
Vent screws are not fitted to the fuel injection pump. Air will usually be removed from the fuel pump automatically.

Caution: If the fuel system is empty or if the canister(s) of the fuel filter have been renewed, it will be necessary to eliminate air from the fuel system, especially the fuel injection pump.

1 Loosen the vent plug on the filter head of the pre-filter (A2). Operate the priming lever of the fuel lift pump (B1) until fuel, free of air, comes from the vent plug. Tighten the vent plug.

Note: If the drive cam of the fuel lift pump is at the point of maximum lift, it will not be possible to operate the priming lever. In this situation, the crankshaft must be rotated one revolution.

2 Loosen the vent plug (A1) on the top of the filter head. Operate the priming lever (B1) of the fuel lift pump until fuel, free of air, comes from the vent plug. Tighten the vent plug.



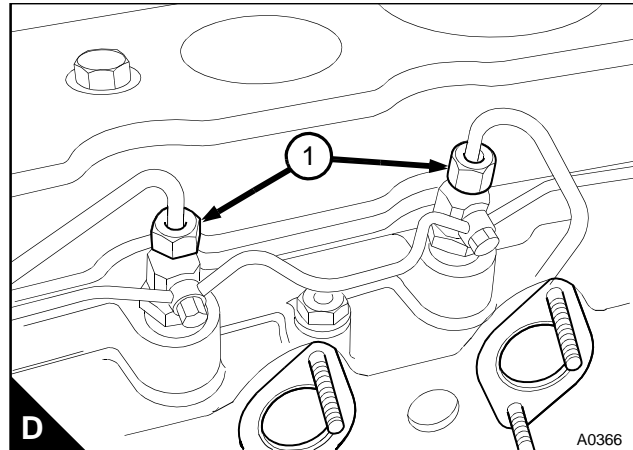
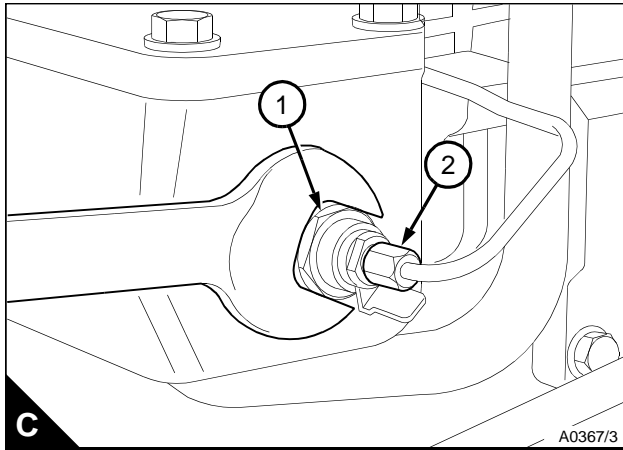
Continued

Caution: Use a spanner to prevent movement of the fuelled starting aid (C1) when the union nut (C2) is loosened or tightened.

3 Loosen the union nut (C2) at the fuelled starting aid and operate the priming lever of the fuel lift pump until fuel, free of air, comes from the connection. Tighten the union nut at the starting aid.

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

4 Loosen the high-pressure connections at two of the atomisers (D1).



Caution: Damage to the fuel injection pump, battery and starter motor can occur if the starter motor is used excessively to eliminate air from the fuel system.

5 Put the electrical system switch to the "ON" position. Ensure that the manual stop control, if one is fitted, is in the "RUN" position. Operate the starter motor until fuel, free from air, comes from the pipe connections. Tighten the high-pressure pipe connections to 27 Nm (20 lbf ft) 2,8 kgf m. Return the switch to the "OFF" position.

6 The engine is now ready to start.

Caution: Operate the engine at low idle speed for a minimum of five minutes immediately after air has been removed from the fuel system. This will ensure that the pump is free of air and prevent any damage to the pumps internal parts by metal to metal contact.

Note: 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.

12

Cooling system

General information

Note: Refer to the "Cooling system flow diagram" on page 196 for illustration references.

Coolant (A4) from the bottom of the radiator passes through the centrifugal coolant pump, which is fitted onto the front of the timing case to assist the flow of the coolant through the system.

The pump is driven by a "V" belt from the crankshaft pulley.

From the pump, the coolant passes through a rubber hose to a passage in the left side of the cylinder block and to the inlet of the cassette type oil cooler. The coolant passes through the oil cooler and is returned to the inlet side of the centrifugal coolant pump.

The coolant (A6) passes from the passage to the cylinder block through two holes in the cylinder block casting.

The coolant then passes around the cylinders and up into the cylinder head through a series of large holes. A small hole at the rear of the cylinder block ensures that there are no air pockets.

The coolant leaves the cylinder head at the front and passes through a short hose into the thermostat housing. When the engine is cold the thermostat is fully closed (A1) and the coolant (A5) goes directly through a by-pass valve in the thermostat to the inlet side of the coolant pump.

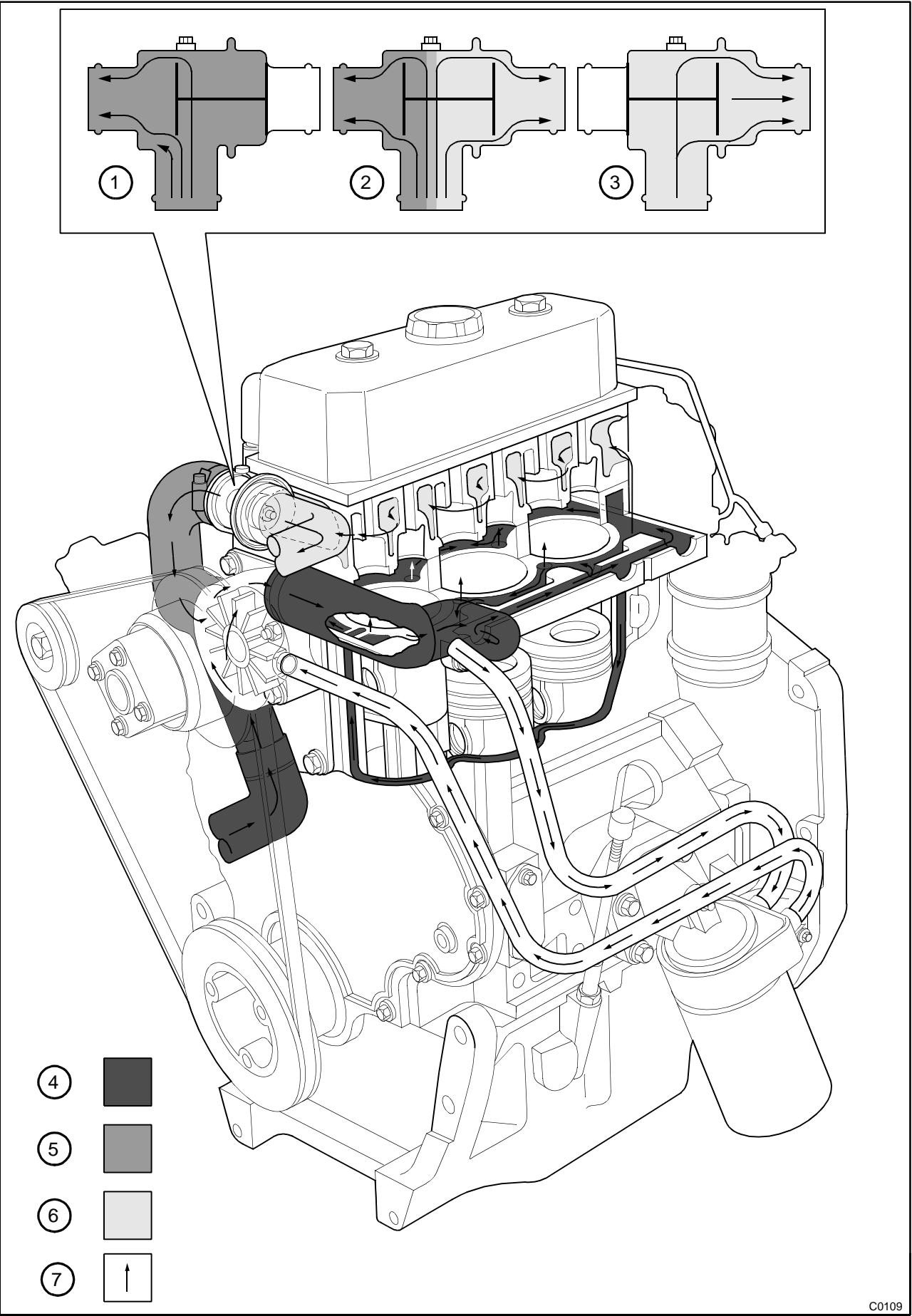
As the engine warms up the thermostat begins to open (A2) and some of the coolant flows to the top of the radiator.

The thermostat will open fully (A3) when the engine reaches the normal temperature of operation. When the thermostat is open (A3), the by-pass valve is closed and the coolant passes to the top of the radiator.

The thermostat maintains the correct engine temperature by a balance of by-pass flow and full flow to the top of the radiator.

Air passes over the radiator fins and heat is removed from the coolant as it passes through the radiator. The coolant leaves the radiator through the bottom hose and returns to the coolant pump.

Cooling system flow diagram



C0109

Thermostat

The thermostat is held in a sealed brass or sealed plastic housing, and held in position by three hoses: the top radiator inlet hose, the by-pass hose to the coolant pump and the outlet hose from the cylinder head. The thermostat housing can be fitted in the horizontal position (A) or the vertical position (B) in accordance with the engine application.

If the thermostat does not operate correctly the complete assembly must be renewed.

To remove and to fit

Operation 12-1

To remove

- 1 Drain the cooling system until the coolant level is below the thermostat position.
- 2 Release the clips of the three thermostat hose connections. Remove the thermostat unit from the hoses.

To fit

- 1 Ensure that the hose connections are clean and that the jiggle pin fitted inside the thermostat valve is free to move.

Caution: The flange (A2) or (B1) on the brass thermostat housing must be toward the radiator connection when the thermostat is fitted. If the assembly is fitted incorrectly, the engine will overheat as the flow of coolant will not pass through the radiator.

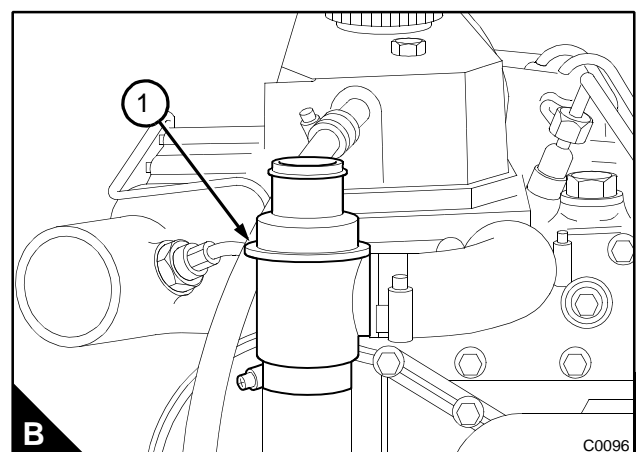
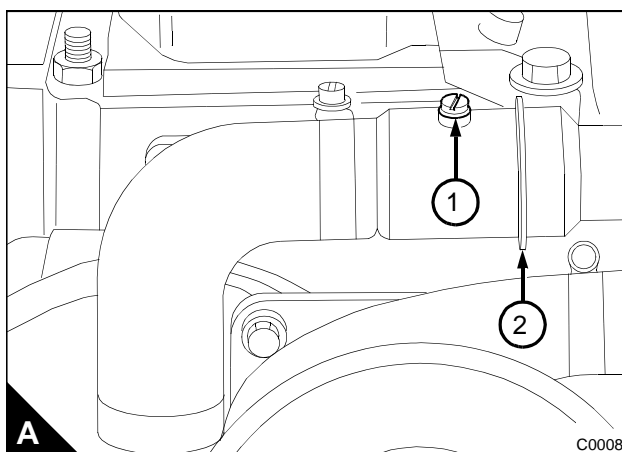
- 2 Put the new brass thermostat into position on the three hoses, if the brass thermostat is fitted horizontally (A), ensure that the vent screw (A1) is at the top. If the thermostat is fitted in the vertical position (B), ensure that the flange on the thermostat body is at the top (B1) and is connected to the radiator hose.

Caution: If the brass thermostat is fitted horizontally, it is important to eliminate air from the cooling system when it is filled. Ensure that the vent screw (A1) is released until it tightens. When coolant, free from air flows from the vent point, tighten the vent screw to 3-4 Nm (2-3 lb ft).

- 3 If a plastic thermostat is fitted, connect the radiator, engine and the pump hoses to the correct outlets, identified by the arrows on the thermostat body

Note: if a plastic thermostat is fitted, it is not necessary to eliminate air from the thermostat housing as no vent screws are fitted

- 4 Tighten the three hose clips.
- 5 Fill the cooling system, see Operation 12-3



To test

Operation 12-2

Caution: *If the thermostat does not operate correctly, it must be renewed. Do not try to adjust the settings.*

- 1 Hang the thermostat unit in a suitable container filled with coolant.
- 2 Heat the coolant gradually. Use a thermometer to check the temperature at which the valve starts to open and the temperature at which it is fully open. The correct temperature is given in the relevant Data and dimensions for the "Thermostat" on page 26.

How to fill the cooling system

To fill and vent the system

Operation 12-3

Warning! Do not remove the filler cap of the cooling system while the engine is still hot and the system is under pressure because dangerous hot coolant can be discharged.

Caution: See "Coolant specification" in Chapter 5 of the User's handbook for details of the correct coolant to be used in the cooling system. If coolant is to be added to the system during service, it must consist of the same original mixture as used to fill the system. The engine must be allowed to cool before coolant is added.

Note: In order to eliminate air from the system, the coolant must be added very slowly.

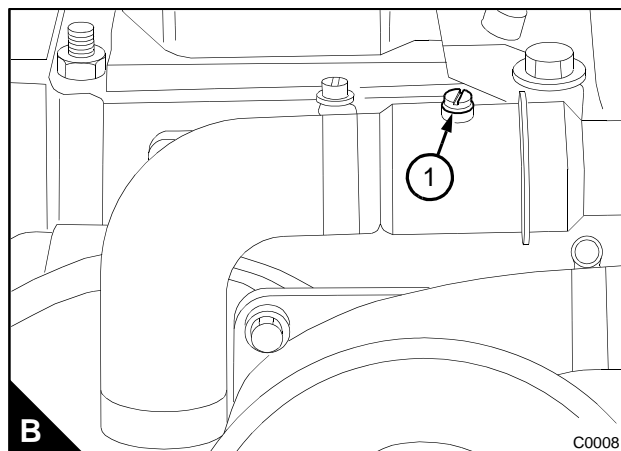
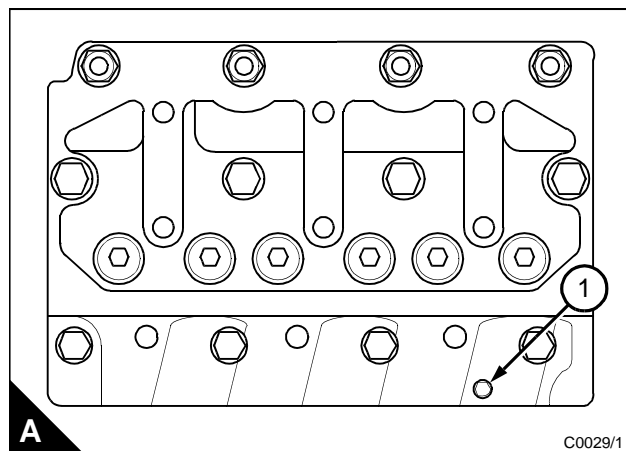
- 1 Remove carefully the filler cap of the cooling system.
- 2 Fill the cooling system until coolant reaches the bottom of the filler tube.
- 3 If a vent screw (A1) is fitted in the cylinder head, loosen the vent screw.

Note: Early cylinder heads did not have vent screws fitted

- 4 When coolant, free from air, flows from the vent point, tighten the vent screw in the cylinder head.
- 5 Eliminate air from the thermostat, if necessary:

If a brass thermostat assembly is fitted horizontally as shown in (B), loosen the vent screw (B1) on top of the thermostat assembly until just it tightens.

- 6 When coolant, free from air flows from the vent point, tighten the vent screw in the thermostat assembly.



Notes:

- It will not be necessary to eliminate air from the thermostat assembly if:
- The brass thermostat assembly is fitted vertically.
- If a plastic thermostat assembly is fitted.

7 Remove carefully, the filler cap and add coolant until the level of the coolant reaches the bottom of the filler tube. Fit the filler cap.

8 Start the engine. Allow the engine to operate at 1750 rev/min. for two minutes. Stop the engine and allow it to cool.

9 Repeat steps 3, 4, 5, 6 and 7.

10 Start the engine. Allow the engine to operate at a fast idle until the engine reaches its normal temperature of operation. Stop the engine and allow it to cool.

11 Repeat steps 3, 4, 5, 6 and 7 until all the air is eliminated from the cooling system.

Coolant pump

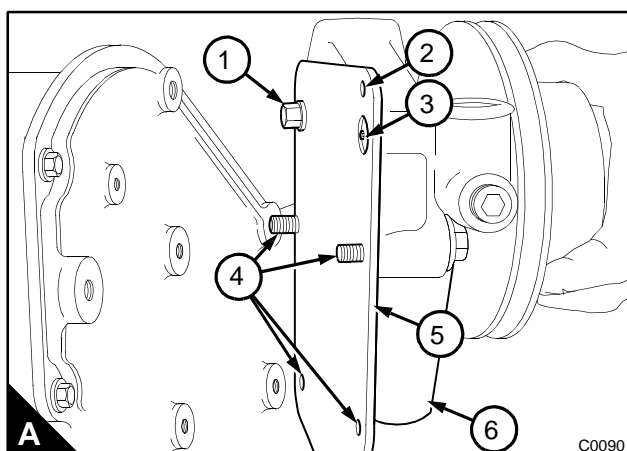
To remove

Operation 12-4

Note: A small amount of leakage of coolant across the surface of the face seal in the coolant pump is normal. Its purpose is to provide lubrication for the seal. There is a hole in the water pump body to allow coolant to drain. Small amounts of coolant might be seen to leak intermittently from the drain hole during the engine operation cycle. Signs of a small leakage through the drain hole are not an indication that the pump is faulty. Coolant stains or intermittent drops of coolant from the hole, indicate normal operation of the pump.

- 1 Remove the fan, see Operation 12-8.
- 2 Remove the fan belt, see Operation 14-3.
- 3 Disconnect the hose connections of the coolant pump.
- 4 Remove the four flange head setscrews from the pump pulley and remove the pulley from the hub.
- 5 Remove the five setscrews (A4) and (A2) that secure the pump to the timing case and remove the pump from the engine.
- 6 If it is necessary to remove the adaptor plate (A5) from the pump body (A6) release the nut and bolt (A1) and the Allen screw (A3).

Note: If the pump is to be dismantled, it will be necessary to use an extractor to remove the pulley hub from the pump shaft.



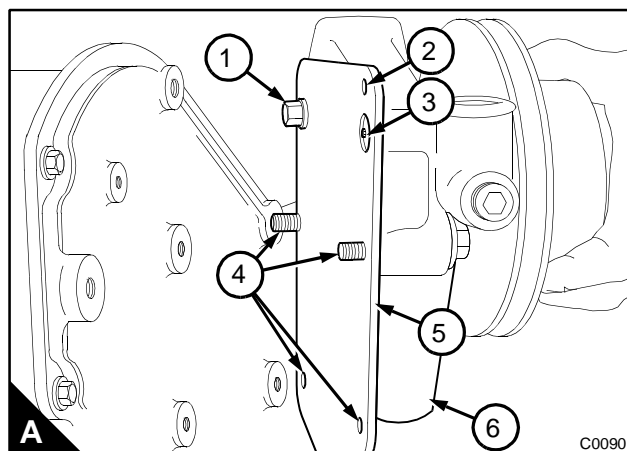
To fit

Operation 12-5

Special requirements

Consumable products			
Description	Part number	Description	Part number
POWERPART Thread lock (pipe)	27610033	POWERPART Jointing compound	27610122

- 1 If the adaptor plate (A5) has been removed, thoroughly clean the joint faces of the adaptor plate (A5) and the coolant pump body (A6). Apply a narrow bead of POWERPART jointing compound to the joint face of the coolant pump. Fit a new joint between the adaptor plate and the coolant pump body. Fit the adaptor plate. Remove the excess jointing compound.
- 2 Fit the nut and bolt (A1) and tighten the nut to 44 Nm (33 lbf ft) 4,5 kgf m. Tighten the Allen screw (A3).
- 3 Thoroughly clean the mounting faces of the timing case and the rear of the adaptor plate.
- 4 Apply POWERPART Thread lock (pipe) to the first three threads of the four setscrews (A4). Put them into their positions in the pump body and the adaptor plate.
- 5 Fit the coolant pump to the timing case and tighten the five setscrews to 44 Nm (33 lbf ft) 4,5 kgf m.
- 6 Put the pulley onto the hub of the pump shaft and tighten the four M8 setscrews to 22 Nm (16 lbf ft) 2,2 kgf m to secure the pulley to the hub.
- 7 Connect the hoses to the coolant pump and tighten the clips.
- 8 Fit the fan belt, see Operation 14-3.
- 9 Fit the fan, see Operation 12-8.



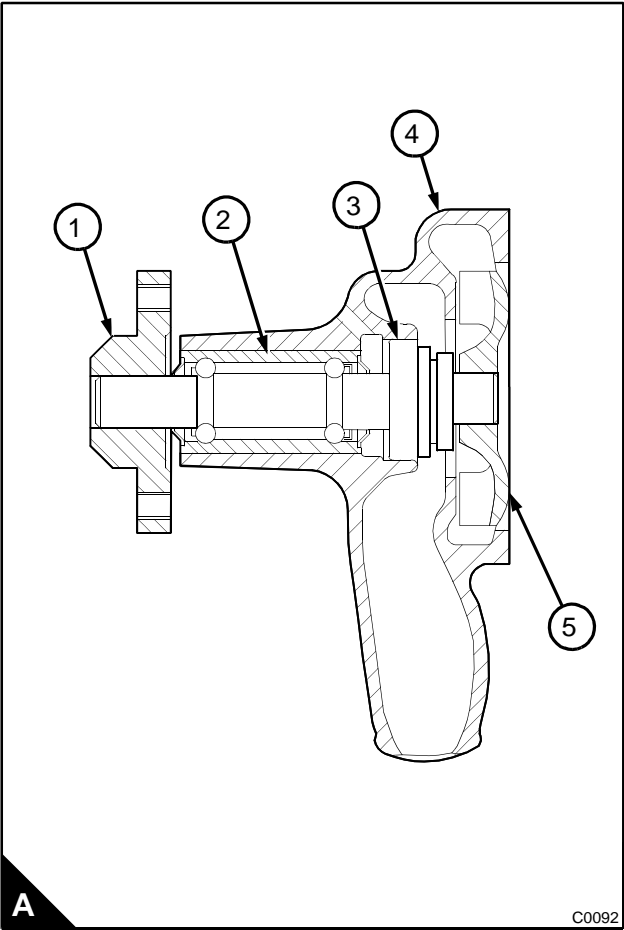
To dismantle

Operation 12-6

Special requirements

Special tools			
Description	Part number	Description	Part number
Puller	21825565	Adaptors (for use with the puller)	21825568

- 1 Remove the coolant pump (A4) from the engine, see Operation 12-4.
- 2 Withdraw the hub (A1) with the puller and the adaptors.
- 3 Support the pulley end of the pump body. Use a suitable adaptor to press the shaft and bearing assembly (A2) through the impeller (A5) and coolant seal (A3). Continue to press until the shaft and bearing assembly are out of the pump body.
- 4 Discard the impeller and the shaft and bearing assembly. Remove and discard the coolant seal.
- 5 Clean the body of the pump with a suitable safe cleaning fluid. Inspect the pump body for cracks.



To assemble

Operation 12-7

Special requirements

Consumable products	
Description	Part number
POWERPART Retainer (oil tolerant)	21820603

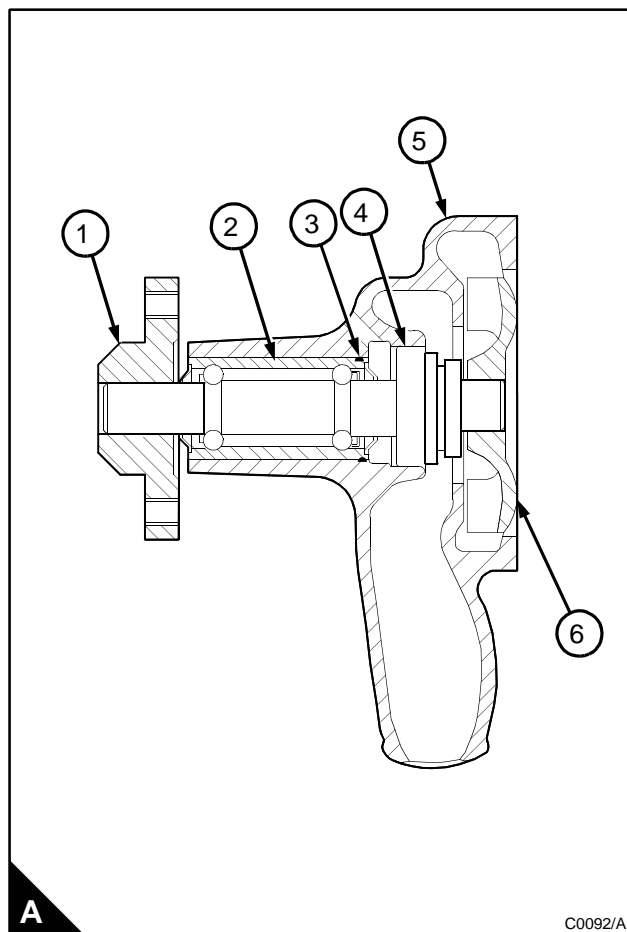
Notes:

- The service kit for the pump contains a bearing and shaft assembly, a coolant seal and an impeller.
- The bearing is filled with grease and sealed by the manufacturer. The bearing will not need attention during service.

1 Support the impeller end of the pump body. Apply a narrow ring (A3) of POWERPART Retainer (oil tolerant) to the face of the outer race of the bearing (A2).

2 Put the bearing and shaft assembly into position on the pump body (A5). The smallest shaft diameter must enter the pump body first. Use a suitable adaptor on the outer race of the bearing and press the bearing and shaft assembly into the pump body until the outer race of the bearing is level with the pulley end of the pump body. Do not apply pressure to the end of the shaft as this will damage the bearing. Remove excess retainer.

3 Support the pulley end of the pump body and fit a new coolant seal (A4) using the following procedure.



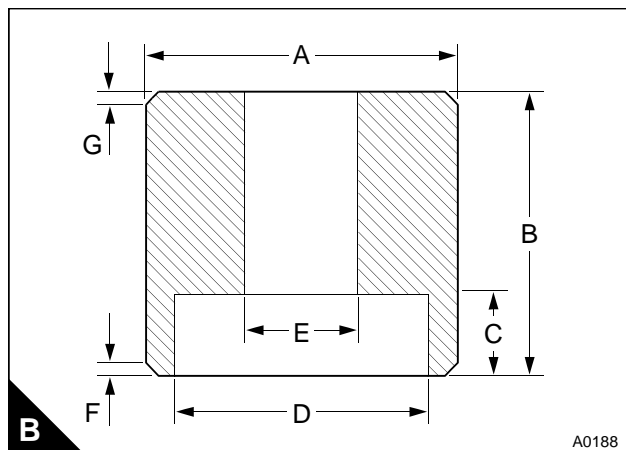
Continued

Caution: It is important that only the tool, shown in (B), is used to fit the new coolant seal.

The coolant seal is an interference fit on the shaft and a tool will be necessary to fit the seal correctly.

The tool should be made of mild steel bar to the dimensions shown in (B), listed as follows:

A	44,0 mm (1.73 in)	D	37,3 mm (1.47 in)	G	2,00 mm (0.08 in) at 45°
B	40,0 mm (1.57 in)	E	16,1 mm (0.63 in)		
C	11,6 mm (0.46 in)	F	1,00 mm (0.04 in) at 45°		



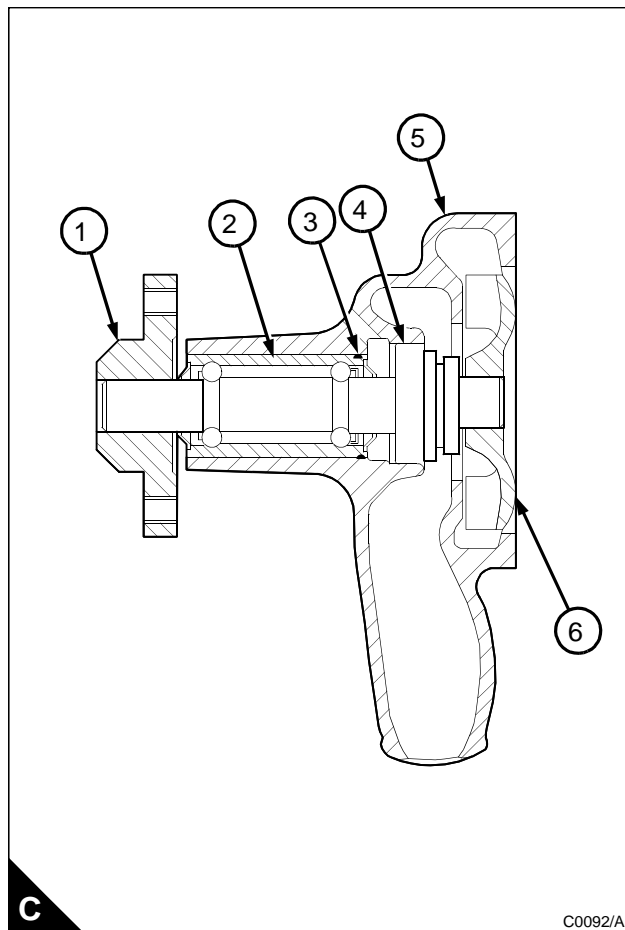
The dimensions of the tool to fit the coolant seal, will ensure that the seal is the correct length after it is installed. It will also prevent axial distortion of the seal when it is pressed onto the shaft.

Note: Do not lubricate the seal. It is important that the seal is not contaminated by oil or grease and if it is held in the hand, it should be held by the edge of the flange. Do not damage the ring of green sealant applied to the body of the coolant seal just behind the flange of the seal.

4 Ensure that there are no sharp edges on the edge of the shaft and put the seal into position on the end of the shaft. Ensure that the ring of sealant is towards the bearing. Use the tool to press the seal onto the shaft until the bottom of the seal flange is in complete contact with the pump body. Continue to apply force for approximately ten seconds to ensure that the seal remains in position when the force is released.

Continued

- 5** Support the pulley end of the shaft and press the new impeller (C6) onto the shaft until the back of the impeller is exactly level with the rear of the coolant pump body. This will ensure that the clearance between the impeller blades and the pump body is correct. Rotate the shaft to ensure that the impeller is free.
- 6** Apply a narrow ring of POWERPART Retainer (oil tolerant) to the pump shaft. Support the impeller end of the shaft and press the hub onto the shaft until the end of the shaft is level with the front face of the hub. Remove the excess retainer.
- 7** Fit the coolant pump to the engine, see Operation 12-5.



Fan

To remove and to fit

Operation 12-8

To remove

Release the four setscrews and remove the fan. If necessary, fit the setscrews to retain the fan extension and the pulley to the hub.

To fit

Clean thoroughly the rear of the fan where it fits onto the fan extension. Also ensure that all paint is removed from this area. Put the pulley into position on the hub and the fan extension onto the pulley. Clean the front face of the fan extension. Fit the fan and tighten the setscrews to 22 Nm (16 lbf ft) 2,2 kgf m.

13

Flywheel and flywheel housing

General description

The steel flywheel is fitted with a hardened starter ring. The flywheel housing is normally made of cast iron.

Flywheel

To remove and to fit

Operation 13-1

Special requirements

Consumable products	
Description	Part number
POWERPART Retainer (oil tolerant)	21820603

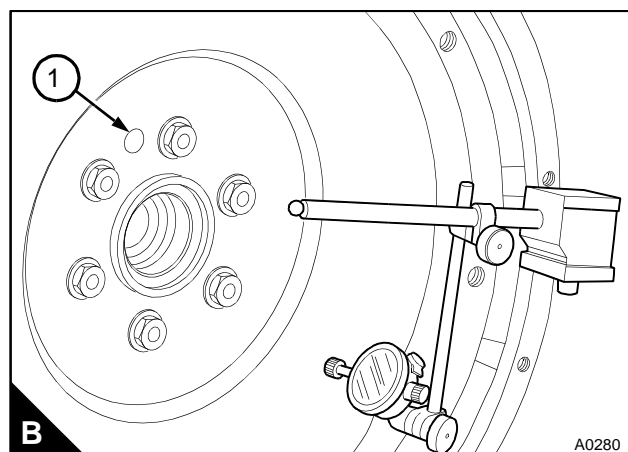
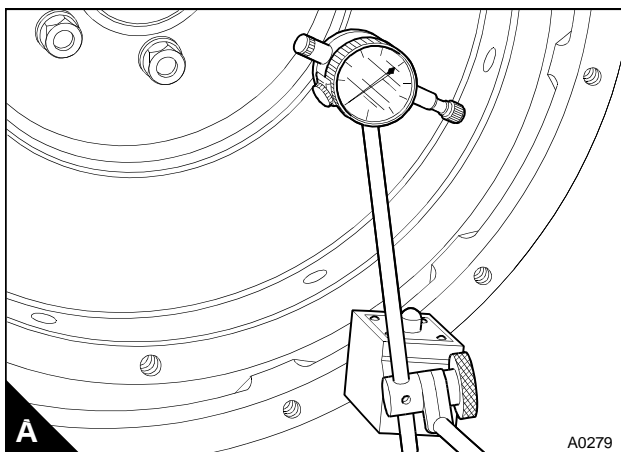
Warning! The flywheel is very heavy, use lift equipment or get assistance with the lift operation before removal of the flywheel fasteners.

To remove

- 1 Remove two opposite setscrews from the flywheel and fit temporarily two guide studs to ensure safety when the flywheel is removed and fitted.
- 2 Remove the remainder of the setscrews and washers and remove the flywheel.
- 3 Check the flywheel and ring gear for damage and renew, if necessary.

To fit

- 1 Ensure that the location faces of the crankshaft and the flywheel are clean and free from damage.
- 2 Fit temporarily two guide studs in opposite holes in the crankshaft palm to ensure safety when the flywheel is fitted. Fit the flywheel over the guide studs, ensure that the hole (B1) for the dowel in the crankshaft palm is in the correct position. Apply POWERPART Retainer (oil tolerant) to the first three threads of the setscrews and fit four setscrews and their washers. Remove the guide studs and fit the remainder of the setscrews and the washers. Tighten the setscrews to 105 Nm (77 lbf ft) 10,7 kgf m.
- 3 Check the flywheel run-out with a dial test indicator (A). This must be less than 0,30 mm (0.012 in) total indicator reading.
- 4 Check the alignment of the flywheel face (B). The error in alignment must not be more than 0,03 mm (0.001 in) total indicator reading for every 25 mm (1.0 in) of the flywheel radius from the crankshaft axis to the indicator plunger. During this operation, keep the crankshaft pressed toward the front to remove the effect of crankshaft end-float.



Ring gear

To remove and to fit

Operation 13-2

To remove

Warning! *Wear eye protection during this operation.*

Before the ring gear is removed, check the position of the chamfer on the teeth. 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

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 250 °C (480 °F). Ensure that the chamfer on the teeth of the gear is in the correct direction.

Flywheel housing

To remove and to fit

Operation 13-3

Warning! *The flywheel housing is heavy, use lift equipment or get assistance with the lift operation before removal of the flywheel housing fasteners.*

To remove

- 1 Remove the starter motor, see Operation 14-6, and the flywheel, see Operation 13-1.
- 2 Release the six setscrews and the two Allen screws. Carefully hit the housing, with a soft face hammer, to remove it from the dowels.

To fit

- 1 Ensure that the rear face of the cylinder block and the faces of the housing are clean and free from damage. Ensure that the location dowels are fitted correctly.
- 2 Fit the housing onto the dowels and tighten the setscrews and the two Allen screws to 44 Nm (32 lbf ft) 4,5 kgf m.
- 3 Fit the flywheel, see Operation 13-1, and the starter motor, see Operation 14-6.

14

Electrical equipment

Alternators

General description

The alternator is driven from the crankshaft pulley by a single belt.

The Magneti Marelli A127 alternator has solid state regulator fitted at the rear. The regulator of the Magneti Marelli A127 alternator includes the brush box as a part of the unit. The regulator is sealed and repair is not possible.

Precautions

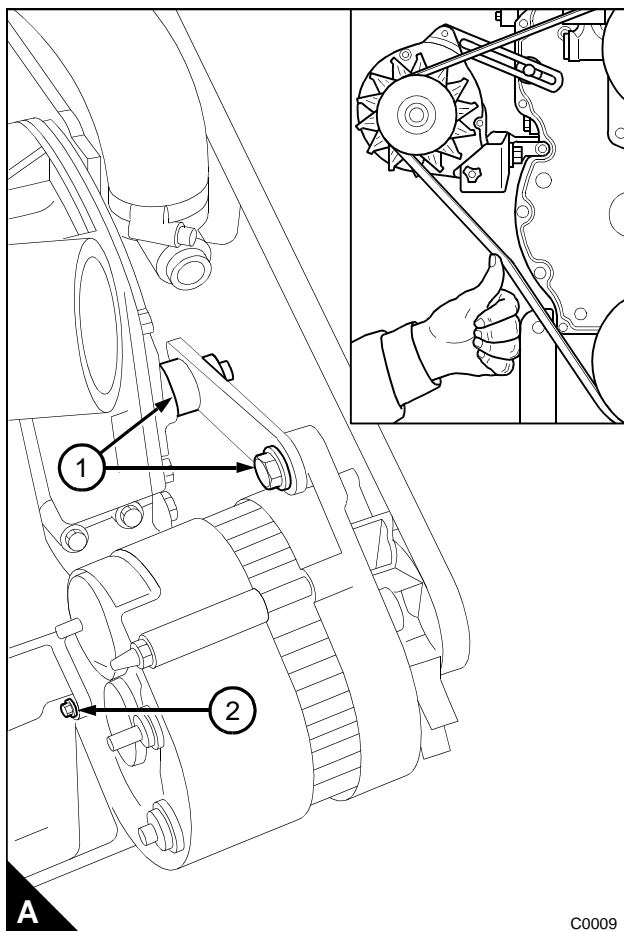
To prevent damage to the diodes and to the resistors, the precautions given below must be followed:

- Do not disconnect the battery while the engine is in operation. This will cause a voltage surge in the alternator charge system that 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 connections 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 check the drive belts

Operation 14-1

- 1 Renew the belt if it is worn or damaged.
- 2 The condition of the belt should be checked at the intervals shown in the User's Handbook. The belt should be renewed if there are cracks in the belt or if the belt is contaminated by oil or grease.
- 3 To check the tension, press the belt with the thumb (A) at the centre of the longest free length and check the deflection. With moderate thumb pressure 45 N (10 lbf) 4,5 kgf the correct deflection of the belt is 10 mm ($\frac{3}{8}$ in).

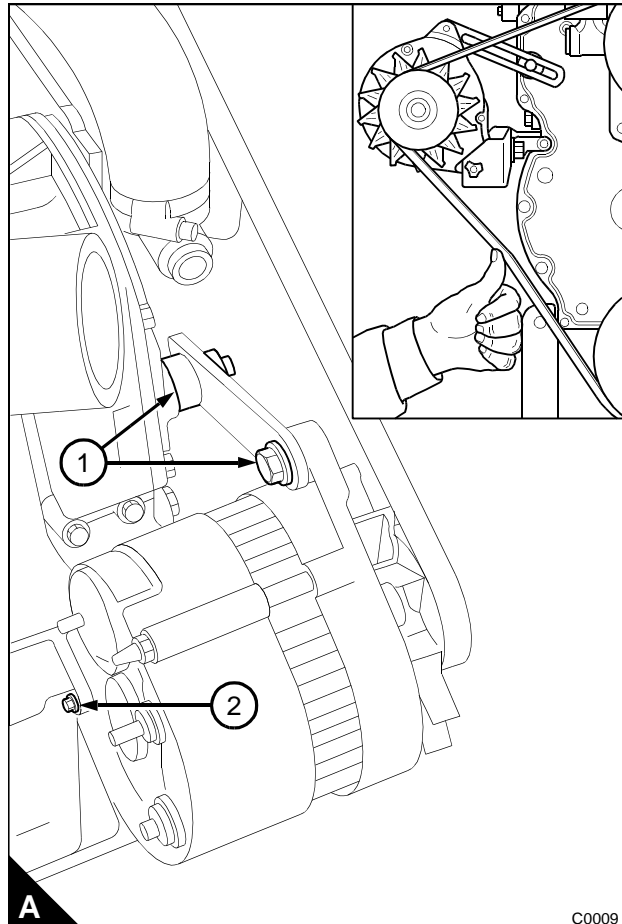


To adjust the drive belt tension

Operation 14-2

- 1 Loosen the pivot fasteners (A2) of the alternator and the fasteners of the adjustment link (A1).
- 2 Change the position of the alternator to give the correct tension. Tighten the adjustment link fasteners and then the pivot link fasteners.
- 3 Check the belt tension again to ensure that it is still correct.

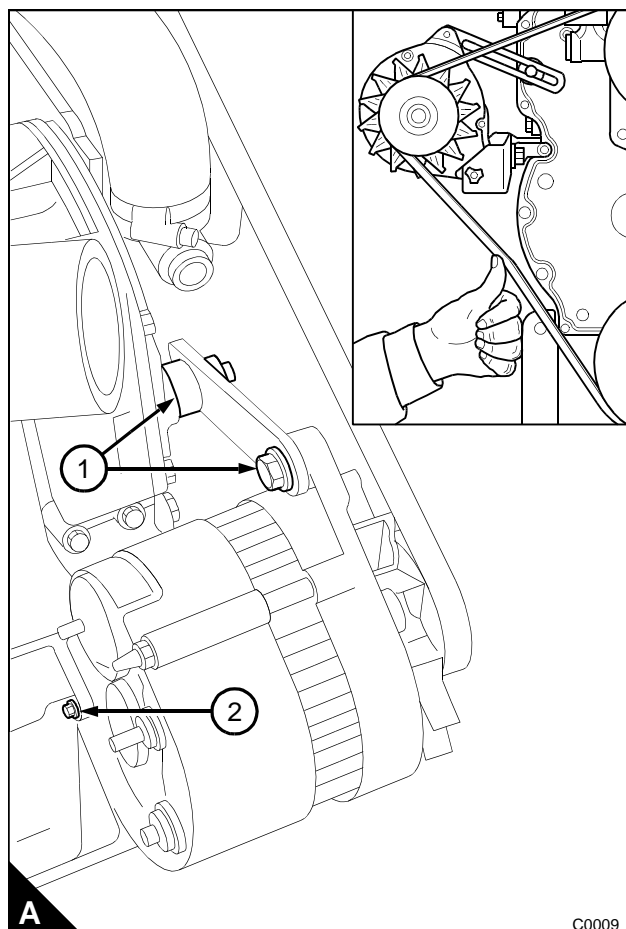
Note: If a new belt is fitted, the belt tension must be checked again after the first 25 hours of operation.



To remove and to fit the drive belts

Operation 14-3

- 1 Loosen the pivot fasteners (A2) of the alternator and the adjustment link fasteners (A1). Ensure that the spacer between the link fastener and the timing case is not lost.
- 2 Release all of the tension from the belt and remove the belt.
- 3 Fit the new belt and adjust the tension, see Operation 14-2.



To remove and to fit the alternator

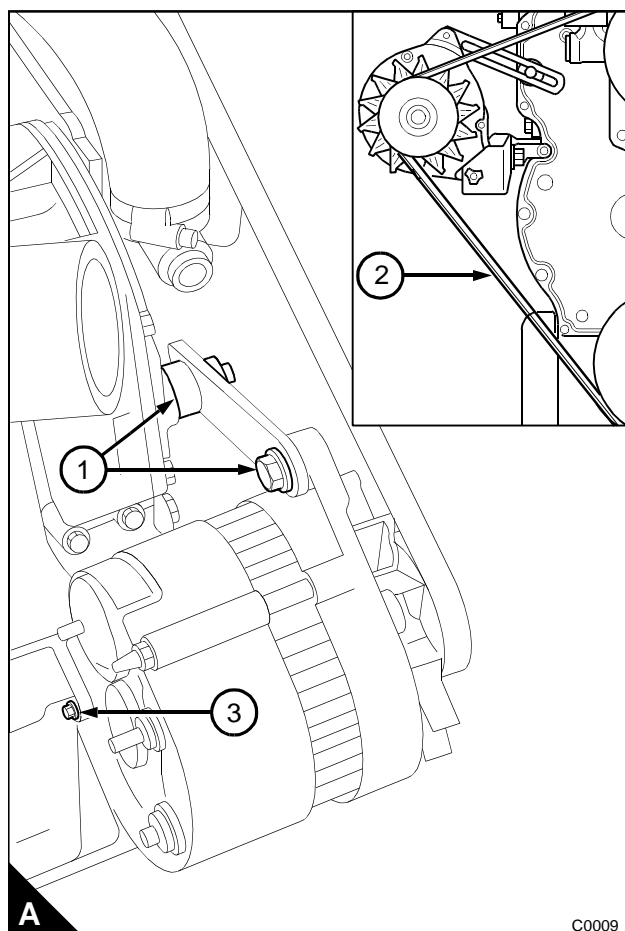
Operation 14-4

To remove

- 1 Disconnect the electrical connection.
- 2 Loosen the pivot fasteners of the alternator and the fasteners of the adjustment link.
- 3 Release all the belt tension and remove the drive belt(s) (A2).
- 4 Remove the adjustment link and fasteners (A1) from the alternator and remove the pivot fasteners (A3). Make a note of the position of any washers and distance pieces to ensure that they are fitted correctly. Remove the alternator.

To fit

- 1 Put the alternator in position and assemble loosely the pivot fasteners and the adjustment link and its fasteners. Ensure that any washers and the distance pieces are fitted in their correct positions and that the alternator pulley is aligned to the crankshaft pulley within $\pm 2,4 \text{ mm}$ ($\frac{3}{32} \text{ in}$).
- 2 Fit the drive belt(s) and adjust the drive belt tension, see Operation 14-2. Tighten the fasteners and check the tension again.
- 3 Connect the electrical connection.



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To maintain the alternator

Operation 14-5

- 1 Ensure that the drive belts are not worn and that the belt tension is correct.
- 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.

Alternator fault diagnosis

The operation of the alternator is correct when a flow of current (indicated by no light at the warning light or a reading shown on an ammeter) shows that the system is in correct operation. 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 is not illuminated when the alternator is stationary and the switch is in the "on" position, or it is illuminated 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 Move 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, given in the relevant Data and dimensions for the "Alternator" on page 27.
- 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. This procedure is not suitable for A127 alternators and, if a fault is found, the alternator should be removed for test by a specialist.

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:

Check the bulb. If no fault:

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

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.

Continued

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

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

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 or 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:

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:

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.

Starter motors

General description

The Magneti Marelli M127 starter motor is operated by a solenoid and has a five roller clutch. The solenoid engages the starter drive in two operations to ensure that the motor gets its maximum torque only when the starter motor is engaged fully with the flywheel. The clutch prevents rotation of the armature at high speed if the starter is held in the engaged position.

To remove and to fit

Operation 14-6

Special requirements

Consumable products	
Description	Part number
POWERPART Silicone RTV Sealing and Jointing Compound	1861108

To remove

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

To fit

- 1 If one is fitted, 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. If the engine has a flywheel housing that is oil filled, the starter motor must be sealed before it is fitted. Clean the flange face of the starter motor and the face of the flywheel housing. Apply a 2,0 mm (0.080 in) continuous bead of POWERPART Silicone RTV Sealing and Jointing Compound to the flange face of the starter motor near to the spigot.
- 3 Connect the battery.

To maintain the brush gear and the commutator

Operation 14-7

M127 Starter motor

Repair of this starter motor is difficult. If necessary, remove the starter motor for specialist repair.

To test on the engine

Operation 14-8

1 Ensure that the battery is fully charged.

Turn on the 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.

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

Note: Failure 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. This can prevent free pinion movement.

3 Clean the shaft thoroughly with gasoline, or a fluid made especially for the purpose, and apply a small quantity of Aero Shell 6B or its equal.

Cold starting system

General description

The fuelled starting aid (A) is a device which is operated electrically and ignites a controlled amount of diesel fuel in the induction manifold to heat the induction air. A heater coil in the body expands a valve holder to allow fuel to flow into the device. The fuel is ignited by the hot coil and the heated air enters the induction manifold when the starter motor is operated.

Starting aid

To remove and to fit a fuelled starting aid

Operation 14-9

To remove

- 1 Disconnect the fuel pipe (A1) and the electrical connection (A2).
- 2 Remove the starting aid.

To fit

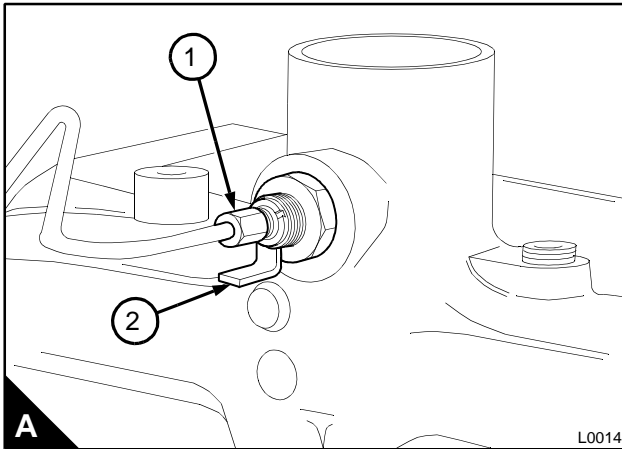
- 1 Ensure that the contact faces of the manifold and the starting aid are clean. Put the sealing washer into position and fit the starting aid. Tighten the starting aid to 31 Nm (23 lbf ft) 3,2 kgf m.
- 2 Check the fuel pipe and, if it is still full of fuel, connect it to the starting aid. If the fuel has drained from the pipe, eliminate the air from the pipe as follows:

Loosen the fuel pipe connection at the fuelled starting aid.

Operate the priming lever of the fuel lift pump until fuel, free of air, comes from the pipe connection.

Tighten the connection.

- 3 Connect the electrical connection (A2).



To check the fuelled starting aid

Operation 14-10

If the inside of the induction manifold is wet, check that there is not a fuel leak from the fuelled starting aid.

- 1** Disconnect the fuel pipe and the electrical connection at the starting aid. Remove the starting aid from the manifold and fit a suitable plug in the manifold.
- 2** Connect the fuel pipe to the starting aid, but leave the connection loose. Do not fit the electrical connection, but ensure that the connector has a suitable insulator fitted. Operate the priming lever of the fuel lift pump until fuel free of air comes from the connection. Tighten the connection.
- 3** Start the engine and operate it at low speed. Check that there is no fuel leakage from the valve of the starting aid.
- 4** If there is no leakage, remove the plug from the induction manifold and fit the starting aid. Connect the fuel pipe to the starting aid and remove the air from the pipe as shown above. Connect the electrical connection. If there is a leak from the valve of the starting aid, fit a new starting aid.

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Auxiliary equipment

Not used

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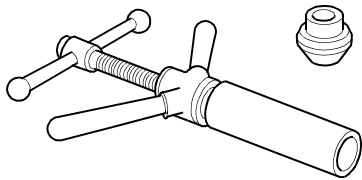
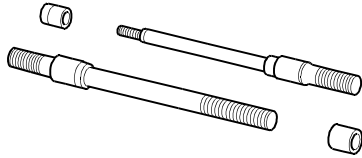
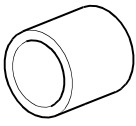
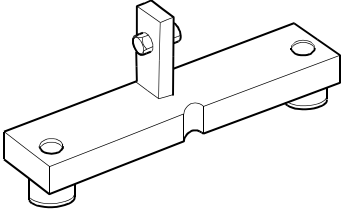
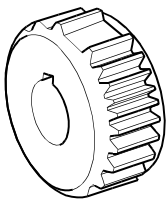
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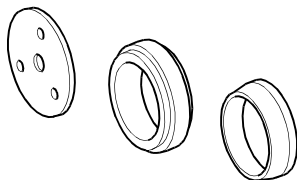
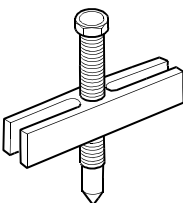
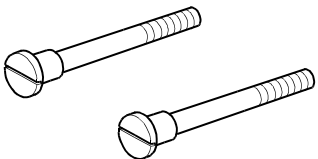
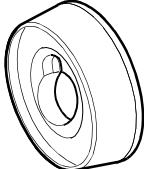
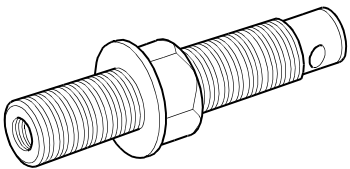
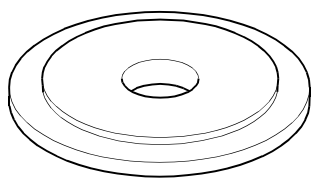
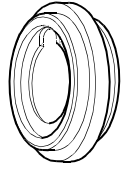
Special tools


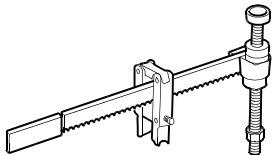
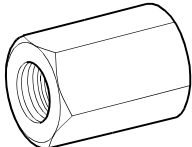
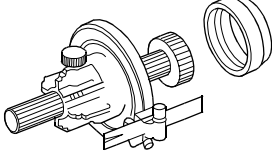
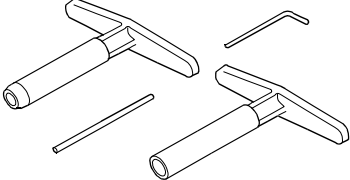

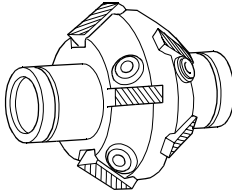
These tools are available through your local Perkins Distributor. If you cannot obtain the correct tool locally contact:

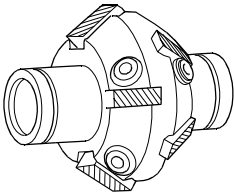
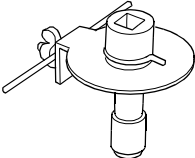

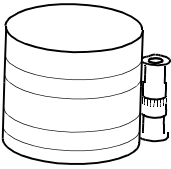
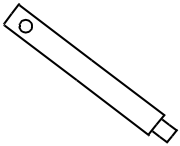
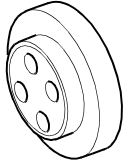
The Perkins Service Department, Peterborough, PE1 5NA, England, UK. Tel: 01733 583000, Fax 01733 582240, Telex 32501 PERKEN G.

List of special tools

Tool number	Description	Illustration
21825478	Remover/replacer for valve guides (main tool) PD.1D	
21825552	Adaptor for use with PD.1D PD.1D-1A	
21825937	Adaptor for use with PD.1D and PD.1D-1A PD.1D-12	
21825496	Gauge for piston height, valve depth and cylinder liner flange PD.41D; for use with PD.208	
21825513	Gear adaptor for use with MS.67B PD.67-3	

Tool number	Description	Illustration
21825540	Replacer tool for crankshaft rear seal PD.145D	
21825565	Basic puller for fuel pump gear and coolant pump hub PD.155C	
21825568	Adaptors for use with PD.155C PD.155B-5	
21825571	Centralising tool for timing case cover 3 cylinder PD.159A	
21825577	Replacer tool for seal of timing case cover (main tool) PD.170	
21825578	Pressure plate for use with PD.170 PD.170 -1	
21825582	Adaptor for use with PD.170 PD.170 -5	

Tool number	Description	Illustration
21825617	Dial gauge for use with PD.41D PD.208	
21825666	Valve spring compressor PD.6118B	
21825934	Stud adaptor for use with PD.6118B PD.6118B-10	
21825610	Universal timing gauge MS.67B	
21825619	Handle set for valve seat cutters (also included in MS.73) MS.76B	
21825550	Adjustable pilot for valve seat cutters (also included in MS.73) MS.76-150-7	
21825633	Cutter for exhaust valve seats (also included in MS.73) MS.76-285	

Tool number	Description	Illustration
21825977	Cutter for inlet valve seats MS.76-692	
21825607	Angle gauge to tighten cylinder head setscrews MS.1531	
21836001	Locking pin for crankshaft PD.241	
21825491	Piston ring compressor No. 8	
27610033	Timing pin for Delphi and Stanadyne fuel injection pumps PD.246	
27610024	Liner fitting adaptor PD.2576	
27610122	FIP drive gear Torx screw remover 867/1451 PR	