
Perkins 1100 Series

Models RE, RF, RG, RH, RJ and RK

WORKSHOP MANUAL

4 cylinder diesel engines for industrial, agriculture and construction applications

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General information

Introduction

This Workshop Manual has been written to provide assistance in the service and overhaul of Perkins 1100 Series 4 cylinder engines. It should be used in conjunction with normal workshop practise and information contained in current service bulletins. Mention of certain accepted practices therefore, has been purposely omitted in order to avoid repetition. For overhaul procedures the assumption is made that the engine is removed from the application.

The engine conforms with USA (EPA/CARB) stage 2 and EEC stage 2 emissions legislation for agriculture, construction and industrial applications.

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

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

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

- Delphi - DP210 Series
- Bosch - VP 30
- Bosch - EPVE.

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

Special tools have been made available and a list of these is given in Chapter 16, Special tools. Reference to the relevant special tools is also made at the beginning of each operation.

POWERPART recommended consumable products are listed under "POWERPART recommended consumable products" on page 9. Reference to the relevant consumable products is also made at the beginning of each operation.

Data and dimensions are included in Chapter 2, Specifications.

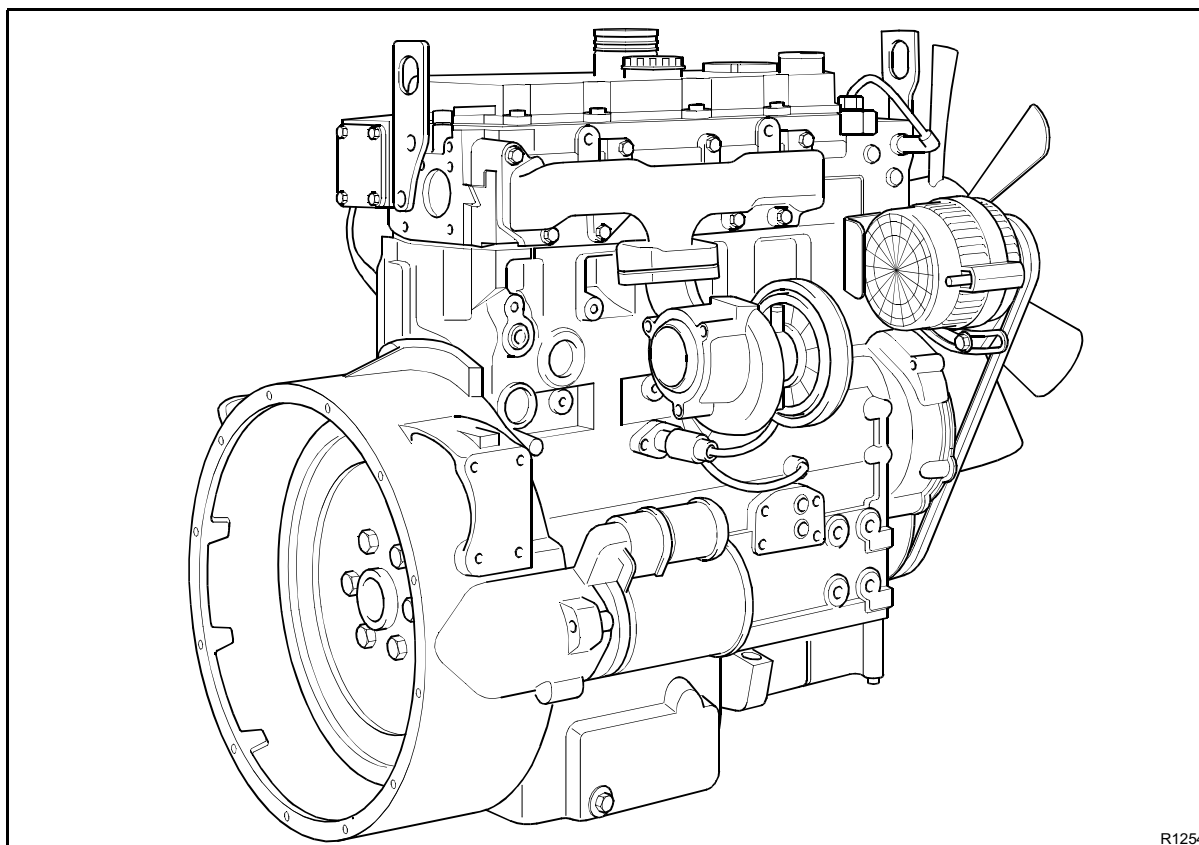
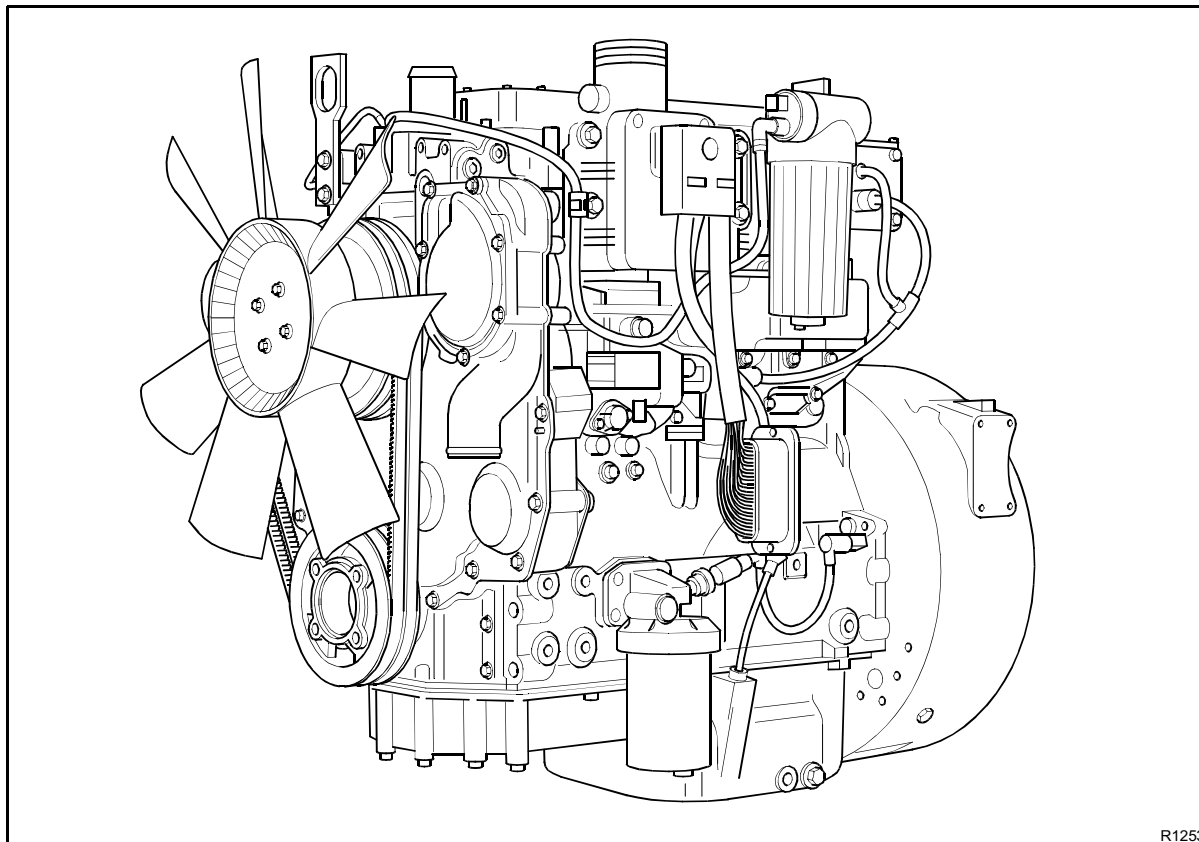
Read and remember the "Safety precautions" on page 5. They are given for your protection and must be used at all times.

Danger is indicated in the text by two methods:

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

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

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

Engine views

Engine identification

The Perkins 1100 Series 4 cylinder engines have been designed for industrial, construction and agricultural applications. There are a range of four cylinder engines with or without electronics, available in naturally aspirated, turbocharged and air to air charge cooled models.

In this Workshop Manual, the different models are indicated by their code letters. The first two letters of the engine number are indicated below:

RE	Naturally aspirated
RF	Naturally aspirated, electronic
RG	Turbocharged
RH	Turbocharged, electronic
RJ	Turbocharged, charge cooled
RK	Turbocharged, charge cooled, electronic

Continued

The Perkins 1100 Series 4 cylinder engines have been designed for agricultural, industrial and construction applications.

The correct identification of the engine is by the full engine number.

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

RE.....*U.....*

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

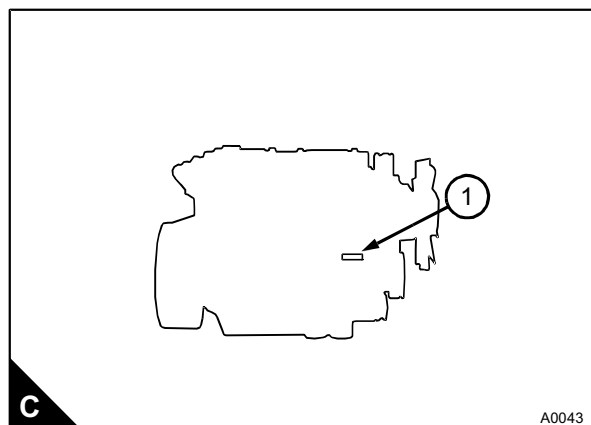
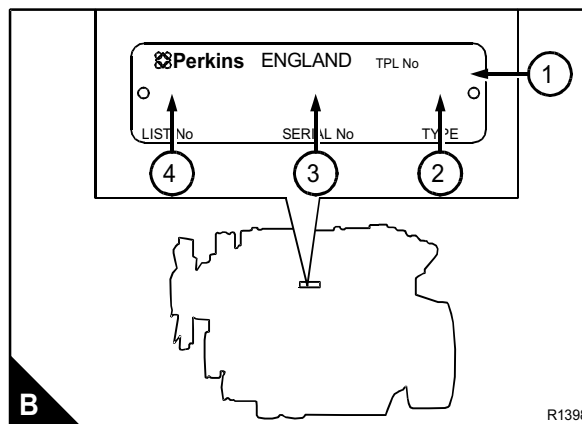
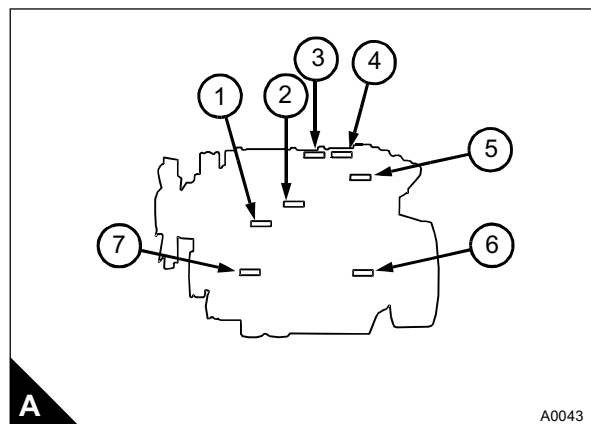
Other identification labels fitted to the engine include:

- A label (A1) with the fuel injection pump part numbers.
- An emissions legislation label (A3), (A6), (A7) and (C1) can be fitted in four different positions on the engine.
- A "Ether" warning label (A5) is fitted on the intake manifold.
- A "caution please read User's Handbook label" (A4) is screen printed into the atomiser cover.

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

The engine serial number plate (B) contains the following information:

- TPL number (1).
- Type (2).
- Serial number (3).
- List number (4).



Safety precautions

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

- Only use these engines in the type of application for which they have been designed.
- Do not change the specification of the engine.
- Do not smoke when you put fuel in the tank.
- Clean away fuel which has been spilt. Material which has been contaminated by fuel must be moved to a safe place.
- Do not put fuel in the tank while the engine runs (unless it is absolutely necessary).
- Do not clean, add lubricating oil, or adjust the engine while it runs (unless you have had the correct training; even then extreme care must be used to prevent injury).
- Do not make adjustments that you do not understand.
- Ensure that the engine does not run in a location where it can cause a concentration of toxic emissions.
- Other persons must be kept at a safe distance while the engine or auxiliary equipment is in operation.
- Do not permit loose clothing or long hair near moving parts.
- Keep away from moving parts during engine operation.

Warning! *Some moving parts cannot be seen clearly while the engine runs.*

- Do not operate the engine if a safety guard has been removed.
- Do not remove the filler cap, or any component of the cooling system while the engine is hot and while the coolant is under pressure because dangerous hot coolant can be discharged.
- Do not allow sparks or fire near the batteries (especially when the batteries are on charge) because the gases from the electrolyte are highly flammable. The battery fluid is dangerous to the skin and especially to the eyes.
- Disconnect the battery terminals before a repair is made to the electrical system.
- Only one person must control the engine.
- Ensure that the engine is operated only from the control panel or from the operator's position.
- If your skin comes into contact with high-pressure fuel, obtain medical assistance immediately.
- Diesel fuel and lubricating oil (especially used lubricating oil) can damage the skin of certain persons. Protect your hands with gloves or a special solution to protect the skin.
- 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, see "Viton seals" on page 8 for safety precautions.
- 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.
- Read and use the instructions relevant to "Engine lift equipment" on page 7.

Continued

- 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 speed 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

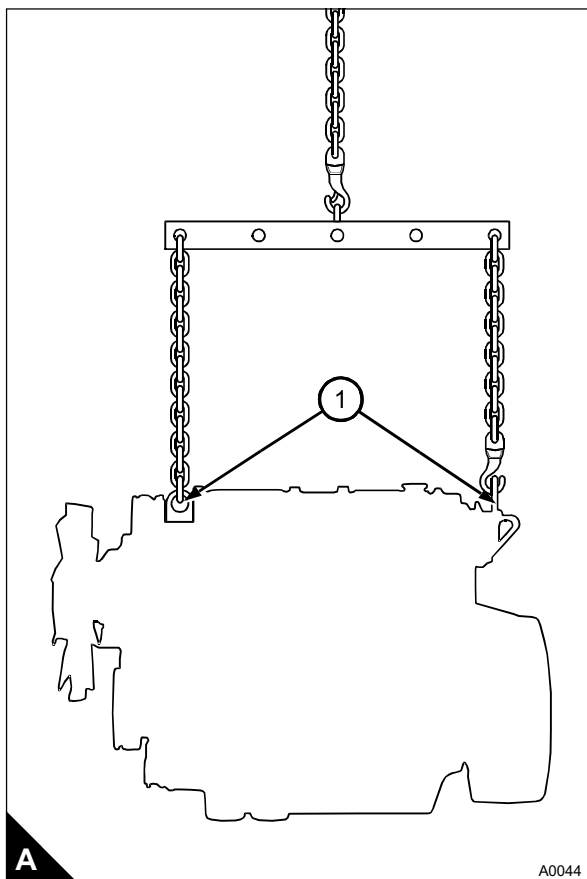
The maximum weight of the engine without coolant, lubricant, or a gearbox fitted will vary for different applications. It is recommended that lift equipment of the minimum capacity listed below is used:

Four cylinder engines	600 kg (1320 lbs)
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Note: Use lift equipment or obtain assistance to lift heavy engine components such as the cylinder block, cylinder head, balancer unit, flywheel housing, crankshaft and flywheel.

Before the engine is lifted:

- Always use 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.



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:

- 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.

Safety cautions when an engine is cleaned

Care should be taken, when an engine is cleaned with a high pressure cleaning system.

Cautions:

- *Do not wash an engine while it runs or while it is hot. If cold cleaning fluids are applied to a hot engine, certain components on the engine could be damaged.*
- *Leave the engine to cool for at least one hour and disconnect the battery connections before cleaning.*
- *Do not wash any part of the fuel injection pump (FIP), cold start device, electrical shut off solenoid (ESOS) or electrical connectors.*
- *Ensure that the alternator, starter motor and any other electrical components are shielded and not directly cleaned by the high pressure cleaning system.*

If these cautions are ignored, the engine or certain components could be damaged, fail to operate and also make the manufacturer's warranty invalid.

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 Dealer/Distributor.

POWERPART Antifreeze

Protects the cooling system against frost and corrosion. Part number 21825166.

POWERPART Atomiser thread sealant

To seal the threads of the atomiser into the cylinder head. Part number 21825474.

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.

Continued

POWERPART Radiator stop leak

For the repair of radiator leaks. Part number 21820127.

POWERPART Red rubber grease

Provides lubrication for the fitting of "O" rings. Part number 21820221.

POWERPART Retainer (high strength)

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

POWERPART Retainer (oil tolerant)

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

POWERPART Safety cleaner

General cleaner in an aerosol container. Part number 21820128.

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 that 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 that seals joints. Part number 1861117.

2

Specifications

Basic engine data

Number of cylinders:

RE, RF, RG, RH, RJ, RK. 4

Cylinder arrangement... ..In line

Cycle Four stroke

Direction of rotation Clockwise from the front

Induction system:

RE, RF. Naturally aspirated

RG, RH Turbocharged

RJ, RK. Turbocharged, charge cooled

Combustion system. Direct injection

Nominal bore:

RE, RF, RG, RH, RJ, RK. 105 mm (4.133 in)

Stroke 127 mm (5.00 in)

Compression ratio:

RE, RF. 19.3:1

RG, RH, RJ, RK... .. 18.2:1

Cubic capacity:

RE, RF, RG, RH, RJ, RK. 4,4 litres (268 in³)

Firing order:

RE, RF, RG, RH, RJ, RK. 1, 3, 4, 2

Valve tip clearances (cold):

Inlet... .. 0,20 mm (0.008 in)

Exhaust 0,45 mm (0.018 in)

Lubricating oil pressure ⁽¹⁾

RE, RF, RG, RH, RJ, RK. 300 kpa (43 lbf/in²) 3,0 kgf/cm²

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

Data and dimensions

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

Cylinder head

Angle of valve seat:

- Intake ... 30° (120° included angle)
- Exhaust ... 30° (120° included angle)

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

Head thickness ... 117,95/118,05 mm (4.643/4.647 in)

Rz and Rmaz to be measured to DIN EN ISO 4287

Surface finish of head face for cylinder head joint. ... Rz < 15um Rmax < 20um

Permissible wave depth:

Wt ≤ 4um with a wave distance Wd < 2,0 mm

Wt ≤ 6um with a wave distance Wd < 4,0 mm

Wt ≤ 8um with a wave distance Wd < 6,0 mm

Wt ≤ 10um with a wave distance Wd < 8,0 mm

Diameter of parent bore for valve guide:

- Intake ... 13,000/13,027 mm (0.5118/0.5129 in)

- Exhaust ... 13,000/13,027 mm (0.5118/0.5128 in)

Minimum permissible thickness after head face has been machined ... 117,20 mm (4.614 in)

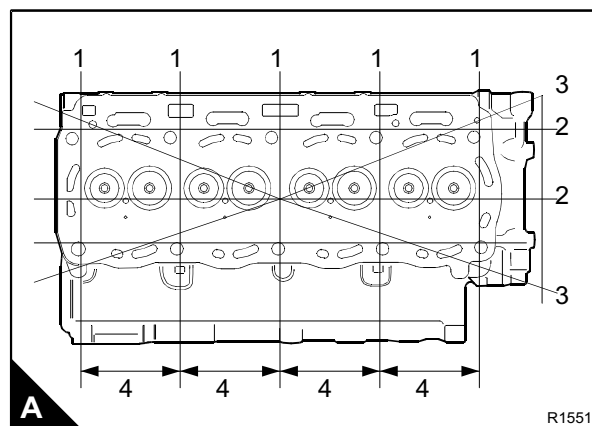
Maximum permissible distortion of cylinder head face

A1 ... 0,03 mm (0.0012 in)

A2 ... 0,05 mm (0.0019 in)

A3 ... 0,05 mm (0.0019 in)

A4 ... 0,03 mm (0.0012 in)



Intake and exhaust valves

Intake valves

Diameter of valve stem 8,953/8,975 mm (0.3525/0.3533 in)

Clearance in valve guide 0,025/0,069 mm (0.001/0.0027 in)

Maximum permissible clearance in valve guide:

- Production limit... .. 0,069 mm (0.0027 in)

- Service limit... .. 0,13 mm (0.005 in)

Diameter of valve head 46,20/46,45 mm (1.819/1.829 in)

Angle of valve face 30°

Full length 128,92/129,37 mm (5.076/5.093 in)

Seal arrangement Stem seal with integral seating washer

Depth of valve head below the face of cylinder head:

- Production limits, RE and RF. 0,58/0,84 mm (0.023/0.033 in)

- Service limit, RE and RF 1,09 mm (0.043 in)

- Production limits, RG, RH, RJ, RK.. .. 1,58/1,84 mm (0.062/0.072 in)

- Service limit, RG, RH, RJ, RK 2,09 mm (0.082 in)

Exhaust valves

Diameter of valve stem 8,938/8,960 mm (0.3519/0.3528 in)

Clearance in valve guide 0,040/0,84 mm (0.0016/0.033 in)

Maximum permissible clearance in valve guide:

- Production limits 0,084 mm (0.003 in)

- Service limit... .. 0,15 mm (0.006 in)

Diameter of valve head 41,51/41,75 mm (1.634/1.644 in)

Angle of valve face 30°

Full length 128,92/129,37 mm (5.075/5.093 in)

Seal arrangement Stem seal with integral seating washer

Depth of valve head below face of cylinder head:

- Production limits, RE and RF 0,53/0,81 mm (0.021/0.032 in)

- Service limit, RE and RF 1,06 mm (0.042 in)

- Production limits, RG, RH, RJ, RK 1,53/1,81 mm (0.060/0.071 in)

- Service limit, RG, RH, RJ, RK... .. 2,06 mm (0.081 in)

Dimensions of recesses for valve seat inserts

Models RE and RF

Intake

A1.....	9,910/10,040 mm (0.3902/0.3953 in)
A2.....	47,820/47,845 mm (1.8827/1.8837 in)
A3.....	Radius 0,38 mm (0.015 in) maximum

Exhaust

A1.....	9,910/10,040 mm (0.3901/0.3952 in)
A2.....	42,420/42,445 mm (1.6701/1.6711 in)
A3.....	Radius 0,38 mm (0.015 in) maximum

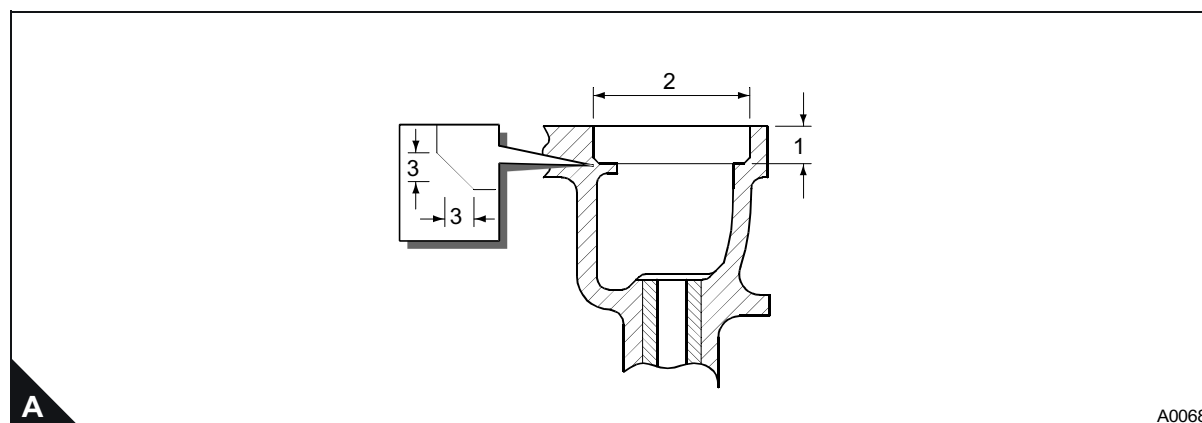
Models RG, RH, RJ and RK

Intake

A1.....	10,910/11,040 mm (0.4295/0.4346 in)
A2.....	47,820/47,845 mm (1.8827/1.8837 in)
A3.....	Radius 0,38 mm (0.015 in) maximum

Exhaust

A1.....	10,910/11,040 mm (0.4295/0.4346 in)
A2.....	42,420/42,445 mm (1.6701/1.6711 in)
A3.....	Radius 0,38 mm (0.015 in) maximum

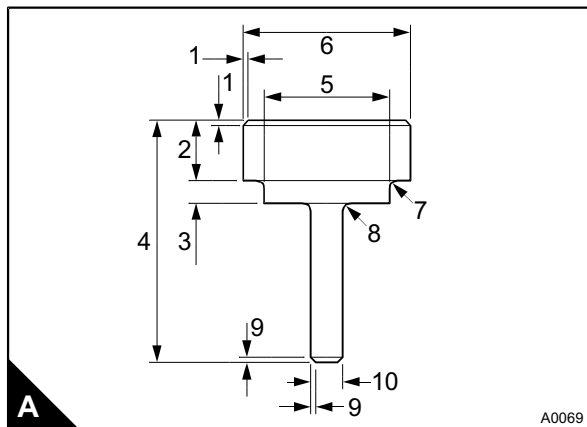


Valve seat insert tool**Intake**

A1	1,5 mm (0.06 in)
A2	20 mm (0.800 in)
A3	6,8/7,1 mm (0.267/0.279 in)
A4	100 mm (3.94 in)
A5	38,10/38,30 mm (1.500/1.507 in)
A6	46,25/46,50 mm (1.820/1.830 in)
A7	Radius 1,4 mm (0.055 in) maximum
A8	Radius 1,5 mm (0.06 in)
A9	1,5 mm (0.06 in)
A10	8,77/8,80 mm (0.345/0.346 in)

Exhaust

A1	1,5 mm (0.06 in)
A2	20 mm (0.800 in)
A3	7,2/7,5 mm (0.283/0.295 in)
A4	100 mm (3.94 in)
A5	34,38/34,58 mm (1.353/1.361 in)
A6	41,75/42,00 mm (1.643/1.653 in)
A7	Radius 1,4 mm (0.055 in) maximum
A8	Radius 1,5 mm (0.06 in)
A9	1,5 mm (0.06 in)
A10	8,77/8,80 mm (0.345/0.346 in)



Valve guides and valve springs

Valve guides

Inside diameter of partially finished guide... 8,250/8,350 mm (0.3248/0.3287 in)

Inside diameter of finished guide ... 9,000/9,022 mm (0.3543/0.3552 in)

Outside diameter:

- Intake... 13,034/13,047 mm (0.5131/0.5137 in)

- Exhaust ... 13,034/13,047 mm (0.5131/0.5137 in)

Interference fit of valve guide in cylinder head... 0,007/0,047 mm (0.0003/0.0019 in)

Full length ... 51,00/51,50 mm (2.008/2.028 in)

Protrusion from bottom of recess for valve spring . 12,35/12,65 mm (0.486/0.498 in)

Valve springs

Fitted length:

Models, RE and RF ... 33,5 mm (1.319 in)

Models RG, RH, RJ and RK ... 34,5 mm (1.358 in)

Load at fitted length:

Models, RE and RF ... 254 N (57 lbf) 26,0 kgf

Models RG, RH, RJ and RK ... 229 N (51 lbf) 23,0 kgf

Number of active coils ... 3.8

Number of damper coils. ... 0

Direction of coils. ... Right hand

Tappets, rocker shaft, rocker levers

Tappets

Diameter of tappet stem. ... 18,987/19,012 mm (0.7480/0.7485 in)

Diameter of tappet bore in cylinder block... 19,050/19,082 mm (0.7500/0.7513 in)

Clearance of tappet in cylinder block. ... 0,038/0,095 mm (0.0015/0.0037 in)

Rocker shaft

Outside diameter ... 24,962/24,987 mm (0.9828/0.9837 in)

Rocker levers and bushes

Diameter of parent bore for rocker lever ... 25,013/25,051 mm (0.9848/0.9863 in)

Clearance between rocker lever bore and rocker shaft . 0,026/0,89 mm (0.0010/0.0035 in)

Maximum permissible clearance between rocker lever bore and rocker shaft .. 0,17 mm (0.007 in)

Pistons and piston cooling jets

Pistons

Type. "Fastram" combustion bowl, re-entrant angle 80° (turbocharged), 70° (naturally aspirated)

Diameter of bore for gudgeon pin 39,703/39,709 mm (1.5631/1.5633 in)

Height of piston above top face of cylinder block 0,21/0,35 mm (0.008/0.0137 in)

Width of groove for top ring:

- Engine types RE and RF 2,58/2,60 mm (0.1015/0.1023 in)

- Engine types RG, RH, RJ, RK..... Tapered

Width of groove for second ring..... 2,54/2,56 mm (0.0999/0.1007 in)

Width of groove for third ring 3,52/3,54 mm (0.1385/0.1393 in)

Piston cooling jets

Valve open pressure 150/250 kPa (22/36 lbf/in²) 1,5/2,5 kgf/cm²

Piston rings

Top compression ring:

- Engine types, RE and RF..... Barrel face, molybdenum insert, rectangular

- Engine types RG, RH, RJ, RK..... Barrel face, molybdenum insert, keystone

Second compression ring Taper face, cast iron, internal bottom chamfer

Oil scraper ring Two piece coil spring loaded, chromium faced

Width of top ring:

- Engine types, RE and RF..... 2,47/2,49 mm (0.097/0.098 in)

- Engine types RG, RH, RJ, RK..... Tapered

Width of second ring 2,47/2,49 mm (0.097/0.098 in)

Width of third ring 3,47/3,49 mm (0.1366/0.1374 in)

Clearance of top ring in groove:

- Engine types, RE and RF..... 0,09/0,13 mm (0.0035/0.0051 in)

- Engine types RG, RH, RJ, RK..... Wedge

Clearance of second ring in groove. 0,05/0,09 mm (0.002/0.003 in)

Clearance of third ring in groove 0,03/0,07 mm (0.0011/0.0027 in)

Gap of top ring. 0,30/0,55 mm (0.0118/0.0216 in)

Gap of second ring 0,70/0,95 mm (0.0275/0.0374 in)

Gap of third ring 0,30/0,55 mm (0.0118/0.0216 in)

Connecting rods and big end bearings

Connecting rods

Type 'H' shape section, wedge shape small end
 Location of cap to connecting rod Fracture split
 Diameter of parent bore for big end 67,21/67,22 mm (2.6460/2.6465 in)
 Diameter of parent bore for small end 43,01/43,03 mm (1.693/1.694 in)
 Length grades F, G, H, J, K, L
 Length between centres (parent bores) 219,05/219,10 mm (8.624/8.626 in)

Big end bearings

Type:

- Naturally aspirated engines 8 x Steel back, tin/aluminium bearing material
 - Turbocharged engines bearing cap 4 x Steel back, tin/aluminium bearing material
 - Turbocharged engines bearing rod 4 x Steel back, leaded bronze bearing material
 Width 31,55/31,88 mm (1.240/1.255 in)
 Thickness at centre of bearings 1,835/1,842 mm (0.0723/0.0725 in)
 Bearing clearance 0,030/0,081 mm (0.0012/0.0032 in)
 Available undersize bearings 0,25 mm (-0.010 in); -0,50 mm (-0.020 in); -0,75 mm (-0.030 in)

Gudgeon pins and small end bushes

Gudgeon pins

Production:

Type Fully floating
 Outside diameter 39,694/39,700 mm (1.5628/1.5630 in)
 Clearance fit in piston boss 0,003/0,015 mm (0.0001/ 0.0006 in)

Small end bushes

Type Steel back, lead bronze
 Outside diameter 43,66/43,84 mm (1.7190/1.7259 in)
 Inside diameter 39,723/39,738 mm (1.5638/1.5645 in)
 Surface finish grade Ra 0,8 micrometers
 Clearance between bush in small end and gudgeon pin 0,023/0,044 mm (0.0009/0.0017 in)

Crankshaft

Diameter of main journals	76,159/76,180 mm (2.9984/2.9992 in)
Maximum wear and ovality on journals and crank pins	0,04 mm (0.0016 in)
Width of centre journal	44,15/44,22 mm (1.738/1.741 in)
Width of all other journals	39,24/39,34 mm (1.545/1.549 in)
Diameter of crank pins	63,47/63,49 mm (2.499/2.500 in)
Width of crank pins	40,35/40,42 mm (1.589/1.591 in)
Diameter of flange	135,27/135,32 mm (5.3257/5.3277 in)
Depth of recess for spigot bearing	20,40/20,60 mm (0.8031/0.8112 in)
Bore of recess for spigot bearing	46,96/46,99 mm (1.8488/ 1.8499 in)
Crankshaft end-float	0,05/0,38 mm (0.002/0.015 in)
Maximum permissible end-float	0,51 mm (0.020 in)
Fillet radii of journals and crank pins	3,68/3,96 mm (0.145/0.156 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

- Induction hardened ... Part number 3131D074, 4114A006
- Nitrocarburised .. Part number 3131D072, 4112A005

Crankshaft overhaul

Notes:

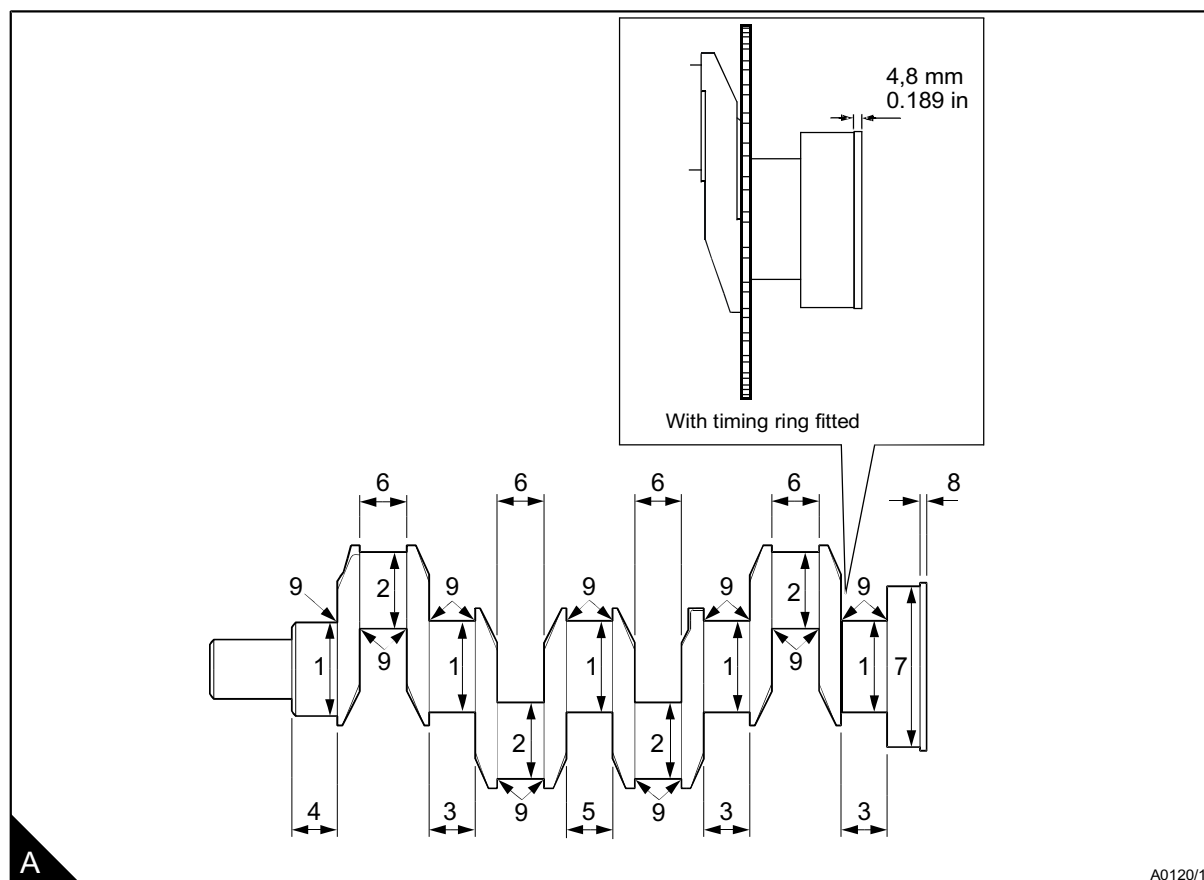
- Nitrocarburised crankshafts must be hardened again each time they are machined. These crankshafts must be nitrocarburised or, if this process is not available, they can be nitrided for 20 hours. If neither process is available a new crankshaft, or a "new for old" crankshaft, must be fitted.
- Check 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 and require Ra 0.4 um.

Continued

The finished sizes for crankshaft journals (A) which have been ground undersize are given in the table below:

Item	0,25 mm (0.010 in)	0,51 mm (0.020 in)	0,76 mm (0.030 in)
1	75,909/75,930 mm (2.9884/2.9892 in)	75,649/75,670 mm (2.9784/2.9792 in)	75,399/75,420 mm (2.9684/2.9692 in)
2	63,220/63,240 mm (2.488/2.4896 in)	62,960/62,982 mm (2.4788/2.4796 in)	62,708/62,728 mm (2.4688/2.4696 in)
3	39,47 mm (1.554 in) maximum	-	-
4	37,44 mm (1.474 in) maximum	-	-
5	44,68 mm (1.759 in) maximum	-	-
6	40,55 mm (1.596 in) maximum	-	-
7	Do not machine	-	-
8	Do not machine	-	-
9	3,68/3,69 mm (0.1448/0.1452 in)	-	-

Surface finish for journals, crank pins and fillet radii must be 0,4 microns (16 micro inches). Surface finish for the seal area of the crankshaft palm must be 0,4/1,1 microns (16/43 micro inches).



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:

Journal	Maximum run-out
1	Mounting
2	0,08 mm (0.0031 in)
3	0,15 mm (0.0059 in)
4	0,08 mm (0.0031 in)
5	Mounting

Run-out must not be opposite. The difference in run-out between one journal and the next must not be more than 0,10 mm (0.004 in).

Run-out on the crankshaft pulley diameter, rear oil seal diameter and the rear flange diameter must not be more than 0,05 mm (0.002 in) total indicator reading.

Main bearings

Type. Steel back with, tin/aluminium bearing material

Bearing width

All bearings.. 31,62/31,88 mm (1.244/1.255 in)

Bearing thickness at centre 2,083/2,089 mm (0.0820/0.823 in)

Bearing clearance

All bearings.. 0,057/0,117 mm (0.0022/0.0046 in)

Available undersize bearings... -0,25 mm (-0.010 in); -0,50 mm (-0.020 in); -0,75 mm (-0.030 in)

Crankshaft thrust washers

Type. Steel back bearing material

Position Each side of centre main bearing

Thickness:

- Standard 2,26/2,31 mm (0.089/0.091 in)

- Oversize 2,45/2,50 mm (0.096/0.098 in)

Balancer unit

Number of teeth on gear of drive shaft 17

Backlash from gear of drive shaft to idler gear 0,097/0,17 mm (0.0038/0.0066 in)

Diameter of bore for idler gear. 37,197/37,212 mm (1.5431/1.5437 in)

Diameter of hub of idler gear... 37,152/37,162 mm (1.4626/1.4630 in)

End-float of idler gear 0,12/0,27 mm (0.0047/0.0106 in)

Number of teeth on idler gear.. 44

Lubricating oil pump on the balancer

Type. Differential rotor, gear driven

Number of lobes:

- Inner rotor.. 4

- Outer rotor. 5

Clearance of outer rotor to body 0,13/0,23 mm (0.005/0.009 in)

Clearance of inner rotor to outer rotor 0,05/0,20 mm (0.0020/0.0079 in)

End clearance

- Inner rotor 0,032/0,125 mm (0.0013/0.0049 in)

- Outer rotor 0,032/0,125 mm (0.0013/0.0049 in)

Timing case and drive assembly

Camshaft

Diameter of number 1 journal	50,711/50,737 mm (1.9965/1.9975 in)
Diameter of number 2 journal	50,457/50,483 mm (1.9865/1.9875 in)
Diameter of number 3 journal	49,949/49,975 mm (1.9665/1.9675 in)

Cam lift:

- Intake for models RE, RF	7,382/7,482 mm (0.2906/0.2946 in)
- Intake for models RG, RH, RJ, RK	7,031/7,13 mm (0.2768/0.2807 in)
- Exhaust for models RE, RF	7,404/7,504 mm (0.2914/0.2954 in)
- Exhaust for models RG, RH, RJ, RK	7,963/8,063 mm (0.3135/0.3174 in)

Maximum permissible ovality and wear on journals... ..0,05 mm (0.021 in)

End-float:

- Production limits	0,10/0,55 mm (0.004/0.022 in)
- Service limits	..0,60 mm (0.023 in)

Width of spigot for thrust washer5,64/5,89 mm (0.222/0.232 in)

Camshaft thrust washer

Type	360°
Depth of recess in cylinder block for thrust washer	5,54/5,64 mm (0.218/0.222 in)
Thickness of thrust washer	5,486/5,537 mm (0.216/0.218 in)
Relationship of thrust washer to front face of cylinder block	-0,154/-0,003 mm (-0.0006/-0.0001 in)

Camshaft gear

Number of teeth	68
Diameter of bore	34,92/34,95 mm (1.3750/1.3760 in)
Outside diameter of the camshaft hub	34,90/34,92 mm (1.3741/1.3747 in)

Fuel pump gear electronic engines

Number of teeth	68
Bore	29,995/30,021 mm (1.417/1.419 in)

Fuel pump gear mechanical engines

Number of teeth	68
Bore	36,00/36,06 mm (1.1809/1.1819 in)

Crankshaft gear

Number of teeth	34
Diameter of bore	47,625/47,650 mm (1.8750/1.8760 in)
Diameter of hub for gear on crankshaft	47,625/47,645 mm (1.8750/1.8758 in)
Transition fit of gear on crankshaft	-0,020/+0,020 mm (-0.0008/ +0.0008 in)

Idler gear and hub

Number of teeth	73
Diameter of bore of gear	57,14/57,18 mm (2.2495/2.2512 in)
- with roller bearings	72,35/72,36 mm (2.8482/2.8489 in)
Width of gear and split bush assembly (fitted in position)	30,14/30,16 mm (1.186/1.187 in)
Inside diameter of flanged bushes (fitted in position)	50,78/50,80 mm (1.999/2.000 in)
Outside diameter of hub	50,70/50,74 mm (1.9990/1.9999 in)
- with needle roller bearings	49,975/49,988 mm (1.967/1.968 in)
Clearance of bushes on hub	0,04/0,10 mm (0.0016/0.0039 in)
End float of gear:	
- Production limits	0,10/0,20 mm (0.004/0.008 in)
- with needle roller bearings	0,10/0,75 mm (0.0039/0.0295 in)
- Service limit	0,38 mm (0.015 in)

Timing gear backlash values

Oil pump gear (with oil pump idler)	0,046/0,106 mm (0.0018/0.0041 in)
Oil pump idler gear (with crankshaft gear)	0,095/0,160 mm (0.0037/0.0063 in)
Crankshaft gear (with idler gear)	0,064/0,124 mm (0.0025/0.0049 in)
Camshaft gear (with idler gear)	0,052/0,107 mm (0.0020/0.0042 in)
Power take off LHS (PTO) gear (with idler gear)	0,112/0,172 mm (0.0044/0.0068 in)
Fuel injection pump gear (with idler gear)	0,054/0,109 mm (0.0021/0.0043 in)
Coolant pump gear (with fuel injection pump gear)	0,073/0,133 mm (0.0028/0.0052 in)

Cylinder block assembly**Cylinder block**

Height between top and bottom faces	441,073/441,374 mm (17.3657/17.3769 in)
Diameter of cylinder bore	105,000/105,025 mm (4.1338/4.1348 in)
Diameter of first oversize cylinder bore	105,500/105,525 mm (4.1535/4.1545 in)
Diameter of second oversize cylinder bore	106,000/106,025 mm (4.1732/4.1742 in)
Maximum permissible cylinder bore wear	0,15 mm (0.0059 in)
Diameter of parent bore for main bearing	80,416/80,442 mm (3.1660/3.1670 in)

Camshaft bore diameter

Number 1 (for bush)	55,563/55,593 mm (2.188/2.189 in)
Number 2	50,546/50,597 mm (1.990/1.992 in)
Number 3	50,038/50,089 4mm (1.969/1.972 in)

Turbocharger

The make and type and part number of turbocharger fitted is marked on the turbocharger identification plate, that is fitted to the turbocharger body.

As a general guide, the make and type of turbocharger fitted is Garrett GT25

Waste-gate test pressure for rod movement of 1,00 mm (0.039 in)

Turbocharger part number	Waste-gate pressure		
	(kPa) (+/-5)	(lbf/in ²) (+/-0.72)	(kgf/cm ²) (+/-0,05)
2674A200	100	14.5	1,01
2674A201	110	15.9	1,12
2674A202	128	18.5	1,30
2674A209	100	14.5	1,01
2674A211	128	18.5	1,30
2674A215	128	18.5	1,30
2674A223	136	19.7	1,38
2674A224	136	19.7	1,30
2674A225	136	19.7	1,38
2674A226	100	14.5	1,01
2674A227	128	18.5	1,30

Lubrication system**Canister type oil filter**

Type. Full flow, screw-on type canister
 Pressure to open by-pass valve in filter. 80/120 kPa (16/24 lbf/in²)

Element type oil filter

Type. Full flow, replaceable element
 Pressure to open by-pass valve in filter. 130/170 kPa (26/12 lbf/in²)

Lubricating oil pump

Type. Differential rotor, gear driven
 Number of lobes:

- Inner rotor. 5
 - Outer rotor. 6
 Clearance of outer rotor to body. 0,152/0,330 mm (0.0059/0.0129 in)
 End clearance
 - Inner rotor. 0,038/0,089 mm (0.0014/0.0035 in)
 - Outer rotor. 0,025/0,076 mm (0.0010/0.0029 in)

Idler gear for lubricating oil pump

End float. 0,050/0,275 mm (0.0019/0.0108 in)
 Inside diameter of bush (fitted). 16,012/16,038 mm (0.6303/0.6314 in)
 Outside diameter of idler shaft. 15,966/15,984 mm (0.6285/0.6292 in)
 Clearance of bush of idler gear on shaft. 0,028/0,072 mm (0.0011/0.0028 in)

Oil pressure relief valve (oil pump)

Diameter of bore for plunger. 19,250/19,300 mm (0.7578/0.7598 in)
 Outside diameter of plunger. 19,186/19,211 mm (0.75553/0.7563 in)
 Clearance of plunger in bore. 0,039/0,114 mm (0.0015/0.0044 in)
 Length of spring (fitted). 59,8 mm (2.3543 in)
 Load on spring (fitted) turbocharged with lubricating oil cooler. 121 N (27.1 lbf) 12,0 kgf
 Load on spring (fitted) naturally aspirated without lubricating oil cooler. 90,9 N (20.1 lbf) 9,2 kgf

Oil pressure relief valve (balancer)

Diameter of bore for plunger. 14,52/14,54 mm (0.5716/0.5724 in)
 Outside diameter of plunger. 14,46/14,48 mm (0.5692/0.5700 in)
 Clearance of plunger in bore. 0,04/0,08 mm (0.0015/0.0031 in)
 Length of spring (fitted). 45 mm (1.77 in)
 Load on spring (fitted) Turbocharged. 77/84 N (17.3/18.9 lbf) 7,8/8,5 kgf
 Load on spring (fitted) Naturally aspirated oil cooled. 70/77 N (15.7/17.3 lbf) 7,1/7,8 kgf
 Load on spring (fitted) Naturally aspirated non oil cooled. 59/65 N (13.3/14.6 lbf) 6,0/6,6 kgf

Cooling system

Coolant pump

Type	Centrifugal gear driven
Outside diameter of shaft... ..	21,425/21,438 mm (0.8435/0.8440 in)
Diameter of bore of drive gear	21,375/21,400 mm (0.8415/0.8425 in)
Interference fit of drive gear on shaft.	0,025/0,063 mm (0.0009/0.0024 in)
Diameter of bore of impeller... ..	11,943/11,971 mm (0.4701/0.4712 in)
Outside diameter of shaft for impeller	11,997/12,008 mm (0.4723/0.4727 in)
Interference fit of impeller on shaft.	0,026/0,065 mm (0.0010/0.0025 in)
Diameter of bore for bearing	39,989/40,014 mm (1.5743/1.5753 in)
Diameter of bearing	39,989/40,000 mm (1.5743/1.5747 in)
Interference fit of bearing in pump body (transition fit)... ..	+0,025/-0,011 mm (0.0009/-0.0005 in)
Dimension of impeller boss to front face of pump body (fitted)..	7,030/7,33 mm (0.276/0.288 in)
Dimension of gear from rear flat face of pump body (fitted)... ..	31,60/32,10 mm (1.244/1.263 in)

Fan drive housing

Bore of housing for bearing	61,986/62,005 mm (2.4403/2.4411 in)
Outside diameter of bearing... ..	61,987/62,000 mm (2.4404/2.4409 in)
Interference fit of bearing in housing..	0,014/-0,018 mm (0.0006/-0.0007 in)
Outside diameter of shaft... ..	25,002/25,011 mm (0.9843/0.9846 in)
Maximum permissible end-float of shaft	0,200 mm (0.0079 in)

Thermostat

Type:

- Single... ..Wax element, by-pass blanking

Part number	Nominal temperature stamped on thermostat by-pass valve	"Start to open" temperature	"Fully open" temperature	Minimum valve lift, fully open
2485C034	82 °C	79/84 °C	93 °C	10 mm

Fuel system

Bosch fuel injection pump

Type. Bosch VP30 electronic, pin timed, with a locking screw
 Direction of rotation from drive end Clockwise from drive end

Bosch fuel injection pump

Type. EPVE, with a locking screw
 Direction of rotation from drive end Clockwise from drive end

Delphi fuel injection pump

Type. DP210, with a locking screw
 Direction of rotation from drive end Clockwise from drive end

Fuel lift pump

Type. Electrically operated
 Method of drive Electric motor 12v / 24v

Blue fuel filter

Type. Single element

Green fuel filter

Type. Replaceable paper element

Atomiser service settings

Colour code	Holder	Nozzle	Set and reset pressure		
			atm	(lbf/in ²)	MP
Yellow	2645A321	2645A611	290 +8/-0	4262 +117.6/-0	29,4 +0,8/-0
Blue	2645A321	2645A612	290 +8/-0	4262 +117.6/-0	29,4 +0,8/-0
Red	2645A322	2645A613	290 +8/-0	4262 +117.6/-0	29,4 +0,8/-0
Black	2645A322	2645A614	290 +8/-0	4262 +117.6/-0	29,4 +0,8/-0
White	2645A322	2645A612	290 +8/-0	4262 +117.6/-0	29,4 +0,8/-0

Flywheel and housing

Limits for flywheel housing run-out and alignment (total indicator reading)

Diameter of housing flange bore		Maximum limit (total indicator reading)	
mm	in	mm	in
410	16.14	0,25	0.010

Electrical equipment

Alternators

Note: The information which follows is general and can change with specific applications.

Make and type Denso

Rating:

Denso A115i 12V 12V/65A, 12V/75A, 12V/85A,

Denso A127i 24V 12V/100A, 12V/120A, 24V/55A, 24V/80A

Rotation.. Clockwise from the drive end

Starter motors

Note: The information which follows is general and can change with specific applications.

Make and type Denso

Voltage:

Denso P95RL 12V 3,0 kW rhs

Denso R4.5 24V 4,5 kW rhs

Number of teeth on pinion.. 10

Maximum starter cable resistance at 200 °C (680 °F):

- 12V 0.0017 ohms

- 24V 0.0034 ohms

Starting aids

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

Type..... Glow plugs

Voltage..... 12V or 24V

Thread sealant

When setscrews or studs are fitted into holes which are tapped through the cylinder block, a suitable sealant must be used to prevent leakage.

Micro encapsulated anaerobic sealant (M.E.A.S) fasteners have been introduced instead of jointing compounds or other sealants when the fasteners are fitted in through holes into oil or coolant passages. The identification of these fasteners, as supplied, is by a red, blue, or other colour sealant around the fastener threads.

With M.E.A.S. sealed studs, the sealed end must be fitted into the cylinder head / cylinder block etc. Ensure that the threaded holes have a 1,59 mm (0.0625 in) 45° chamfer, to ensure that when the new fasteners are fitted the M.E.A.S. sealant is not removed. If the fasteners have to be removed and fitted again, the threads must be cleaned and a suitable sealant used.

Note: New setscrews have sealant applied by the manufacturer to the first 13,0 mm (0.50 in) of the threads. If the setscrews are to be used again, clean the old sealant from the male and female threads and apply new sealant, (POWERPART Threadlock and Nutlock) to the setscrews.

Standard torque values

Most of the torque values on the engine are standard. Special torque values are listed in the separate special torque tables. The standard torque values listed in the tables below can be used when a special torque is not necessary.

The torque values below apply to components lubricated with a little clean engine oil before they are fitted.

Standard torques for 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	32	4,5
M12 x 1,25	78	58	8,0
M14 x 2,00	124	92	13,0
M16 x 2,00	190	140	19,3

Standard torques for studs (metal end)

Thread size	Torque		
	Nm	lbf ft	kgf m
M6 x 1,00	5	4	4
M8 x 1,25	11	8	1,1
M10 x 1,50	18	13	1,8
M12 x 1,75	25	18	2,5

Standard torques for pipe unions, plugs, and adaptors

Thread size inches	Torque		
	Nm	lbf ft	kgf m
1/8 PTF	9,5	7	0,9
1/4 PTF	17	12	1,7
3/8 & 1/2 PTF	30	22	3,0
3/4 PTF	45	33	4,6

Specific torque values

The torque values below apply to components lubricated with a little clean engine oil before they are fitted.

Special torques for setscrews and nuts

Description	Thread size	Torque		
		Nm	lbf ft	kgf m
Cylinder head assembly				
Setscrew cylinder head	See Operation 3-10			
Torx screw, rocker shaft	M8	35	26	3,5
Lock nut, rocker lever adjustment	3/8 UNF	27	20	2,7
Fastener, rocker cover	M6	9	7	0,9
Setscrew, heatshield to cover	M6	9	7	0,9
Setscrew, exhaust manifold to cylinder head	M10	33	24	3,3
Piston and connecting rod assemblies				
Setscrew, fracture split connecting rod	See Operation 4-2			
Crankshaft assembly				
Setscrews, main bearings	5/8 UNF	245	180	25
Setscrew, crankshaft pulley	7/16 UNF	115	85	12
Allen screws, bridge piece to cylinder block	M6	16	12	1,6
Torx screw, rear end oil seal housing	M8	22	16	2,2
Setscrews, balancer to cylinder block	M10	54	39	5,5
Timing case and drive assembly				
Setscrew, camshaft gear	M12	95	70	9,7
Setscrew, PTO blanking plate plastic	M10	22	16	2,2
Setscrew, plastic oil filler	M8	22	16	2,2

Description	Thread size	Torque		
		Nm	lbf ft	kgf m
Cylinder block				
Plug, compressor oil feed	M10	22	16	2,2
Plug, oil rail rear face	7/8 UNF	68	50	7,0
Plug, front feet	M12	46	34	4,6
Plug, turbocharger feed	M10x1	19	14	1,9
Plug, coolant drain	1/4 NSPM	40	29	4,0
Fuel system				
Nuts, high-pressure fuel pipes	M12	30	22	3,0
Setscrew, atomiser clamp	M8	35	26	3,5
Nut, fuel injection pump to gear (mechanical)	M14	88	65	9,0
Setscrews, gear to fuel injection pump electronic	M8	22	16	2,2
Setscrew, timing case to fuel injection pump	M8	25	18	2,5
Locking screw on shaft of Bosch fuel injection pump	M10	31	23	3,1
Locking screw in run position of Bosch fuel injection pump	M10	12	9	1,2
Locking screw on shaft of DP 210 fuel injection pump	M12	17	12	1,7
Locking screw in run position of DP 210 fuel injection pump	M12	12	9	1,2
Lubrication system				
Plug, lubricating oil sump	G 3/4	34	25	3,4
Oil inspection valve	M10 x 1	12	9	1,2
Oil inspection valve plug	M10 x 1	12	9	1,2
Nut, dipstick tube	M16	18	13	1,8
Element oil filter	3 1/2 ACME	25	18	2,5
Cooling system				
Setscrews, fan drive housing to cylinder head	M10	44	32	4,5
Setscrews, fan drive pulley to hub	M8	12	9	1,2
Setscrews, fan	M8	12	9	1,2
Flywheel and housing				
Engine types RE, RF, RG, RJ and RH Setscrews, flywheel to crankshaft	1/2 UNF	105	77	10,7
Engine type RK Setscrews, flywheel to crankshaft	1/2 UNF	115	85	11,7
Setscrews, cast iron flywheel housing to cylinder block:	M10	44	32	4,5
- Head stamped 8.8	M12	75	55	7,6
- Head stamped 10.9	M10	63	46	6,4
- Head stamped 10.9	M12	115	85	11,7
Setscrews, flywheel housing to cylinder block (paper joint)	M10	70	52	7,1
Aspiration system				
Nuts, turbocharger to manifold	M10	47	35	4,8
Banjo bolt, turbo feed	M10x1	22	16	2,2
Fastener, breather pipe to cylinder head	M6	9	7	0,9

Description	Thread size	Torque		
		Nm	lbf ft	kgf m
Electrical equipment				
Sensor, engine oil pressure	M12 x 1,5	10	7	1,0
Plug, engine oil pressure	M12 x 1,5	12	9	1,2
Sensor, inlet manifold temperature	M18	20	15	2,0
Plug, inlet manifold temperature	M18	20	15	2,0
Sensor, inlet manifold pressure	M12	10	7	1,0
Plug, inlet manifold pressure	M12	10	7	1,0
Sensor, coolant temperature	M18	20	15	2,0
Plug, coolant temperature	M18	20	15	2,0
Setscrew, ECM plug to ECM.	M5	6	4	0,6
KSB	1/2 PTF	30	22	3,0
Glow plug to cylinder head	M10	18	13	1,8
Nut, bus-bar to glow plug	M4	2	1	0,2
Nut, alternator pulley: - CAV AC5RA and AC5RS - Thin nut A127, and Motorola pulley, 22 mm A/F - Thick nut A127, and Motorola pulley, 24 mm A/F - Bosch 55A - Bosch 55A - Butec 5524	M16	80	59	8,1
Nut, starter motor	M10	44	32	4,5

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, see Operation 3-7.
- 2 Remove the atomisers, see Operation 11-3.
- 3 Fit a suitable gauge into the atomiser hole of the cylinder to be tested.

Warning! Ensure that the engine cannot start.

- 4 Operate the starter motor and record the pressure indicated on the gauge for each cylinder.

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 which indicate when an overhaul is necessary are how easily the engine starts and its general performance.

The cast iron cylinder head is fastened to the cylinder block by flanged head setscrews. The cylinder head gasket is a multi-layer construction. The individual inlet and exhaust ports are designed to assist air swirl and improve air flow.

The intake manifold is integral within the cylinder head, and the rocker cover also contains the engine breather pipe.

The cylinder head assembly has two overhead valves fitted for each cylinder. Each overhead valve is held in place by a single coil spring, cap, and two collets. The face angle of the intake and the exhaust valves are both 30°. The cylinder head has steel valve seat inserts fitted for both the intake and the exhaust valves, and these can be renewed. The angles of the valve seats in the cylinder head for the intake and the exhaust valves are both 30°. The valves move in sintered steel valve guides which can also be renewed. The exhaust valve guides have a counterbore to prevent seizure of the valve stem caused by a build up of carbon under the head of the valve. Each valve stem is fitted with a synthetic rubber oil seal.

The overhead valves are operated by a rocker shaft assembly fitted to the top of the cylinder head and under a composite rocker cover. The forged steel rocker levers are operated by cold drawn push rods with hardened heads. The rocker shaft is secured to the cylinder head by sintered steel brackets between each pair of valves. The rockers and valve gear are lubricated by an oil flow from the hollow rocker shaft that receives a reduced oil flow from the camshaft oil feed.

Tappet adjustment is achieved by adjustment screws and locknuts at the push rod end of each rocker lever.

Atomiser cover

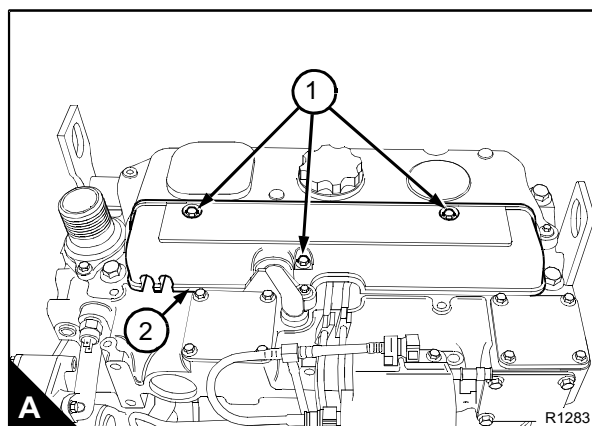
To remove and to fit**Operation 3-1**

To remove

- 1 Remove the atomiser cover setscrews (A1) and remove the atomiser cover (A2).

To fit

- 1 Fit the atomiser cover (A2) and tighten the setscrews (A1) to 9 Nm (7 lbf ft) 0,9 kgf m.



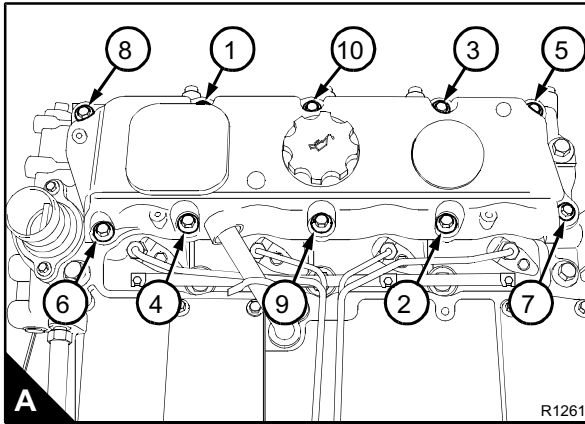
Rocker cover

To remove

Operation 3-2

Note: If a top mounted turbocharger is fitted, the heat shield must be removed first.

- 1 Remove the atomiser cover, see Operation 3-1
- 2 Remove the breather pipe, see Operation 9-5 or Operation 9-6.
- 3 Release the fasteners (A), remove the rocker cover and discard the joint.

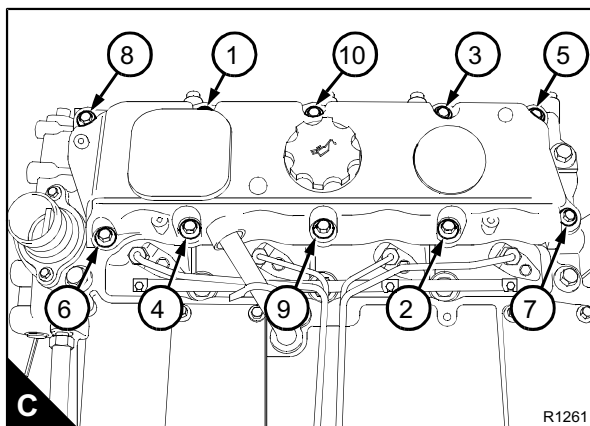
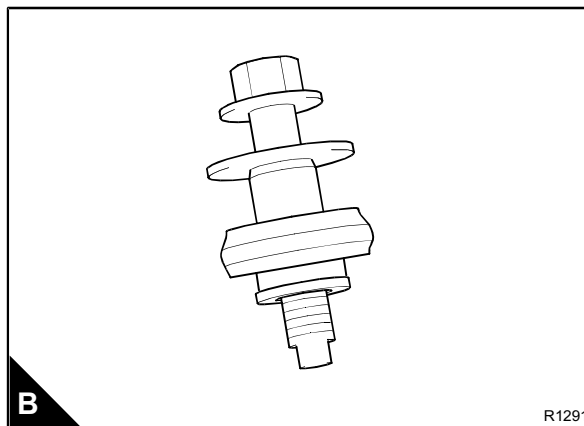
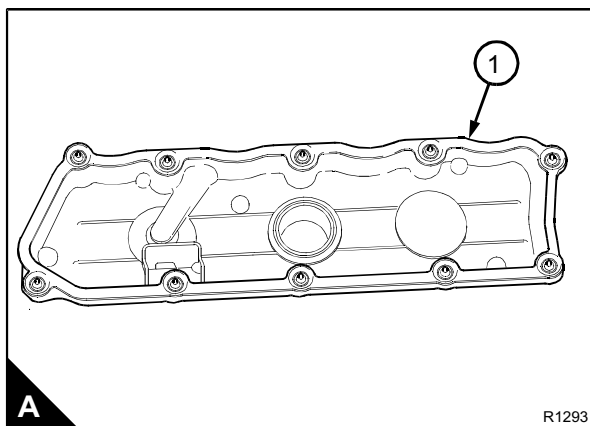


To fit

Operation 3-3

Note: Reflective heat shields fitted to the rocker covers must be kept clean and free from dust, oil or paint. If the surface of the heat shield is not shiny, the component that is protected by the heat shield could be damaged.

- 1 If the rocker cover has an oil filler, check the condition of the “O” ring, renew as required.
- 2 Ensure that the rocker cover and the groove for the joint are clean and free from oil and grease.
- 3 Fit a new joint (A1) to the rocker cover.
- 4 Check the condition of the fasteners (B), renew as required.
- 5 Clean the seal face of the cylinder head and fit the rocker cover.
- 6 Secure the rocker cover to the cylinder head with the fasteners and tighten in sequence (C) to 9 Nm (7 lbf ft) 0,9 kgf m.
- 7 Fit the breather pipe, see Operation 9-5 or Operation 9-6.



Rocker assembly

To remove and to fit

Operation 3-4**Special requirements**

Special tools	
Description	Part number
Rocker assembly tools	27610227

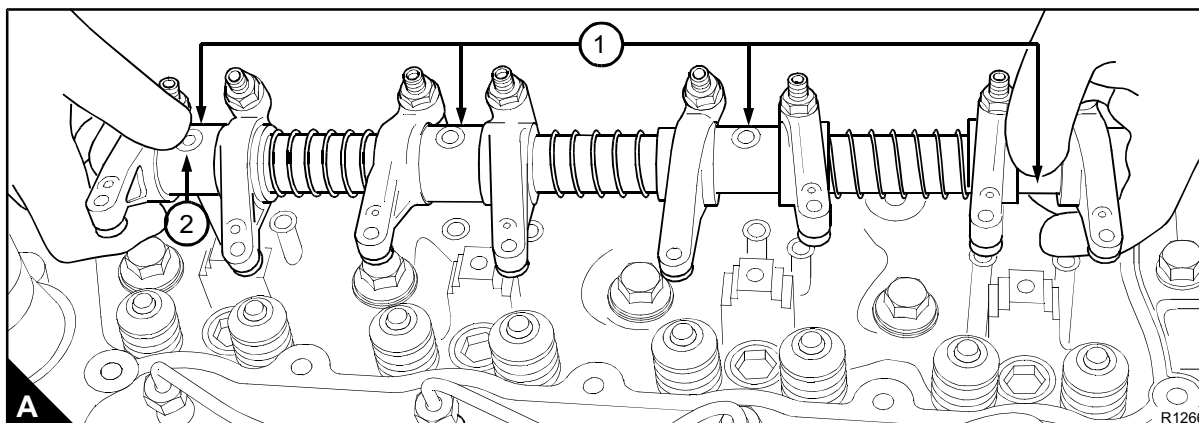
To remove

- 1 Remove the atomiser cover, see Operation 3-1.
- 2 Remove the rocker cover, see Operation 3-2.
- 3 Fit the rocker assembly tools between each pair of rocker levers (A1).
- 4 Release evenly and gradually the Torx screws of the rocker shaft; begin with the end Torx screws and move toward the centre. Remove the Torx screws and lift off the rocker assembly.

To fit

Note: Ensure that the machined square is facing upwards before the rocker assembly is fitted and that the longest Torx screw is fitted in (A2).

- 1 Check that the push rods fit correctly in the sockets of the tappets and ensure that the rocker assembly tools are correctly fitted between each pair of rocker levers (A1). Fit the rocker assembly. Check that the ends of the adjustment screws fit correctly in the sockets of the push rods.
- 2 Fit the Torx screws for the rocker shaft and tighten the Torx screws 35 Nm (26 lbf ft) 3,6 kgf m; begin with the inner Torx screws and work outwards.
- 3 Set valve tip clearance, see Operation 3-7.
- 4 Fit the rocker cover, see Operation 3-3.
- 5 Fit the atomiser cover, see Operation 3-1.



To dismantle and to assemble

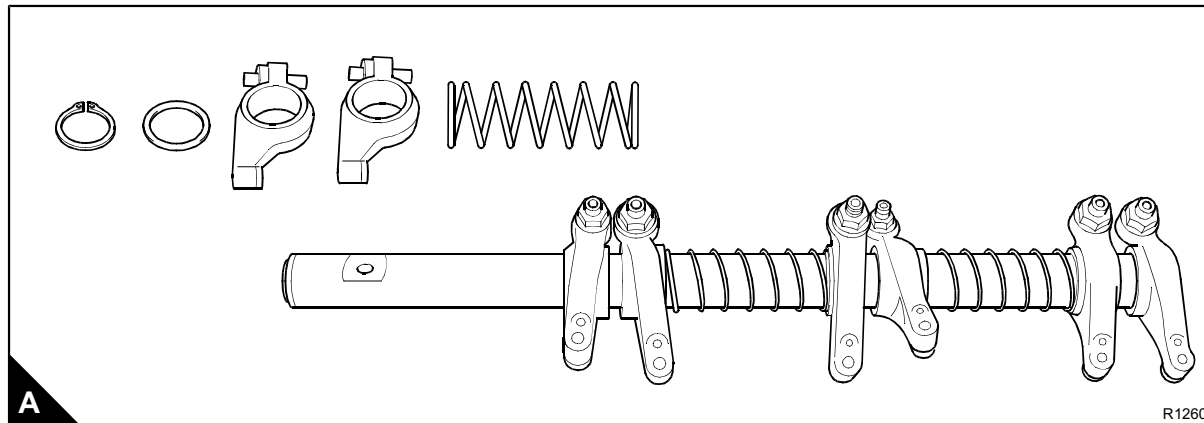
Operation 3-5

To dismantle

- 1 Remove the circlips from both ends of the rocker shaft. Ensure that the ends of the rocker shaft are not damaged.
- 2 Dismantle the assembly and make a note of the position of each component to ensure that they can be assembled in the same position.

To assemble

- 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 order. Fit the circlips to the ends of the rocker shaft.



To inspect and to correct

Operation 3-6

To inspect

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

Valve tip clearances

To check and to adjust

Operation 3-7

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

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

Note: Number 1 cylinder is the furthest cylinder from the flywheel end of the engine.

1 Rotate the crankshaft in the normal direction of rotation until the intake valve (B7) of number 4 cylinder has just opened and the exhaust valve (B8) of the same cylinder has not closed completely. Check the clearances of the valves (B1 and B2) of number 1 cylinder and adjust them, if necessary.

Note: The correct torque for the locknut on the adjusting screws is 27 Nm (20 lbf ft) 2,8 kgf m.

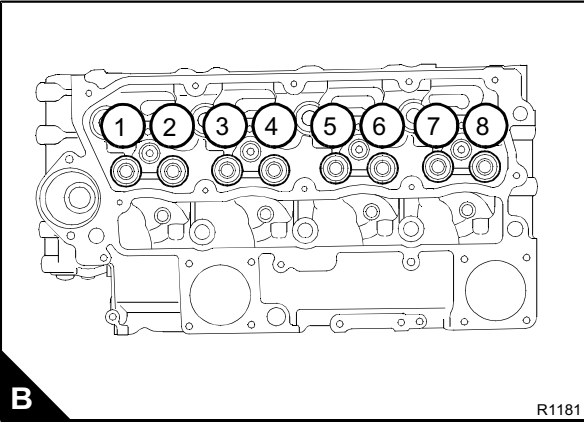
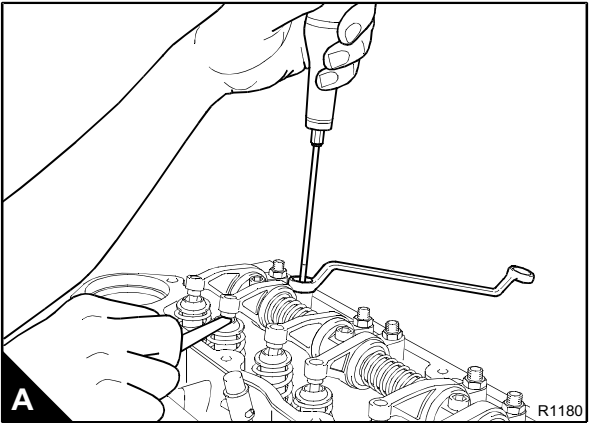
2 Set the valves (B3 and B4) of number 2 cylinder as indicated above for number 4 cylinder. Then check / adjust the clearances of the valves (B5 and B6) of number 3 cylinder.

3 Set the valves (B1 and B2) of number 1 cylinder. Then check / adjust the clearances of the valves (B7 and B8) of number 4 cylinder.

4 Set the valves (B5 and B6) of number 3 cylinder. Then check / adjust the clearances of the valves (B3 and B4) of number 2 cylinder.

Note: After the valve tip clearances have been adjusted, lubricate the rocker assembly with clean engine oil. Apply particular attention to the rocker shaft bearing surfaces, valve tips, push rod sockets and the push rods so that the oil will drain to lubricate the cam followers.

Cylinder and Valve number	1		2		3		4	
	1	2	3	4	5	6	7	8
Valve I = Intake E = Exhaust	I	E	I	E	I	E	I	E



Valve springs

To change the valve springs (with cylinder head fitted)

Operation 3-8

Special requirements

Special tools			
Description	Part number	Description	Part number
Valve spring compressor	21825666	Setscrew adaptor used with 21825666	27610235

Note: Steps 1 to 11 refer to a change of valve spring for a single cylinder.

Warning! Wear eye protection during this operation.

- 1 Remove the atomiser cover, see Operation 3-1.
- 2 Remove the rocker cover, see Operation 3-2.
- 3 Rotate the crankshaft in the normal direction of rotation until the intake 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).
- 4 Remove the rocker assembly, see Operation 3-4.
- 5 Fit the valve spring compressor (A1) and the adaptor (A2).

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

Note: Do not over compress the valve springs so that coils are touching.

- 6 Compress the valve spring and remove the collets. Ensure that the valve spring is compressed squarely or damage to the valve stem can occur.

Caution: Do not rotate the crankshaft while the valve spring is removed.

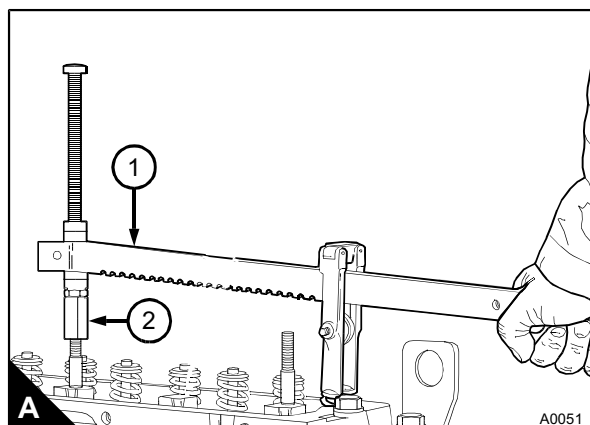
- 7 Release the valve spring compressor and remove the valve spring, cap and valve seal.

Note: The valve stem seal must only be used once.

- 8 Ensure that the new valve stem seal is clean, not damaged and that the spring is present and correctly located on the seal.

- 9 Lubricate the valve stem with clean engine oil. Fit the valve stem seal onto the valve guide and ensure that the seal and the seating washer are correctly located.

- 10 Put the new valve spring in position, ensure that the larger diameter is against the cylinder head.



Continued

11 Fit the valve spring cap.

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

Note: Do not over compress the valve springs so that coils are touching.

12 Fit the valve spring compressor, compress the valve spring and fit the collets. Remove the valve spring compressor.

13 Fit the rocker assembly, see Operation 3-4.

14 Check the valve tip clearances, see Operation 3-7.

15 Fit the rocker cover, see Operation 3-3.

Note: If other or all of the valve springs are to be changed, they can be changed two cylinders at a time. The sets of cylinders are 1 and 4, 2 and 3.

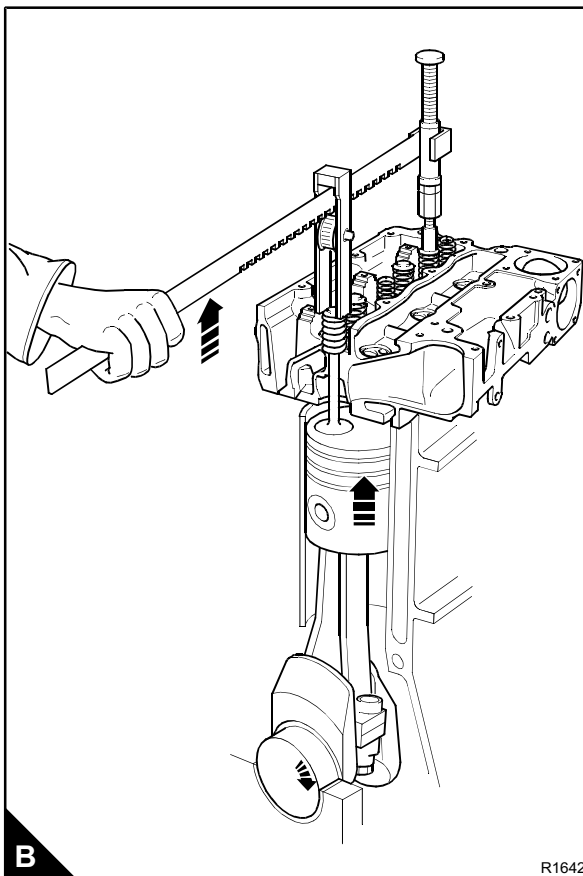
If the rocker assembly has been removed, piston TDC can be found as follows:

1 Fit the valve spring compressor and compress the valve springs to open the valve.

2 Rotate the crankshaft, by hand, in the normal direction of rotation until the piston touches the valve.

Note: Ensure that the collets are fully located before the pressure is released on the valve spring compressor.

3 Continue to rotate the crankshaft, and at the same time, release pressure on the valve spring compressor until the piston is at TDC (B).

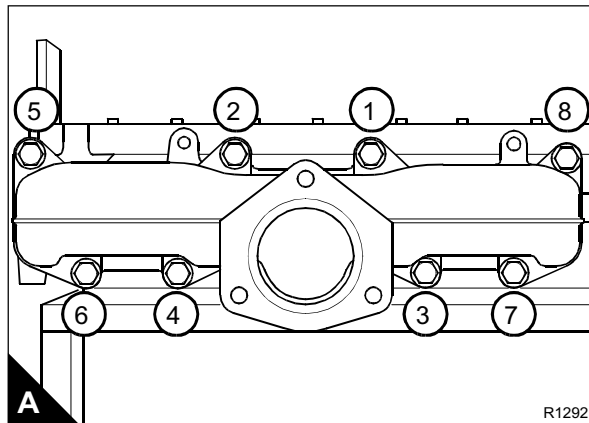


Cylinder head assembly

To remove

Operation 3-9

- 1 Drain the cooling system.
- 2 Disconnect the battery terminals.
- 3 Remove the air filter / cleaner hose at the intake manifold.
- 4 For engines fitted with a boost control device, remove the boost control pipe that is fitted between the intake manifold and the top of the fuel injection pump.
- 5 For engines fitted with a turbocharger, disconnect all connections to the turbocharger and remove the turbocharger, see Operation 9-2.
- 6 Release the exhaust manifold fasteners in the reverse sequence to that shown in (A).



- 7 Remove the low-pressure fuel pipes which are fitted between the fuel injection pump and the fuel lift pump with integral fuel filter.

- 8 Remove the fuel lift pump with integral fuel filter.

Caution: Where access to the fuel injection pump outlet unions is possible, ensure that a separate spanner is used to prevent movement of the fuel injection pump outlets when the connections of the high-pressure pipes are released. Fit suitable covers to all open connections on the fuel injection pump.

- 9 Remove the atomiser cover, see Operation 3-2.
- 10 Remove the high-pressure fuel pipes.
- 11 Remove the atomiser leak-off hoses.
- 12 Remove the atomisers, see Operation 11-3. Fit suitable covers to the nozzles and the open connections.
- 13 Remove the bus-bar and glow plugs.
- 14 Release the setscrews of the coolant by-pass pipe at the timing case. Remove the coolant by-pass pipe from the cylinder head.
- 15 Disconnect the coolant temperature sensor/sender unit.
- 16 Remove the rocker cover, see Operation 3-2.
- 17 Remove the rocker assembly, see Operation 3-4.
- 18 Remove the push rods.

Continued

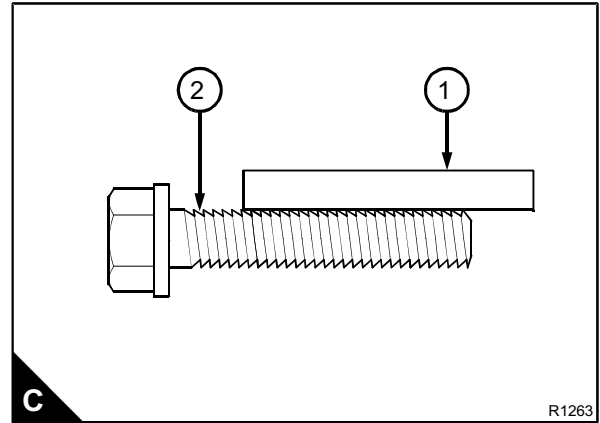
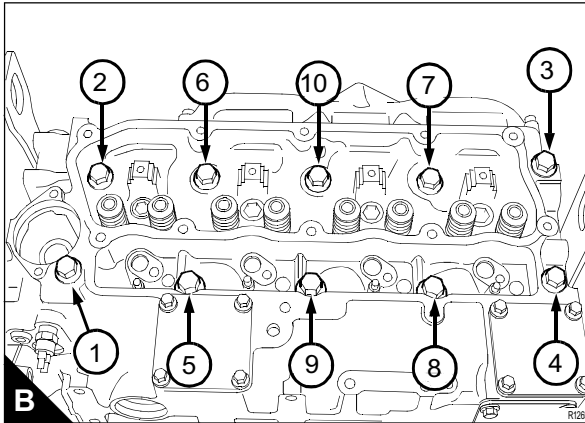
19 Release the cylinder head setscrews evenly and gradually in the reverse sequence to that shown in (B).

20 Check the setscrews for distortion with a straight edge (C1) held along the setscrew (C2). If there is a visual reduction in the diameter of the thread that has not been in engagement with the cylinder block, the setscrew must be discarded.

Caution: Do not use a lever to separate the cylinder head from the cylinder block, as this may damage the face of either the cylinder head or the cylinder block.

21 Remove the cylinder head and put it on a surface that will not damage the bottom face of the cylinder head.

22 Remove the cylinder head gasket.



To fit

Operation 3-10

Special requirements

Special tools	
Description	Part number
Angle gauge (to tighten cylinder head setscrews)	21825607

1 With a suitable cleaner, clean thoroughly the bottom face of the cylinder head and the top face of the cylinder block. Hard carbon and corrosion 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 and there is no debris in the cylinder bores, see "Cylinder head" on page 12.

Note: The engines have two location pins (A2), one at each end of the cylinder head, pressed into the cylinder block to hold the cylinder head and cylinder head gasket in the correct position when the cylinder head is fitted.

Cautions:

- To prevent damage to the cylinder head gasket, ensure that the location pins are pressed in the cylinder block before the cylinder head is fitted.
- The cylinder head gasket must be fitted without jointing compound.

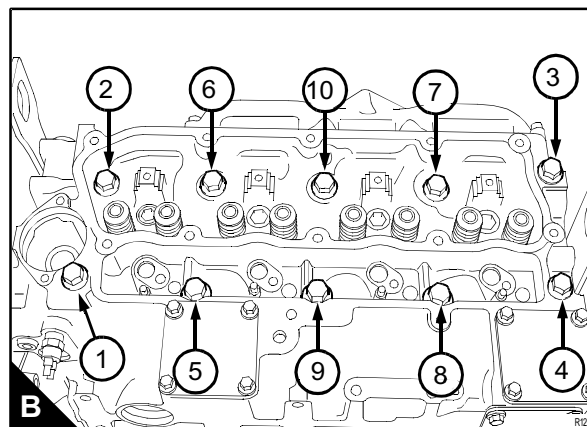
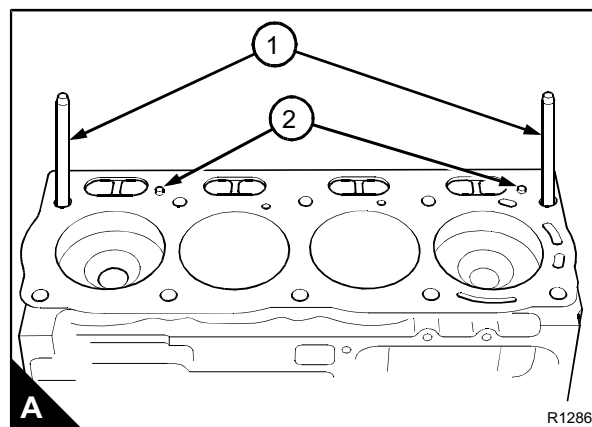
2 Fit a new cylinder head gasket in the correct position.

3 To ensure the cylinder head is fitted into the correct position, fit two suitable M15 guide studs (A1). Put the cylinder head in position. Ensure that the two location pins are fully engaged in the cylinder head.

4 Apply a small amount of lubricant to the threads and the thrust faces of the cylinder head setscrews. Engage the seven short setscrews in positions 2, 5, 6, 7, 8, 9, 10, then remove the guide studs (A1). Fit the three long setscrews in positions 1, 3, 4.

5 Tighten the setscrews to 50 Nm (37 lbf ft) 5,1 kgf m in the sequence shown in (B).

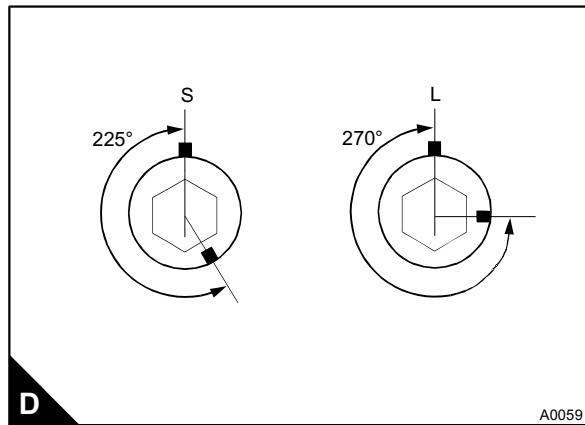
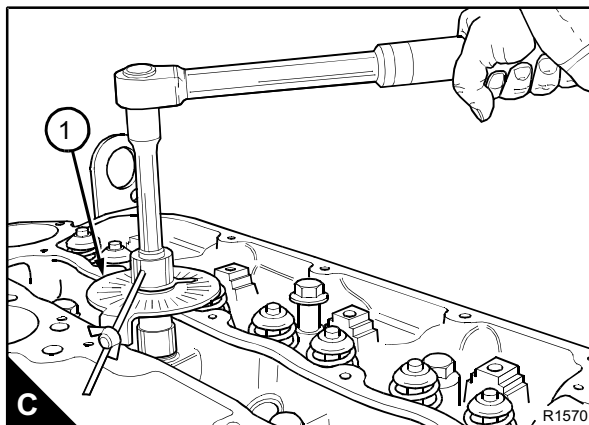
6 Tighten the setscrews to 100 Nm (74 lbf ft) 10,0 kgf m in the sequence shown in (B).



Continued

7 Tighten the setscrews, in the correct sequence, a further part of a turn according to the length of the setscrews. Short setscrews (S) must be turned a further 225°. Long setscrews (L) must be turned a further 270°. A special tool (C) can be used for this operation.

Fit the tool between the socket and the handle. Position the stop (C1) against a suitable protrusion on the cylinder head to prevent movement of the degree dial in a clockwise direction. Rotate the pointer to align with the relevant angle on the degree dial for the length of setscrew. Tighten the setscrew until the pointer on the tool is aligned with the zero position on the degree dial.



If no tool is available, make a suitable mark on the cylinder head in line with a corner of each setscrew (D). Make another mark, at the correct angle (counter-clockwise), on the edge of the flange of each fastener according to the length of the 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.

8 Put the push rods in position. Ensure that the end of each push rod fits correctly in the tappet socket.

9 Fit the rocker assembly, see Operation 3-4.

10 Set the valve tip clearances, see Operation 3-7.

11 Fit the atomisers, see Operation 11-4.

12 Fit the atomiser leak-off hoses.

13 Fit the glow plugs and bus-bar, see Operation 14-10.

14 Fit the high-pressure fuel pipes; tighten the connection nuts to 22 Nm (16 lbf ft) 2,2 kgf m.

Caution: Where access to the fuel injection pump outlet unions is possible, ensure that a separate spanner is used to prevent movement of the fuel injection pump outlets when the connections of the high pressure pipes are tightened.

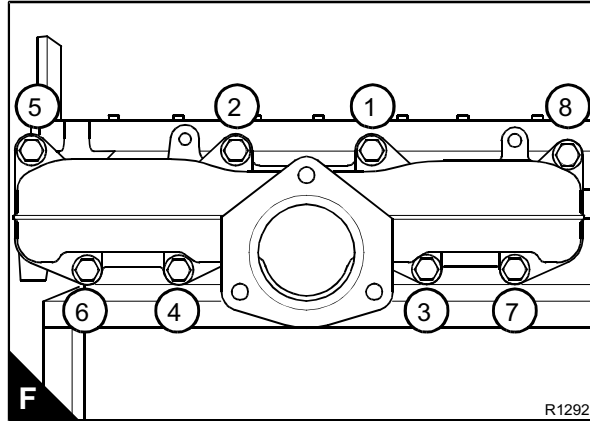
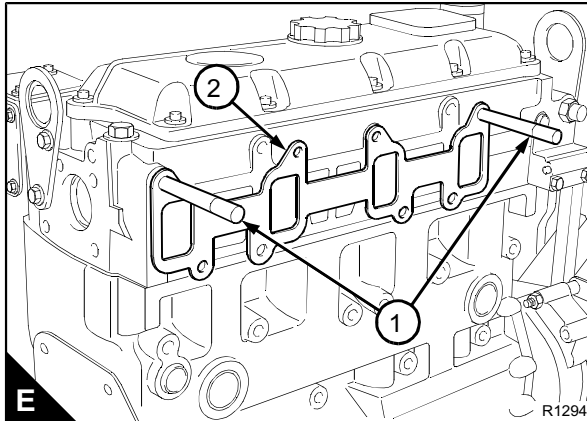
15 Fit the fuel lift pump with integral fuel filter and the bracket. Fit the low-pressure fuel pipes between the fuel injection pump and the fuel lift pump with integral fuel filter.

16 Fit the coolant by-pass pipe, see Operation 12-13.

Continued

17 Fit two suitable temporary studs (E1) then fit the exhaust manifold joint (E2).

Caution: Damage to the exhaust manifold can occur if not aligned and tightened correctly.



18 Fit the exhaust manifold and the fasteners, lightly tighten the fasteners 1 and 2 (F).

19 Remove the two temporary studs, fit the remaining fasteners and lightly tighten.

20 Evenly and gradually tighten the exhaust manifold fasteners to 33 Nm (24 lbf ft) 3,4 kgf m in the sequence shown (F).

21 For engines fitted with turbochargers, fit the turbocharger, see Operation 9-3.

22 Connect the electrical connection to the cold start device.

23 For engines fitted with a boost control device, fit the boost control pipe between the intake manifold and the top of the fuel injection pump.

24 Fit the electrical connection to the coolant temperature sensor/sender unit.

25 Connect the coolant outlet and the hoses for the cab heater. Tighten the clips.

26 Fill the cooling system.

27 Connect the air filter/cleaner.

28 Connect the battery.

29 Eliminate air from the fuel system, see Operation 11-8.

30 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 3-3.

Note: It is not necessary to tighten the cylinder head setscrews again with the engine hot or after a limited period in service.

Valves and valve springs

To remove

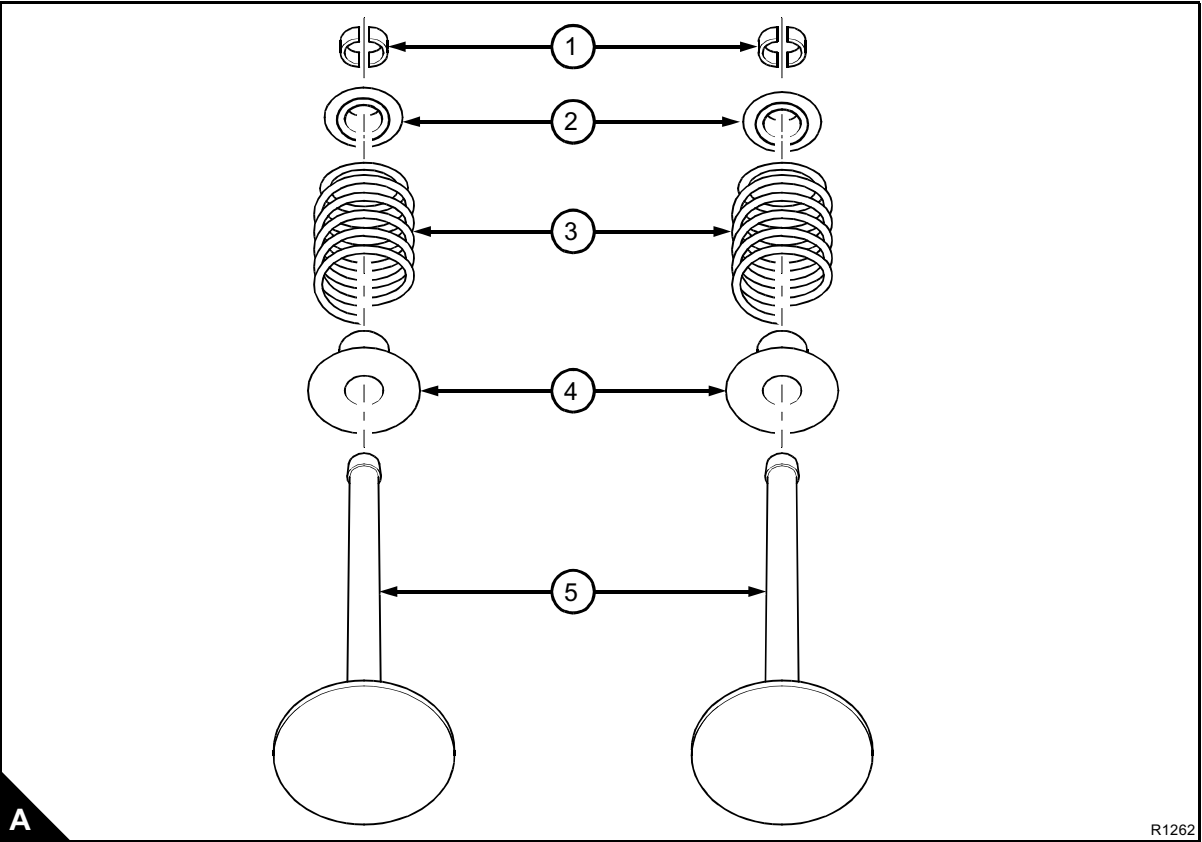
Operation 3-11

Special requirements

Special tools			
Description	Part number	Description	Part number
Valve spring compressor	21825666	Setscrew adaptor used with 21825666	27610235

Warning! Wear eye protection during this operation.

- 1 Remove the cylinder head, see Operation 3-9.
 - 2 Clean the bottom face of the cylinder head and check the depth of the heads of the valves below the face of the cylinder head, see Operation 3-13.
 - 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.
- Caution:** Ensure that the valve springs are compressed squarely or the valve stem can be damaged.
- Note:** Do not over compress the valve springs so that coils are touching.
- 4 Use the valve spring compressor and the relevant adaptor to compress the valve spring (A3) and remove the collets (A1).
 - 5 Release the valve spring compressor and remove the valve spring cap (A2), valve spring and valve stem seal (A4).
 - 6 Repeat steps 4 and 5 for the other valves.



To fit

Operation 3-12

Special requirements

Special tools			
Description	Part number	Description	Part number
Valve spring compressor	21825666	Setscrew adaptor used with 21825932	27610235

Warning! Wear eye protection during this operation.

Cautions:

- Valves must not be lapped, as the special heat resistant layer on the face of the valve will be destroyed.
- If inlet valves are badly worn or damaged they must be replaced.

Note: The intake valve has a larger diameter head than the exhaust valve.

1 Lubricate the valve stem (A5) with clean engine oil and fit the valves in their respective guides.

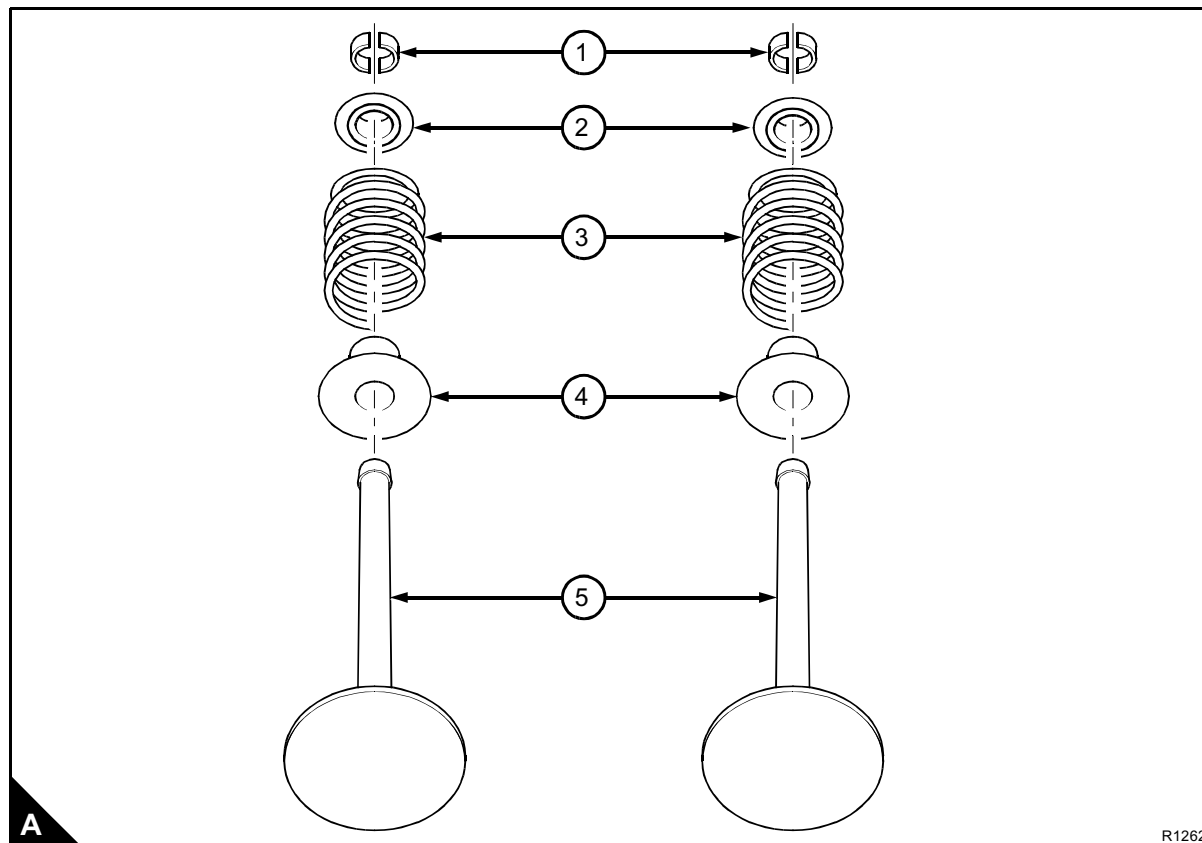
Note: The valve stem seal must only be used once.

2 Fit new valve stem seals (A4) on the valve guides.

3 Put the valve springs in position, ensure that the larger diameter is against the cylinder head. Fit the valve spring cap (A2).

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

4 Use the valve spring compressor and the relevant adaptor to compress the valve spring (A3) and fit the collets (A1).



To inspect and to correct

Operation 3-13

Special requirements

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

- 1 Ensure that the heads of the valves and the bottom face of the cylinder head are clean.
- 2 Put the valve depth gauge on the face of the cylinder head and zero the dial gauge.
- 3 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 the "Intake and exhaust valves" on page 13.
- 4 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 must be renewed, see Operation 3-19.
- 5 Check the valves for cracks. Check the stems of the valves for wear and for correct fit in their valve guides.

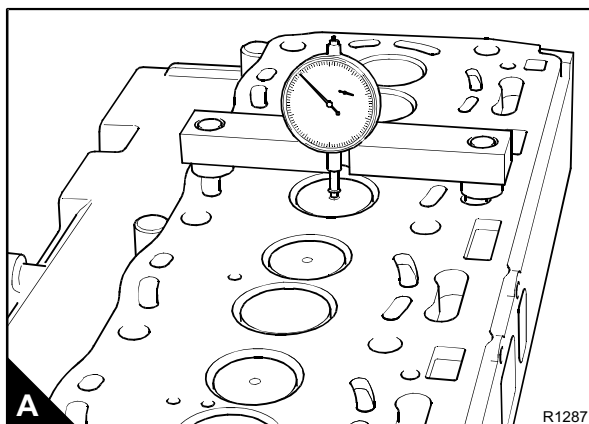
Cautions:

- Valves must not be lapped, as the special heat resistant layer on the face of the valve will be destroyed.
- If inlet valves are badly worn or damaged they must be replaced.

6 Check that the seat faces of the valves are not badly burnt or damaged. Seat faces of valves which are damaged can be ground on a special machine.

When new valves are fitted, the valve depths must be checked after the valve springs are fitted.

7 Check that the load on the valve springs is correct at their fitted length, refer to the relevant Data and dimensions for the "Valve guides and valve springs" on page 16. Fit new valve springs at every complete engine overhaul.



Valve guides

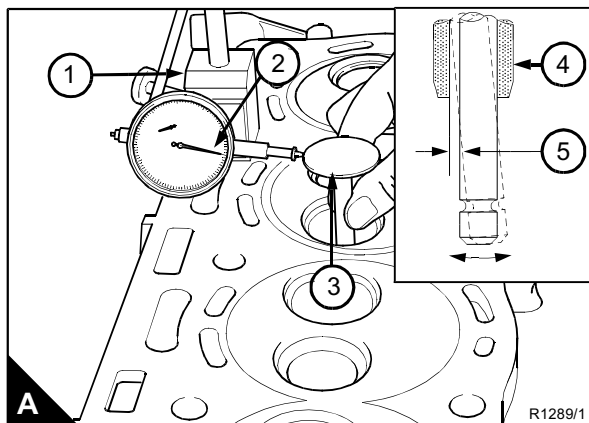
To inspect

Operation 3-14

To check the valve guides for wear. The maximum permissible clearance (A5) with a valve lift of 15,0 mm (0.6 in), between the valve stem and the bore of the guide is 0,22 mm (0.009 in) for intake valves and 0,25 mm (0.010 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 to 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 above, a new valve guide (A4) must be fitted.



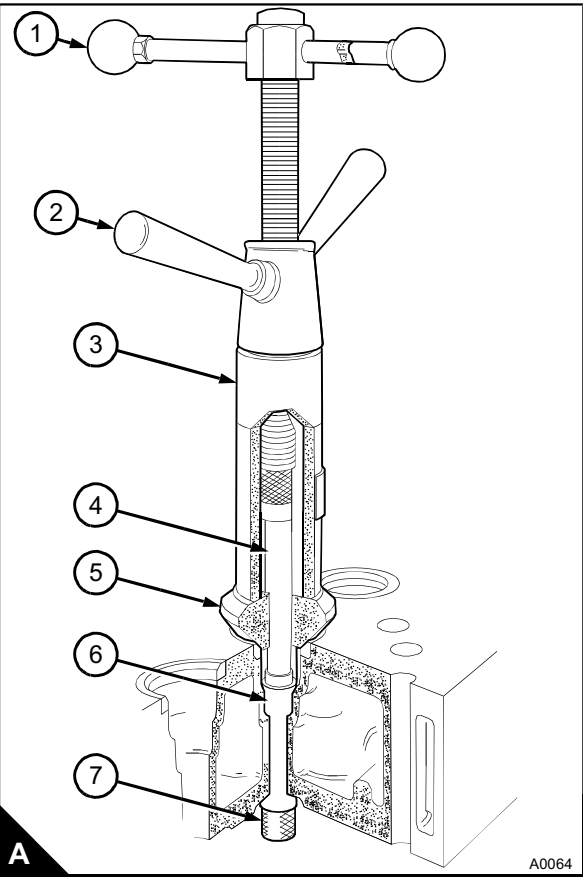
To remove

Operation 3-15

Special requirements

Special tools			
Description	Part number	Description	Part number
Remover/replacer for valve guides	21825478	Adaptor used with 21825478	21825479

- 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 (A4) 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

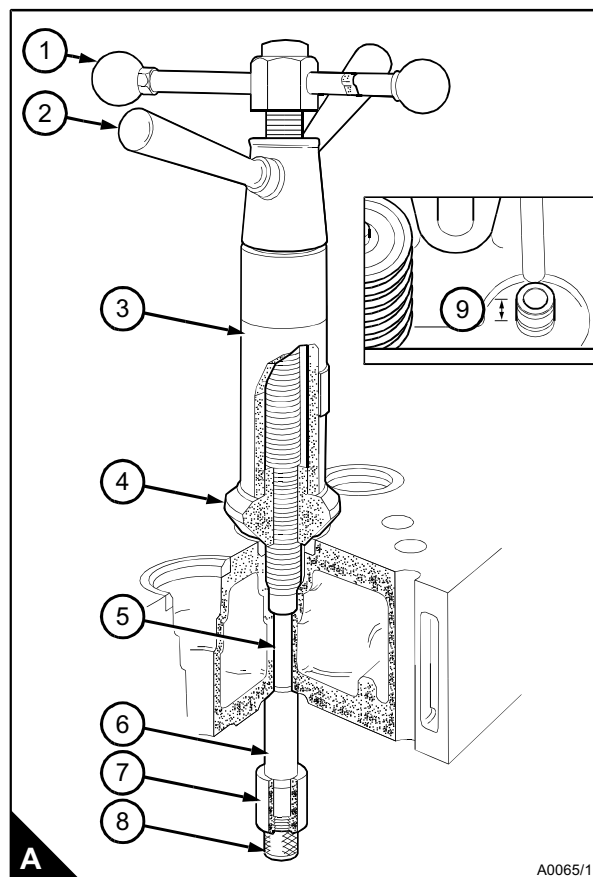
Operation 3-16

Special requirements

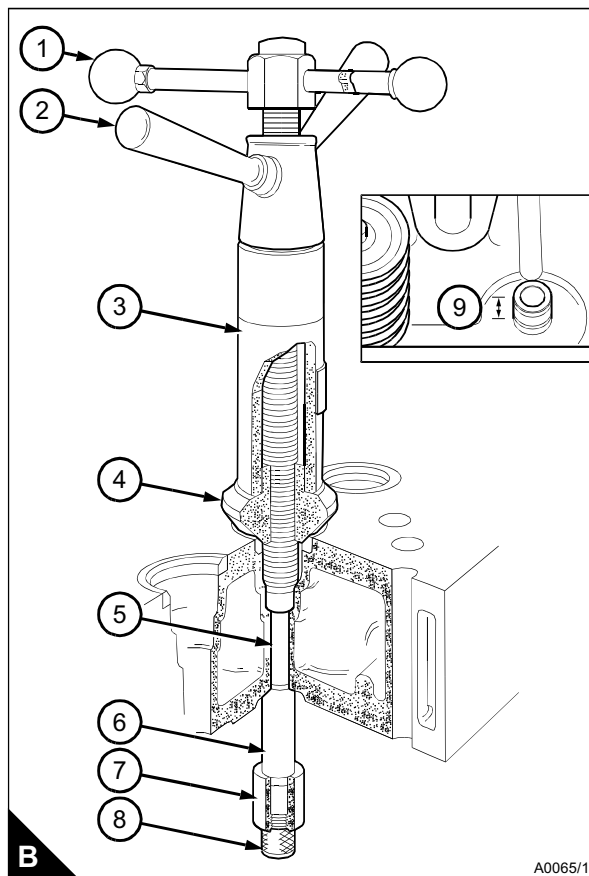
Special tools			
Description	Part number	Description	Part number
Remover/replacer for valve guides	21825478	Adaptor, used with 21825478, and 21825479	27610234
Adaptor used with 21825478	21825479		

Note: The partially finished valve guides are reamed and the valve seats are cut in one operation with a special tool. The valve seat and the guide are cut in one operation to ensure the concentricity of the valve seat to the valve guide. This will ensure a good seal between the guide and its seat. New valves and new valve seat inserts must be fitted each time a new valve guide is fitted. Valves must not be lapped. If all or most of the original valve guides need to be renewed it may be cost effective to overhaul or exchange the cylinder head.

- 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.

*Continued*

- 5** Put the valve guide in position on the adaptor and fit the adaptor (B7). Fit the attachment (B8) to secure the valve guide to the adaptor.
- 6** Hold the top handle (B1) and turn the bottom handle (B2) clockwise to pull the valve guide until the distance piece contacts the cylinder head.
- 7** When the valve guide is fitted correctly, the top of the valve guide will have a protrusion (B9) of 12,35/12,65 mm (0.486/0.498 in) above the valve spring seat.
- 8** Ream the valve guide to the finished size, see Operation 3-18.



Cylinder head

To inspect and to correct

Operation 3-17

- 1 Remove the cylinder head assembly, see Operation 3-9.
- 2 Remove the thermostat housing, see Operation 12-1.
- 3 Inspect the cylinder head for signs of gas or coolant leakage.
- 4 Remove the valve springs and the valves, see Operation 3-11.
- 5 Clean the face of the cylinder head and the passages for coolant and for lubricating oil. The coolant jacket can be cleaned with a special solvent which must be used in accordance with the manufacturer's instructions.
- 6 Test the cylinder head for leaks at the pressure given in the relevant Data and dimensions for the "Cylinder head" on page 12.
- 7 When the cylinder head is thoroughly clean, check it for cracks. Inspect carefully the areas around the valve seats and around the holes for the atomiser nozzles.

Caution: Remove only the minimum material and ensure that the thickness of the cylinder head will not be less than 117,20mm (4.614 in) after the cylinder head has been machined.

- 8 The bottom face of the cylinder head can be machined if there is distortion, or deep scratches, see step 9.
- 9 Use a straight edge and feeler gauges to check the cylinder head for distortion. Refer to the relevant Data and dimensions for the "Cylinder head" on page 12.

If the distortion is more than the given limit, the bottom face can be machined. Refer to the relevant Data and dimensions for the "Cylinder head" on page 12 for the surface grade finish of the cylinder head face.

Cautions:

- After the cylinder head has been machined the valve seats must be corrected to give the correct valve head depth.
 - Work to the minimum limit to allow for later wear.
- 10 Check the valve seats for wear and for damage.
 - 11 Before any work is done on the valve seats, new valve guides must be fitted, see Operation 3-16.
 - 12 Badly damaged valve seats can be corrected by use of the cutter tool, see Operation 3-18, or new inserts can be fitted, see Operation 3-19.

To correct a valve seat with a valve seat cutter

Operation 3-18

Special requirements

Special tools	
Description	Part number
Cutter (30°) for inlet and exhaust valve seats and valve guide reamer	27610030

Caution: Valves must not be lapped.

Note: The partially finished valve guides are reamed and the valve seats are cut in one operation with a special tool. The valve seat and the guide are cut in one operation to ensure the concentricity of the valve seat to the valve guide. This will ensure a good seal between the guide and its seat. New valves and new valve seat inserts must be fitted each time a new valve guide is fitted. Valves must not be lapped. If all or most of the original valve guides need to be renewed it may be cost effective to overhaul or exchange the cylinder head.

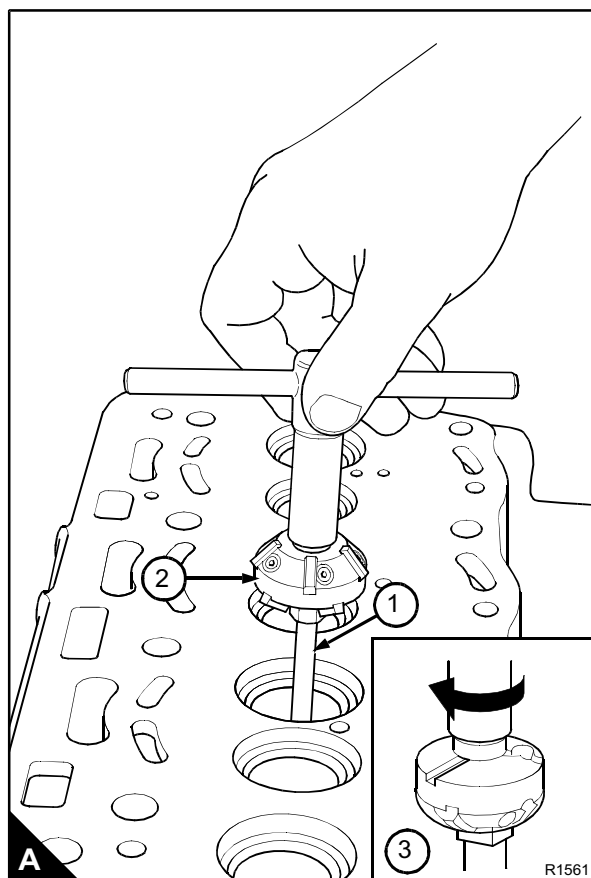
1 Before any work is done on the valve seats, new valve guides must be fitted, see Operation 3-16.

Cautions:

- Ensure that the correct cutter is fitted, for 30° valve seats.
- Ensure that the valve seat cutter is not allowed to fall onto the seat as this can damage the blades.

Note: The intake valve has a larger diameter head than the exhaust valve

2 Select the relevant valve seat cutter, 30° (A2) and the valve guide reamer (A1). Set the blades of the cutters to the diameter of the valve seat to be cut, see "Intake and exhaust valves" on page 13.

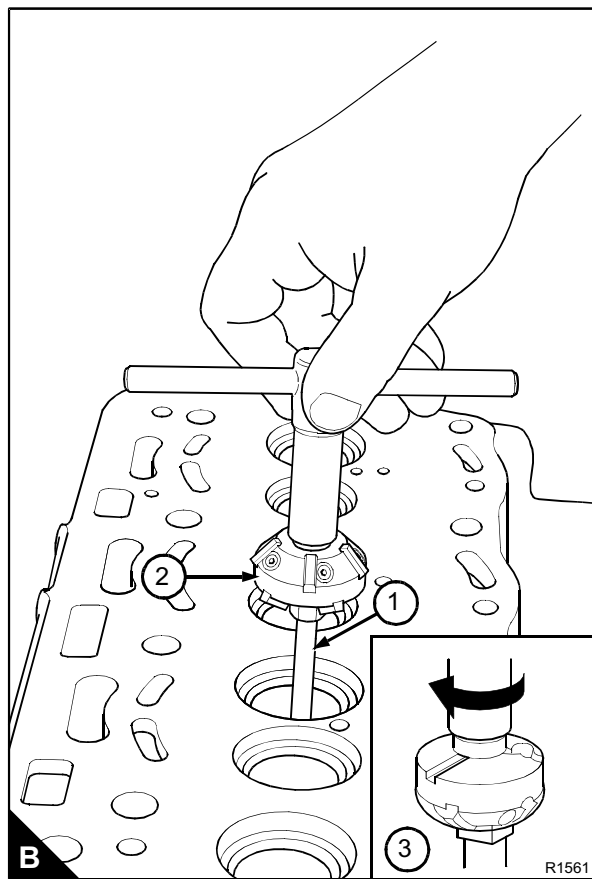


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Note: The blades of the reamer must not cut the valve guide when the seat is cut.

- 3 Fit the cutter onto the reamer and push the handle fully onto the reamer. Ensure that the flat part of the reamer shank is towards the Allen screw. Tighten the Allen screw to secure the reamer to the handle.
- 4 Fit the reamer/cutter assembly into the valve guide. Ensure that the valve seat cutter is not allowed to fall onto the seat as this can damage the blades. Carefully turn the handle in a clockwise direction (B3) and gradually move the reamer into the valve guide until the valve guide is reamed to the finished size. A lubricant is not necessary.
- 5 Continue to turn the handle in a clockwise direction to cut the valve seat. Remove only the minimum material to ensure a good valve seat. Keep the seat as narrow as possible.
- 6 When the seat is cut, remove the reamer/cutter assembly. Remove any debris from the area of the valve guide, valve seat and the port.
- 7 Fit the valve, see Operation 3-12.
- 8 Check that the valve depth is within limits, refer to the relevant Data and dimensions for the "Intake and exhaust valves" on page 13.

Note: If a valve seat has become too damaged or too worn to correct, a valve seat insert can be fitted, see Operation 3-19. If all or most of the original valve seat inserts need to be renewed, it may be cost effective to overhaul or exchange the cylinder head.



To fit valve seat inserts

Operation 3-19

- 1 Remove the valve guide, see Operation 3-15, and clean the bore into which the guide is to be fitted.
- 2 Fit new partially finished valve guides, see Operation 3-16.
- 3 With the bore of the new partially finished valve guide used as a pilot, machine the recess in the cylinder head to the dimensions shown in "Dimensions of recesses for valve seat inserts" on page 14, or machine out the old 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 0,9/1,3 mm (0.035/0.051 in) chamfer at 30° to the vertical.
- 5 With the bore of the new, partially finished, 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. Ensure that the bottom of the insert is in contact with the bottom of the recess.

- 6 Ream the valve guide and cut the valve seat at an included angle of 120° for 30° valve seats, see Operation 3-18.

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 the "Intake and exhaust valves" on page 13.

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

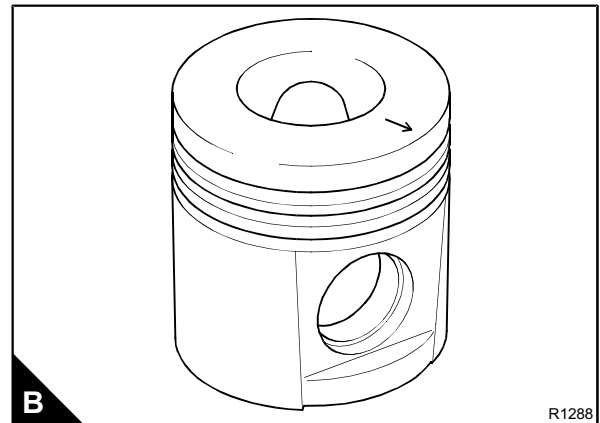
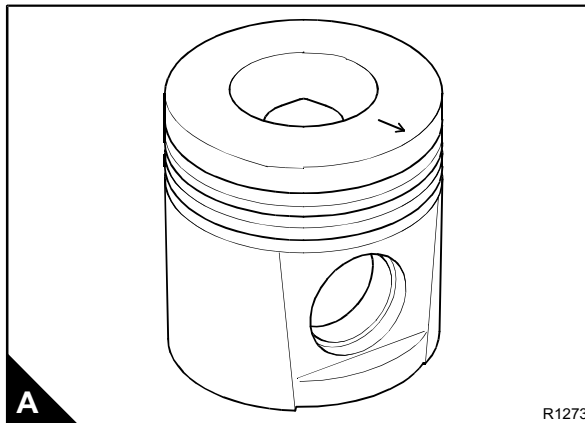
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4

Piston and connecting rod assemblies

General description

The pistons used in the 1100 Series 4 cylinder engines have a combustion chamber in the top of the piston. Piston (A) is for models RE, RF, and piston (B) is for models RG, RH, RJ, and RK. The combustion chamber is designed to give an efficient mix of fuel and air.



The pistons and connecting rods are matched to the relevant cylinder.

The pistons have two compression rings and an oil control ring. The groove for the top ring has a hard metal insert to reduce wear of the groove. The piston skirt has a layer of graphite to improve the wear characteristics.

Axial location of the fully floating gudgeon pin is by circlips. The gudgeon pin is off-centre to reduce the noise level.

Piston cooling jets are fitted in the cylinder block to spray lubricating oil onto the inner surface of the pistons.

The correct piston height is important to ensure that the piston does not contact the cylinder head and to ensure the efficient combustion of fuel.

The piston height is controlled by the length of the connecting rod. There are six length grades of connecting rods used to obtain the correct piston height.

To obtain the different grades, the small-end bush is machined off-centre. The amount that the bush is off-centre gives the different length grades.

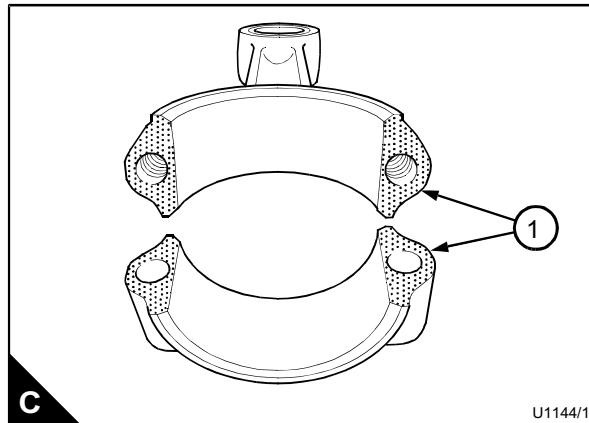
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In service, a partially finished small-end bush is available, which can be fitted to the original connecting rod and machined to obtain the correct length grade, see Operation 4-14. Specialist equipment and personnel with the correct training are needed to machine the partially finished small-end bush. Connecting rod kits are also available with the small end bush fitted and machined to obtain the correct connecting rod grade. For further information refer to your nearest Perkins Dealer/Distributor.

Notes:

- If the crankshaft or the cylinder block is to be renewed, it may be necessary to change the grade of the connecting rods, see Operation 4-11. This will occur if the correct piston height above the cylinder block face cannot be maintained with the original connecting rod assemblies, see Operation 4-6.
- Always use the engine identification number to order new parts.

The connecting rod is a one-piece forging that is fractured hydraulically to split the big end cap from the connecting rod. This process produces rough but accurately matched surfaces (C1).



Big end bearing**To remove****Operation 4-1**

- 1 Drain the engine lubricating oil.
- 2 Remove the lubricating oil sump, see Operation 10-4.
- 3 Remove the lubricating oil pump, see Operation 10-9 or remove the balancer unit, see Operation 5-15.
- 4 Release the fasteners (A4) and remove the bearing cap (A3).

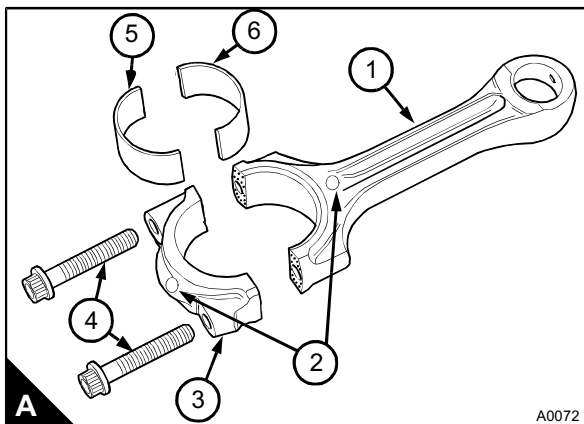
Caution: Do not stamp or punch the connecting rod assembly, as this could cause a fracture.

- 5 Mark the bearing cap and the connecting rod with the cylinder number to ensure correct assembly.

Caution: Engine models RG, RH, RJ and RK have a different shell bearing fitted to the cap and connecting rod. Ensure that the relevant shell bearing is kept with the correct cap or connecting rod.

- 6 Rotate the crankshaft until the relevant connecting rod is at its lowest position.
- 7 Remove the shell bearing (A5) from the cap (A3). Keep the bearing with the cap.
- 8 Carefully push the connecting rod up the cylinder bore just enough to allow access to the upper half of the shell bearing. Remove the shell bearing (A6) from the connecting rod (A1). Keep the bearing with the connecting rod.

Caution: Do not allow the connecting rod to hit the piston cooling jet, if fitted.



To fit

Operation 4-2

- 1 Clean the bearing faces of the connecting rod and the crank pin.

Cautions:

- Engine models RG, RH, RJ and RK have a different shell bearing fitted to the cap and connecting rod. Ensure that the relevant shell bearing is kept with the correct cap or connecting rod.
- Do not stamp or punch the connecting rod assembly, as this could cause a fracture.

- 2 Clean the complete bearing and lubricate the bearing surface and the crank pin with clean engine lubricating oil.

- 3 Fit the upper half of the shell bearing to the connecting rod; ensure that the bearing shell is fitted centrally (A1). Fit the connecting rod to the crank pin. Ensure that the forged marks (B1) face to the front of the engine.

Note: The fasteners used with these connecting rods must only be used once.

- 4 Clean, lubricate and fit the lower half of the shell bearing into the cap; ensure that the bearing shell is fitted centrally (A1). Fit the connecting rod fasteners. Fit the cap to the connecting rod. Ensure that the assembly has both of the forged marks on the same side (B1).

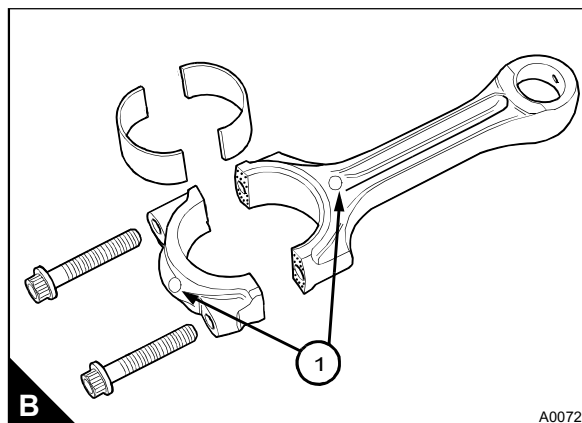
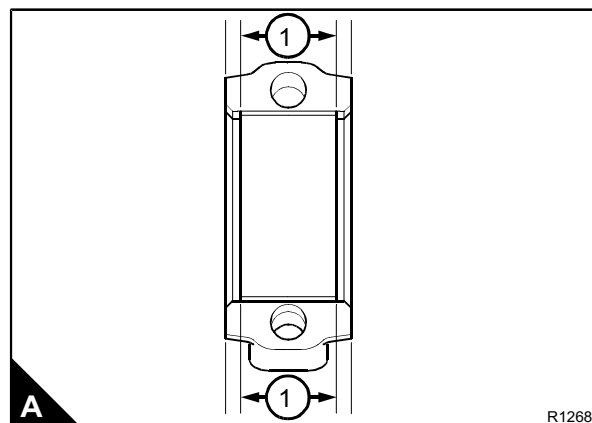
- 5 Tighten the new fasteners to an initial torque of 18 Nm (13 lbf ft) 1,9 kgf m.

- 6 Tighten the new fasteners to 70 Nm (52 lbf ft) 7,1 kgf m. The fasteners must then be tightened a further 120°.

- 7 Ensure that the crankshaft rotates freely.

- 8 Fit the lubricating oil pump, see Operation 10-10, or fit the balancer unit, see Operation 5-15.

- 9 Fit the lubricating oil sump, see Operation 10-5 and fill the sump to the correct level with lubricating oil of an approved grade, refer to Chapter 5 in the User's Handbook.



To inspect

Operation 4-3

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

Piston and connecting rod

To remove

Operation 4-4

- 1 Drain the lubricating oil and the cooling system.
- 2 Remove the cylinder head assembly, see Operation 3-9.
- 3 Remove all carbon from the top of the bores of the cylinders.
- 4 Remove the lubricating oil sump, see Operation 10-4.
- 5 Remove the lubricating oil pump, see Operation 10-9 or remove the balancer unit, see Operation 5-15.

Cautions:

- *Do not stamp or punch the connecting rod assembly, as this could cause a fracture*
- *The pistons and connecting rods are matched to the relevant cylinder. Mark each connecting rod and piston with the cylinder number to ensure correct assembly.*

- 6 Remove the big end caps and the big end bearings from the connecting rods, see Operation 4-1.

Caution: *Do not allow the connecting rods to hit the piston cooling jets. If a cooling jet is hit, renew it if necessary.*

- 7 Rotate the connecting rods 90° to prevent contact with the piston cooling jets. Push the pistons and the connecting rods out through the top of the cylinder liners. Keep the bearings and caps together to ensure that they can be fitted in their original positions.

- 8 Inspect the crank pins for damage.

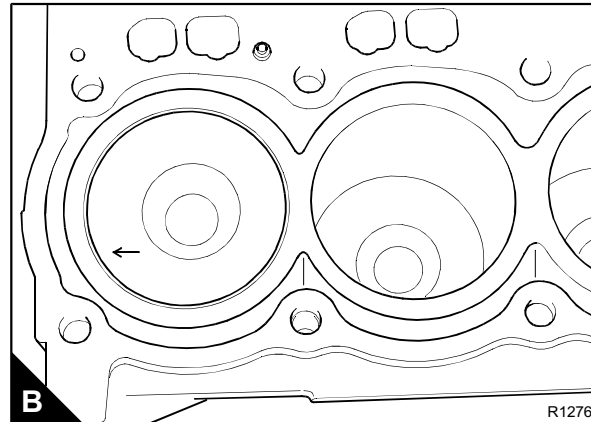
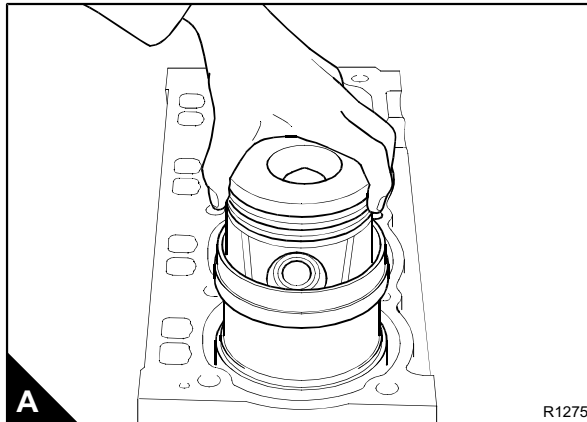
To fit

Operation 4-5

Special requirements

Special tools	
Description	Part number
Piston replacer tool	21825491

- 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 bore with clean engine lubricating oil.
 - 2 Rotate the crankshaft until the relevant crank pin is at its lowest 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 bearing shell is fitted correctly, see Operation 4-2. Lubricate the bearing with clean engine lubricating oil.
 - 4 Put the piston replacer tool in position at the top of the relevant cylinder. The tool has a tapered bore to compress the piston rings when the piston and connecting rod assembly is fitted. Ensure that the smaller end of the tapered bore is towards the face of the cylinder block.
 - 5 Put the piston ring gaps 120° apart. Pass the connecting rod through the piston replacer tool and allow the piston to enter the tool. The arrow mark on the top of the piston (B) must be towards the front of the engine.
- Caution:** Ensure that the connecting rod will not hit the piston cooling jet (if fitted) as the connecting rod assembly is fitted.
- 6 Push the piston and connecting rod assembly through the piston replacer tool (A) and onto the crank pin. The piston and connecting rod assembly must be rotated to ensure that the connecting rod will not hit the piston cooling jet as the assembly is fitted. When the connecting rod has passed the piston cooling jet, rotate the connecting rod until the arrow mark on top of the piston is towards the front of the engine.



Continued

7 Clean the connecting rod cap and the lower half of the bearing. Fit the bearing to the cap; ensure that the bearing is fitted correctly, see Operation 4-2. Lubricate the bearing with clean engine lubricating oil. Fit the cap and ensure that the assembly number is the same as that on the connecting rod and that the numbers are on the same side. Tighten the fasteners gradually and evenly, see Operation 4-2.

8 Check that the crankshaft will rotate freely.

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

10 Fit the lubricating oil pump, see Operation 10-10 or fit the balancer unit, see Operation 5-15.

11 Fit the lubricating oil sump, see Operation 10-5

12 Fit the cylinder head assembly, see Operation 3-10.

13 Fill the sump to the correct level with lubricating oil of an approved grade, refer to Chapter 5 in the User's Handbook.

14 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 for use with 21825496	21825617

Caution: If the correct piston height above the cylinder block is not obtained, damage to the engine can occur and the engine may not be emissions compliant.

Put the piston height tool (A) on the face of the cylinder block and rotate the gauge dial to the zero position. Rotate the crankshaft until the piston crown is approximately at top dead centre (TDC). Carefully put the tool 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.

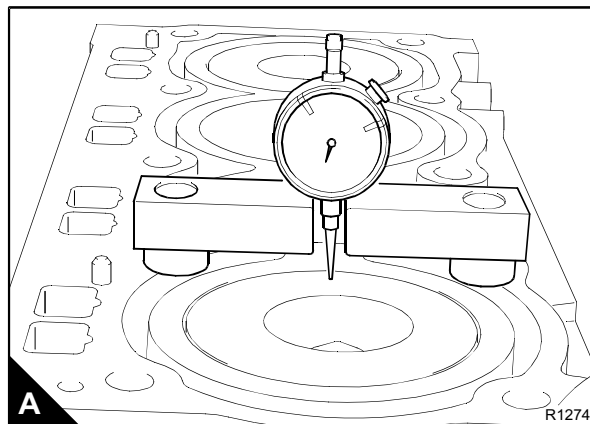
The piston height above the top face of the cylinder block should be 0,21/0,35 mm (0.008/0.014 in).

Notes:

- The top of the piston should not be machined.
- If the original piston is used, ensure that it is assembled to the correct connecting rod and is used in the original cylinder.

If any of the components listed below are renewed, refer to the relevant operation:

- The connecting rod, see Operation 4-11
- The small end bush, see Operation 4-14.



Piston rings

To remove**Operation 4-7**

Note: The pistons have two compression rings and an oil control ring. All the piston rings are above the gudgeon pin. To ensure that the correct type is obtained always use the engine identification number to order new parts.

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.

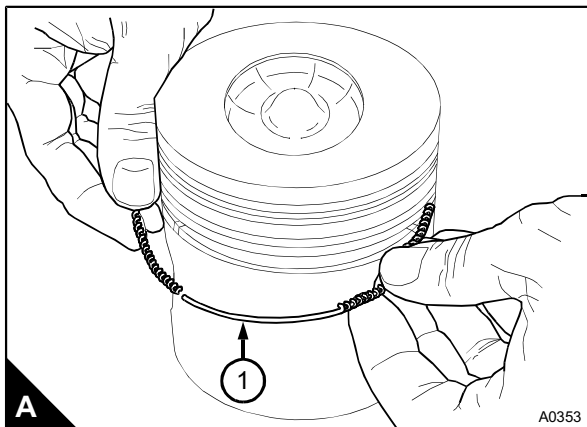
- 1 Remove the piston rings with a suitable ring expander. Keep the rings with their relevant piston.

To fit**Operation 4-8**

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

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.

- 1 Fit the spring of the oil control ring in the bottom groove with the latch pin (A1) inside both ends of the spring (A). Fit the oil control ring over the spring. Ensure that the ring gap is at 180° to the latch pin.



- 2 Fit the cast iron ring with the taper face into the second groove.
- 3 The second ring has a green identification mark which must be on the left of the ring gap when the ring is fitted and the piston is upright, with the word "TOP" towards the top of the piston.
- 4 The first ring has a red identification mark which must be on the left of the ring gap when the ring is fitted and the piston is upright.
- 5 Ensure that the ring gaps are 120° apart.

Piston and connecting rod assembly

To dismantle

Operation 4-9

Caution: The pistons and connecting rods are matched to the relevant cylinder. Note the position of each connecting rod and piston for correct assembly.

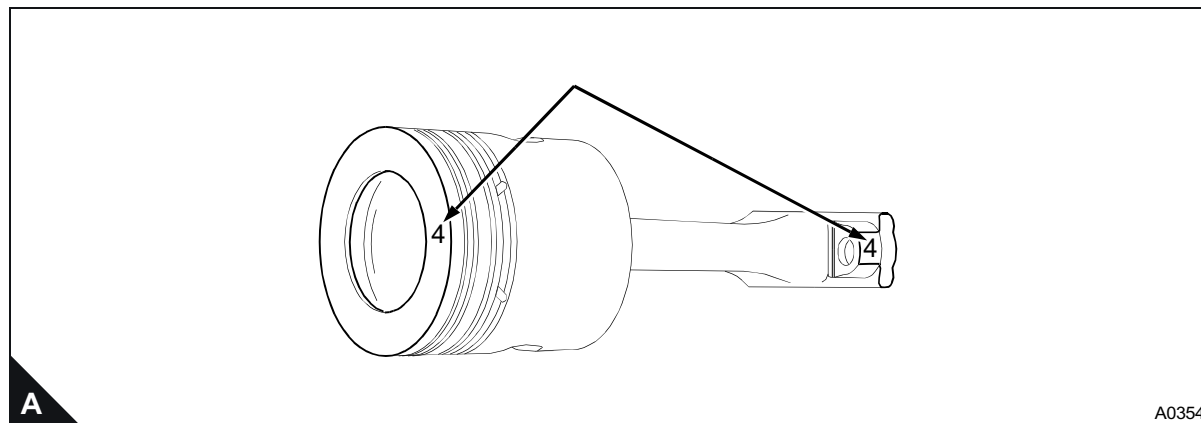
- 1 Remove the piston rings, see Operation 4-7.
- 2 Remove the circlips which retain the gudgeon pin.

Caution: Do not scratch, etch or stamp the piston surface.

3 Put a temporary mark on the piston to indicate the cylinder number as shown on the connecting rod. Put the temporary 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.

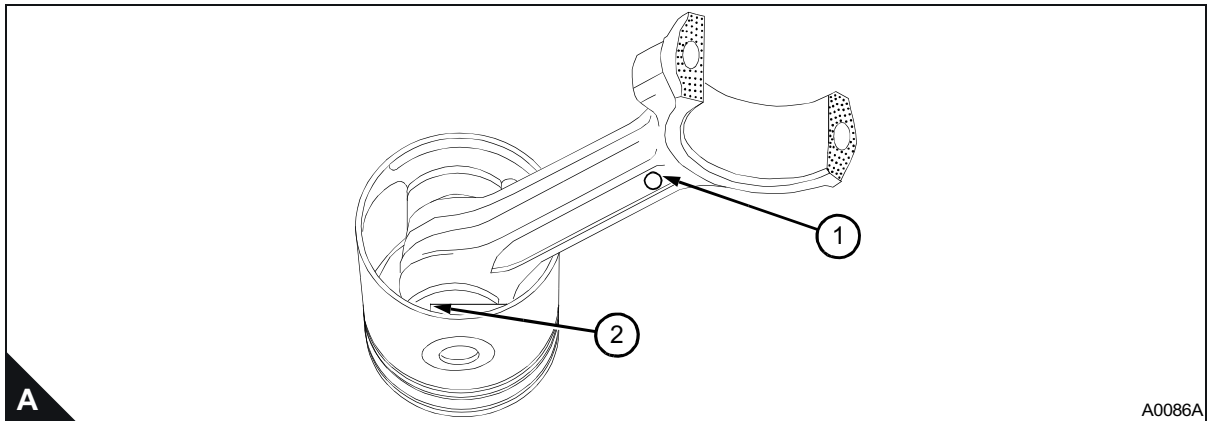
5 Inspect the piston and connecting rod assembly, see Operation 4-12 and Operation 4-13.



To assemble

Operation 4-10

- 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 With the piston upside down, put the connecting rod in position with the forged mark (A1) on the same side as the recess in the gudgeon pin boss (A2). If the original piston is used, ensure that it is assembled to the correct connecting rod and is used in the original cylinder.
- Note:** 1100 Series 4 cylinder engines have six connecting rod length grades controlled by the small end bush machining. If a new connecting rod is fitted, ensure that it is of the correct length grade, see Operation 4-11.
- 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 4-8.



To check the length of a connecting rod

Operation 4-11

A partially finished small end bush, which can be fitted to the original connecting rod and machined to obtain the correct length grade is available, see Operation 4-14. Specialist equipment and personnel with the correct training are needed to machine the partially finished small end bush.

Connecting rod kits are also available with the small end bush fitted and machined to obtain the correct connecting rod grade.

Cautions:

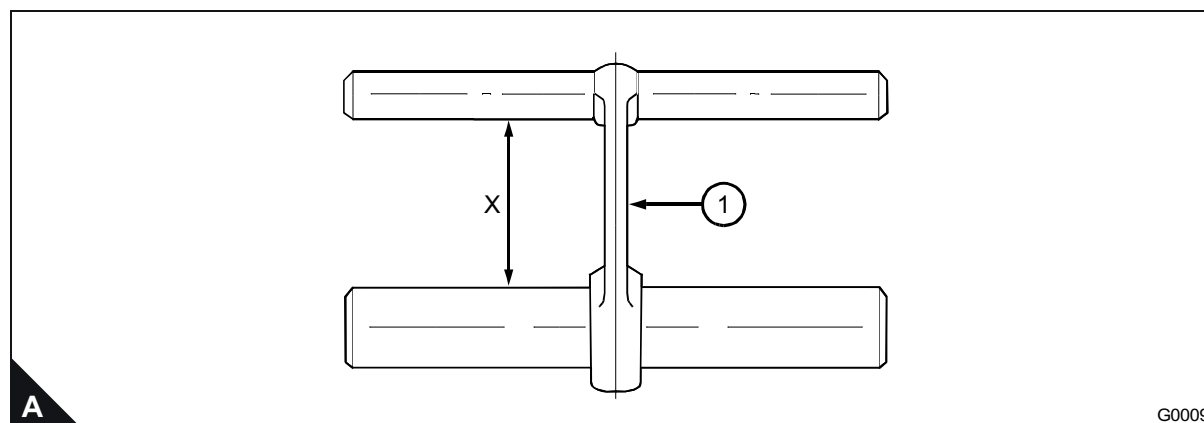
- *It is important that the piston does not contact the cylinder head. Ensure that the piston height above the cylinder block is correct.*
- *Ensure that the connecting rods are fitted in the correct cylinder. Record the position of the connecting rod and its relevant cylinder when it is removed from the engine.*

To ensure that the piston height above the cylinder block is correct, the engine may have up to six length grades (F to L) of connecting rods fitted.

Identification of the length grade is by a letter or colour which is marked on the side of each connecting rod (A1). The letter F is the longest grade of connecting rod and letter L is the shortest grade. The difference between grades is 0,046 mm (0.0018 in).

If the grade letter or colour on the side of the connecting rod cannot be seen, the length can be checked by the measurement of the dimension (X) shown in (A). Before the length of the connecting rod is measured, ensure that the bores of the big end and the small end are square and parallel, see Operation 4-13. The length is checked with the big end bearing removed and the original small end bush fitted. The dimensions for each grade are listed in the table below:

Grade letter	Colour code	Length (mm)
F	Red	165,728/165,761
G	Orange	165,682/165,715
H	White	165,637/165,670
J	Green	165,591/165,624
K	Purple	165,545/165,578
L	Blue	165,499/165,532



Piston and piston rings

To inspect

Operation 4-12

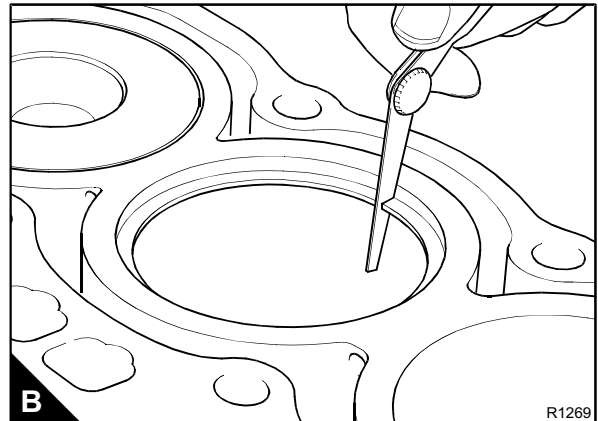
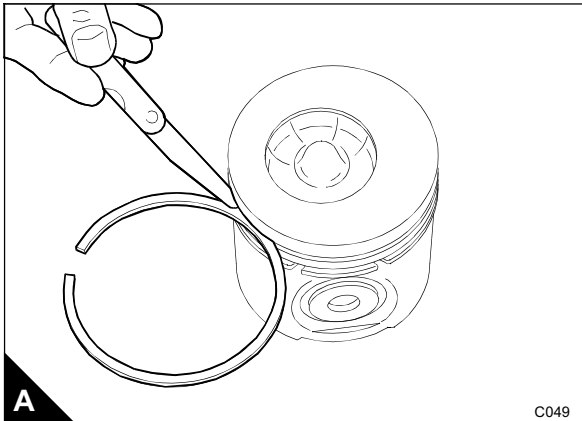
- 1 Check the piston for wear and other damage.
- 2 Check that the piston rings are free to move in their grooves and that the rings are not broken.
- 3 Remove the piston rings, see Operation 4-7, and clean the piston ring grooves and the piston rings.

Note: Engine models RG, RH, RJ, and RK, have pistons that have a tapered top groove and the piston ring is wedge shaped. The top piston ring clearance cannot be checked by this method.

4 Fit new piston rings in the grooves 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 the "Pistons and piston cooling jets" on page 17, and renew the piston if necessary.

5 Clean all carbon from the top of the cylinder bore. Fit each piston ring in the top part of the cylinder bore and measure the ring gap with feeler gauges (B). The coil spring must be removed from 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 the "Piston rings" on page 17.



Connecting rod

To inspect

Operation 4-13

1 Check the small end bush for wear or for other damage and renew it, if necessary.

Note: Connecting rod kits are available with a new small-end bush fitted and finished to the correct grade, see Operation 4-11 to identify the correct connecting rod grade.

A partially finished small end bush, which can be fitted to the original connecting rod and machined to obtain the correct length grade is also available, see Operation 4-14.

2 Check the connecting rod for distortion. Refer to the relevant Data and dimensions for the "Connecting rods and big end bearings" on page 18 to identify the correct mandrel size.

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).

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 the "Gudgeon pins and small end bushes" on page 18.

Partially finished small end bush

To remove and to fit

Operation 4-14

Note: For details on how to change the partially finished small end bush, contact your nearest Perkins Dealer/Distributor for advice.

Piston cooling jets

To remove and to fit

Operation 4-15

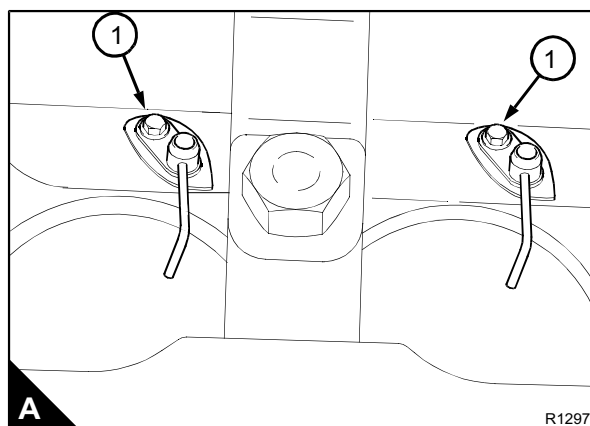
To remove

Release the setscrew (A1) and remove the piston cooling jet assembly.

Note: The crankshaft is removed in (A) to show clearly the piston cooling jet.

To fit

- 1 Check that the spring loaded valve moves freely against spring pressure in the valve assembly and that the jet tube is not damaged. Renew piston cooling jets as necessary.
- 2 Fit the piston cooling jet; ensure that the valve is fitted correctly in the locating hole in the cylinder block.
- 3 Fit the setscrew (A1) and tighten to 9 Nm (7 lbf ft) 0,9 kgf m.



To check the jet alignment

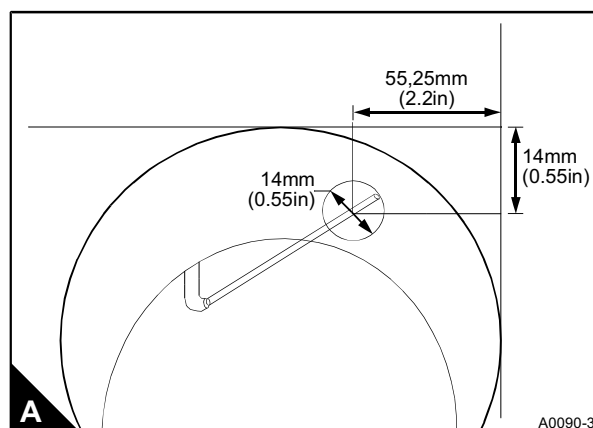
Operation 4-16

Note: Ensure that the end of a 1,70 mm (0.067 in) diameter rod is round, to prevent damage to the piston cooling jet bore.

Carefully insert a 1,70 mm (0.067 in) diameter rod, of 300 mm (11.8 in) in length, into the jet. If a suitable rod is not available, reduce the end of a thicker rod to 1,70 mm (0.067 in) diameter for a length of 16,00 mm (0.630 in).

When the rod is inserted into the jet it must extend out of the top of the cylinder within the area shown in (A).

Replace the piston cooling jet, as necessary.



5

Crankshaft assembly

General description

The crankshaft is forged from chromium molybdenum steel and has five main journals. There is a large flange at the rear of the crankshaft to which the flywheel is fitted.

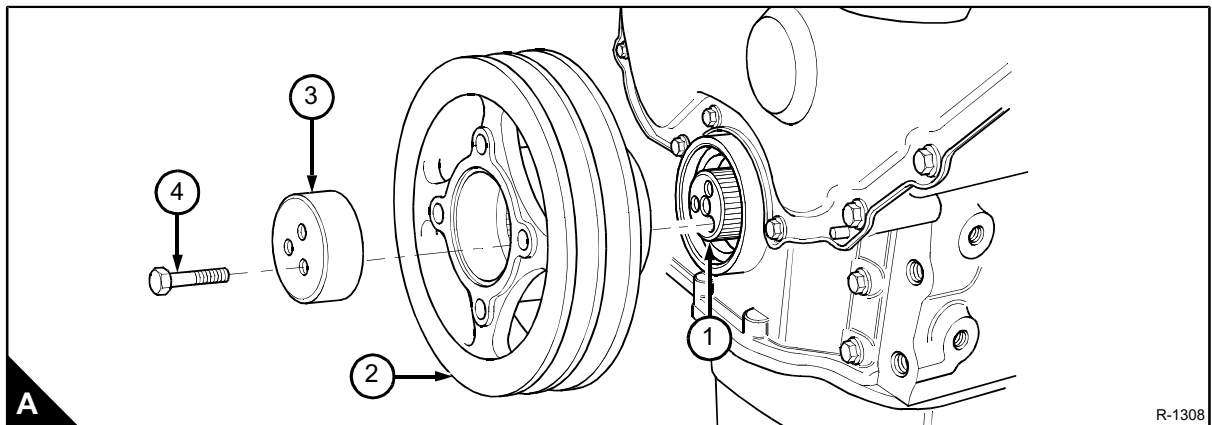
End-float and thrust movements are controlled by two split 360° thrust washers on both sides of the centre main bearing.

The main bearings have steel backs with an aluminium/tin bearing material, and main bearing caps are made of cast iron or spheroidal graphite iron.

The timing ring is an interference fit onto the machined surface of the web. The timing ring is fitted behind the crankshaft palm and is located by a dowel.

The rear end oil seal is made from a PTFE material and is an integral part of the pressed steel housing, which is fitted to the cylinder block.

The crankshaft pulley (A2) is held in position by a plain thrust block (A3) and three setscrews (A4). The nose (A1) of the crankshaft and the pulley is serrated for location.



Crankshaft pulley

To remove and to fit

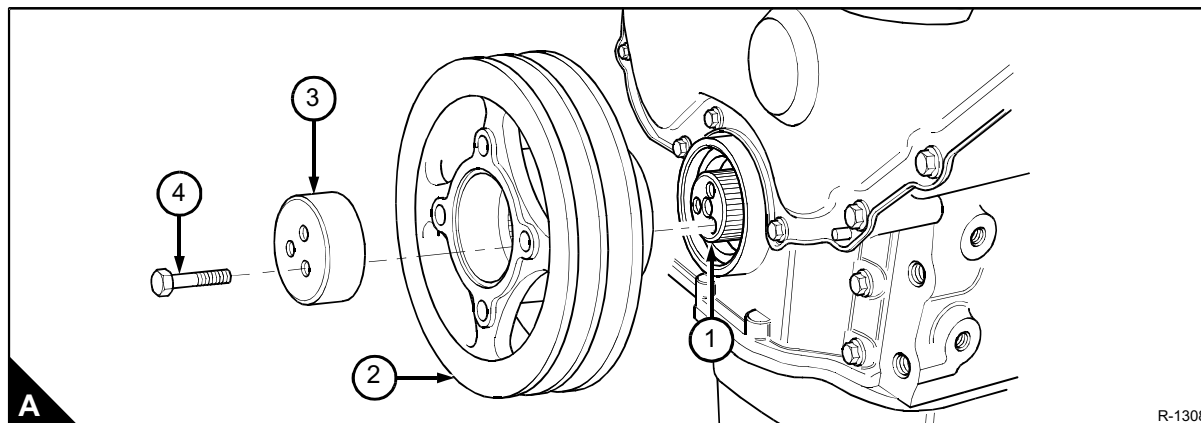
Operation 5-1

To remove

- 1 Remove the fan drive belt(s), see Operation 14-3.
- 2 Remove the three setscrews (A4) which hold the pulley and remove the setscrews, the thrust block (A3) and the pulley (A2).
- 3 Clean the components and check for damage. Renew damaged components as required.
- 4 Check the area of the seal contact on the pulley for wear. If there is excessive wear a wear sleeve can be fitted, see Operation 5-3.

To fit

- 1 Put the pulley (A2) in position on the crankshaft nose (A1). Lubricate lightly the threads of the setscrews (A4) with clean engine lubricating oil. Fit the thrust block (A3) and the setscrews (A4) and tighten the setscrews to 115 Nm (85 lbf ft) 11,8 kgf m.
- 2 Check each setscrew again to ensure that they are still to the correct torque.
- 3 Fit the drive belt(s), see Operation 14-3.



A

R-1308

Rear end oil seal assembly

To remove and to fit the rear end oil seal assembly

Operation 5-2

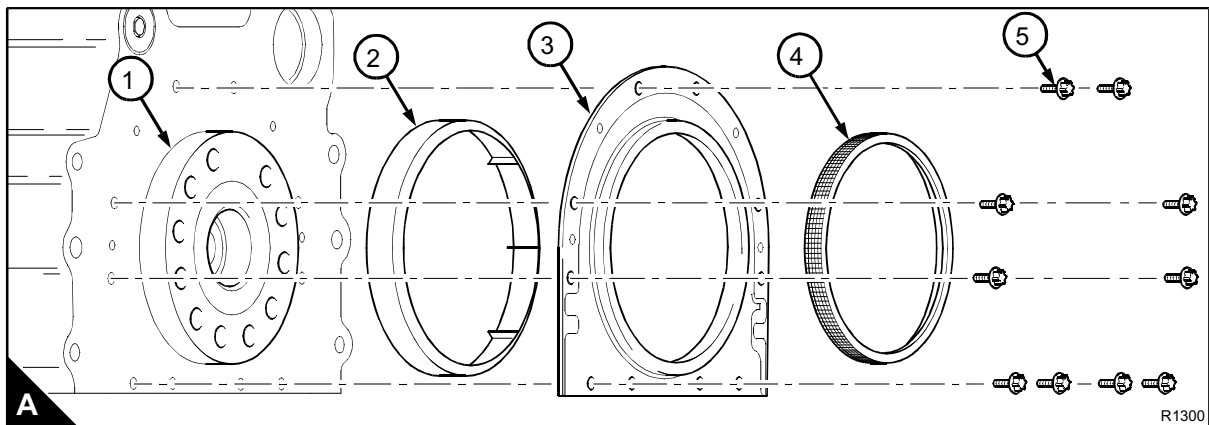
Caution: The new rear end oil seal assembly includes a plastic protection sleeve (A2) that is fitted to the inside of the seal. This sleeve is to protect the oil seal from damage when it is fitted to the crankshaft palm (A1). The plastic sleeve must remain inside the seal until the assembly is fitted. When the assembly is fitted, the plastic sleeve will be pushed out of the oil seal and the assembly. The plastic sleeve must be discarded after the assembly is fitted. The seal of the new rear end oil seal assembly is pre-waxed, there is no need to lubricate the palm or the seal before it is fitted.

Notes:

- The oil seal for the rear end oil seal assembly cannot be renewed, if the seal is faulty, the complete assembly must be renewed.
- If the crankshaft palm has a wear groove caused by the old oil seal assembly, a wear sleeve must be fitted to the crankshaft palm before the new assembly is fitted, see Operation 5-3.
- An alignment tool is needed to fit the rear end oil seal assembly, see page 82.
- The rear end oil seal cannot be used again and must be replaced if removed.

To remove

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



To fit

Caution: To prevent contamination of the oil seal surface, keep the new assembly packed until required for use.

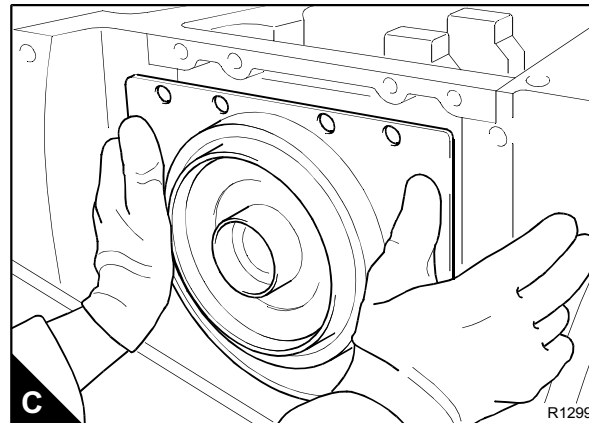
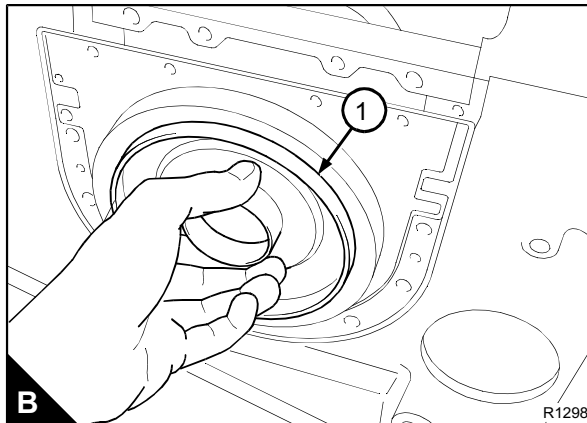
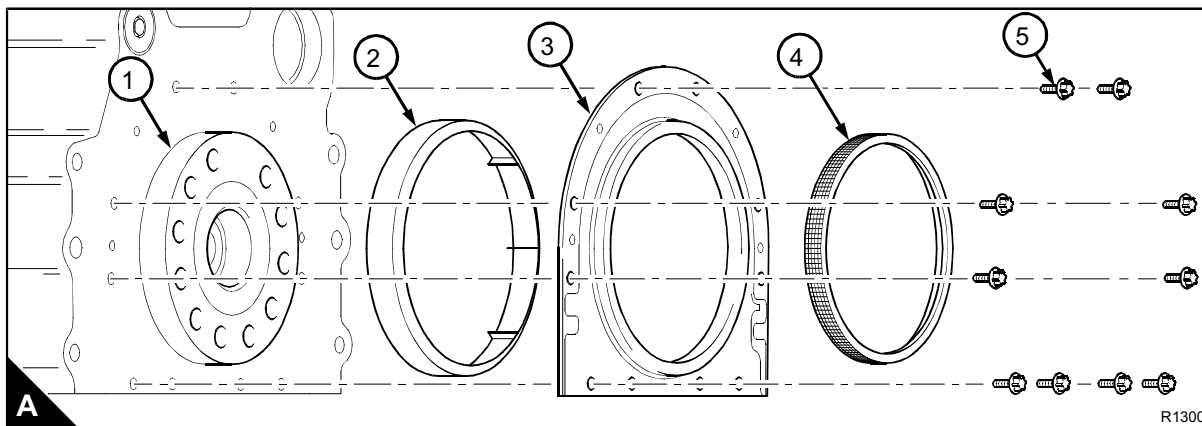
Note: The rear end oil seal cannot be used again and must be replaced if removed.

1 Ensure that the crankshaft palm (A1), the rear face of the cylinder block and the bridge piece are dry, free from dirt, and that there are no rough metal edges. Do not use a lubricant on either the crankshaft palm, or on the rear end oil seal, as the seal is pre-waxed.

2 Remove the new rear end oil seal assembly (A3) from its pack. Ensure that the plastic sleeve (A2) supplied with the rear end oil seal is square within the rear end oil seal. The plastic protection sleeve must be in place when the seal is fitted to the crankshaft palm, this will prevent the seal being damaged when fitted.

3 Place the rear end oil seal over the crankshaft palm and engage the plastic protection sleeve (B1) onto the crankshaft palm (A1).

4 With the plastic protection sleeve engaged on the crankshaft palm, push the rear end oil seal assembly evenly and smoothly onto the crankshaft palm until it is against the cylinder block. The plastic protection sleeve will be pushed out of the assembly (C).



Continued

5 Discard the plastic sleeve.

6 Rotate the rear end oil seal (D3) to align the holes in the rear end oil seal assembly with the holes in the cylinder block rear face and the cylinder block bridge piece.

7 Loosely fit the Torx screws (D5).

8 Place the seal alignment tool (D4), see page 82, onto the crankshaft palm and over the rear end oil seal housing to align the rear end oil seal to the crankshaft palm.

Notes:

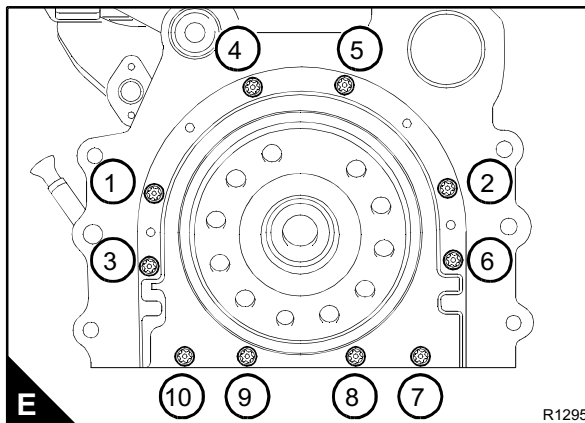
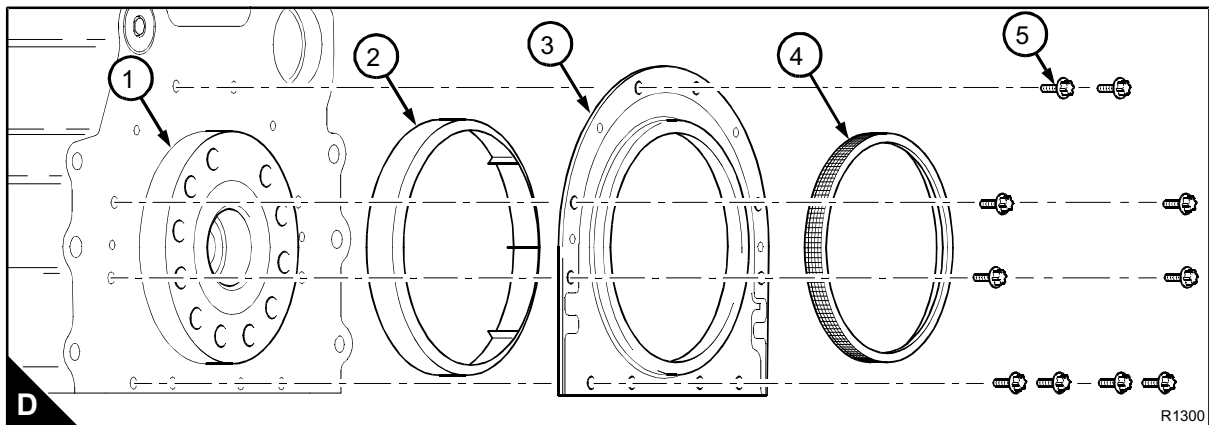
- Ensure that the two rubber locating pins are correctly located into the cylinder block.
- Ensure that there is no distortion of the rubber dust lip and that it is in full contact with crankshaft palm. If there is distortion, discard the seal and replace with a new seal.

9 Tighten setscrews 1, 2, 3, 4, 5, 6, 7, and 10 in the sequence shown in (E) to 22 Nm (16 lbf ft) 2,2 kgf m.

10 Remove the alignment tool and tighten the remaining Torx screws 8 and 9 in sequence (E) to 22 Nm (16 lbf ft) 2,2 kgf m.

11 Fit the flywheel, see Operation 13-1 and the flywheel housing, see Operation 13-3.

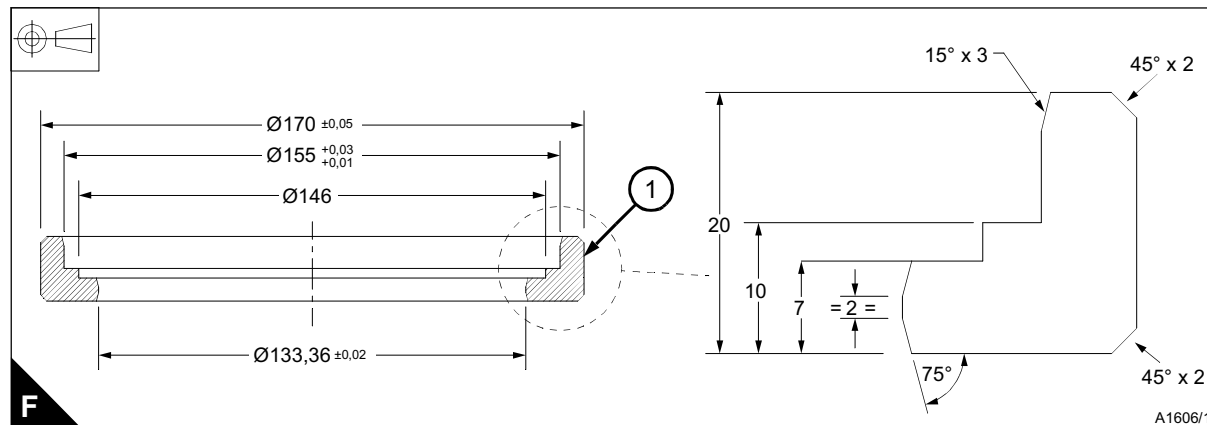
12 Fit the drive components to the rear end of the engine.



Alignment tool

The alignment tool (F) must be manufactured locally to the following specifications:

- 1 Outer surface (F1) to be knurled
- 2 Remove all sharp edges
- 3 To be made from material EN 32, harden 0,5 mm deep.



Note: All dimensions are in millimetres.

To remove and to fit a wear sleeve

Operation 5-3

Special requirements

Consumable products	
Description	Part number
POWERPART Liquid gasket	21820518

To remove

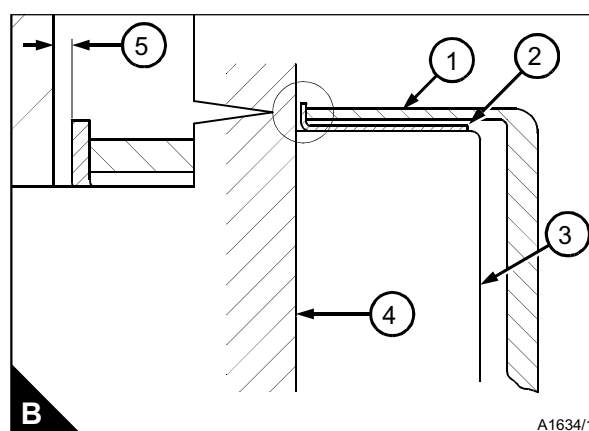
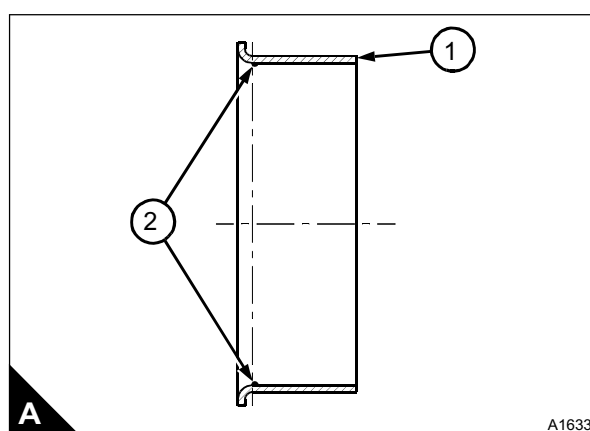
- 1 Remove the rear end oil seal, see Operation 5-2.
- 2 With a sharp tool mark a deep line along the length of the sleeve.
- 3 Insert a suitable thin blade between the crankshaft palm and the sleeve next to the marked line. The wear sleeve will separate along the marked line.
- 4 Remove the wear sleeve. Use a suitable cleaner to remove any sealant from the crankshaft palm.

To fit

- 1 Ensure that the crankshaft palm is dry and free from oil, dirt and sealant.
- 2 Remove any rough areas from the crankshaft palm surface.
- 3 Apply a small continuous bead of sealant (A2), that does not harden, to the inner surface of the wear sleeve 5,0 mm (0.197 in) from the flange end of the sleeve (A1).

Caution: The wear sleeve must be fitted within five minutes of applying the sealant.

- 4 Ensure that the crankshaft is fully forward in the engine.
- 5 Place the wear sleeve onto the crankshaft palm (B3), use the tool (B1) that is supplied with the new wear sleeve and a suitable hammer, to force the wear sleeve (B2) over the crankshaft palm leaving a gap (B5) of 0,4/0,6 mm (0.016/0.024 in).
- 6 Remove the tool and measure the gap (B5) between the wear sleeve flange and the cylinder block in two places 180° apart. The correct gap is 0,4/0,6 mm (0.016/0.024 in).
- 7 After the wear sleeve has been fitted, check and remove any rough metal edges from the crankshaft palm and the wear sleeve.
- 8 Fit a new rear end oil seal, see Operation 5-2.

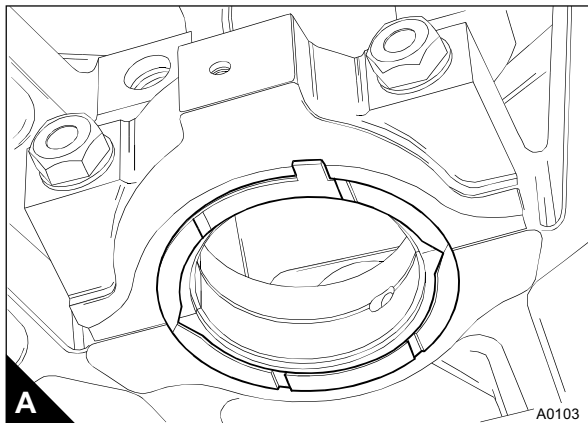


Thrust washers

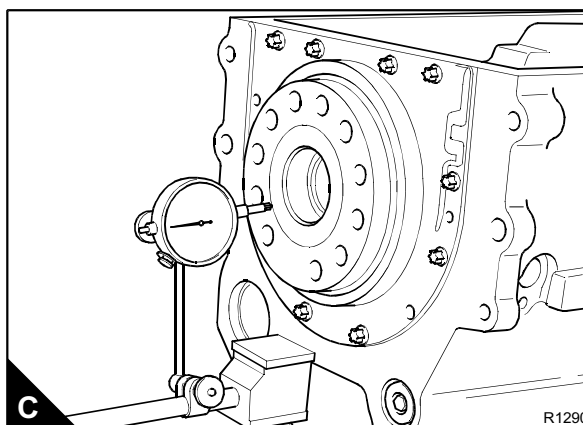
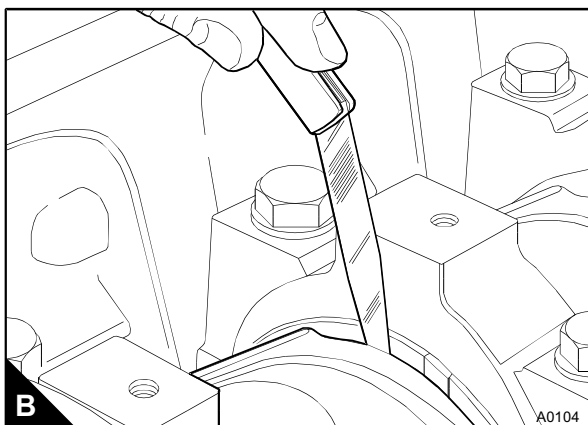
To check crankshaft end-float

Operation 5-4

The axial movement of the crankshaft is controlled by thrust washers fitted both sides of the centre main bearing (A).



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



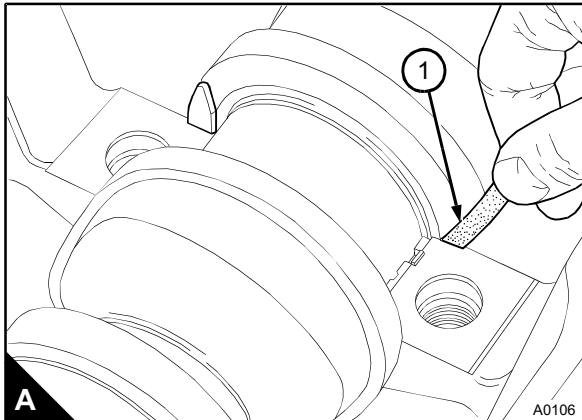
If the end-float is more than the tolerance given in the relevant Data and dimensions for the "Crankshaft" on page 19, thrust washers which are 0,019 mm (0.0075 in) oversize can be fitted.

The oversize thrust washers can be fitted to one or to both sides of the main bearing. They are fitted instead of the standard size washer, to reduce the end-float to the factory tolerances.

To remove

Operation 5-5

- 1 Drain the lubricating oil and remove the lubricating oil sump, see Operation 10-4.
- 2 If necessary, remove the lubricating oil pump, see Operation 10-9, or remove the balancer unit, see Operation 5-15.
- 3 Release the setscrews of the centre main bearing and remove the main bearing cap complete with the lower halves of the thrust washers.
- 4 Use a suitable tool (A1) made of a soft material to push each of the upper halves of the thrust washers from their recesses. Where necessary, move the crankshaft to the front or to the rear to loosen a tight washer.



To fit

Operation 5-6

1 Lubricate the thrust washers with clean engine lubricating oil.

Caution: Factory built engines have an upper shell bearing that has an lubricating oil slot (C1) that is fitted to the number one crankshaft journal. The remaining upper shell bearings have a lubricating oil holes (C2). For service all upper shell bearings will be replaced with bearings that have the lubricating oil slot (C1).

2 Slide each of the upper halves of the thrust washers into their recesses in the cylinder block. Ensure that the sides of the thrust washers that have the grooves (A1) are against the crankshaft.

3 Fit the lower half thrust washers to the main bearing cap with the location tags in their recesses.

4 Ensure that the location thimbles (B2) are fitted correctly in the main bearing cap or in the cylinder block.

5 Ensure that the bearing is fitted correctly in the cap and that the bearing and the crankshaft journal are clean. Lubricate the bearing with clean engine lubricating oil.

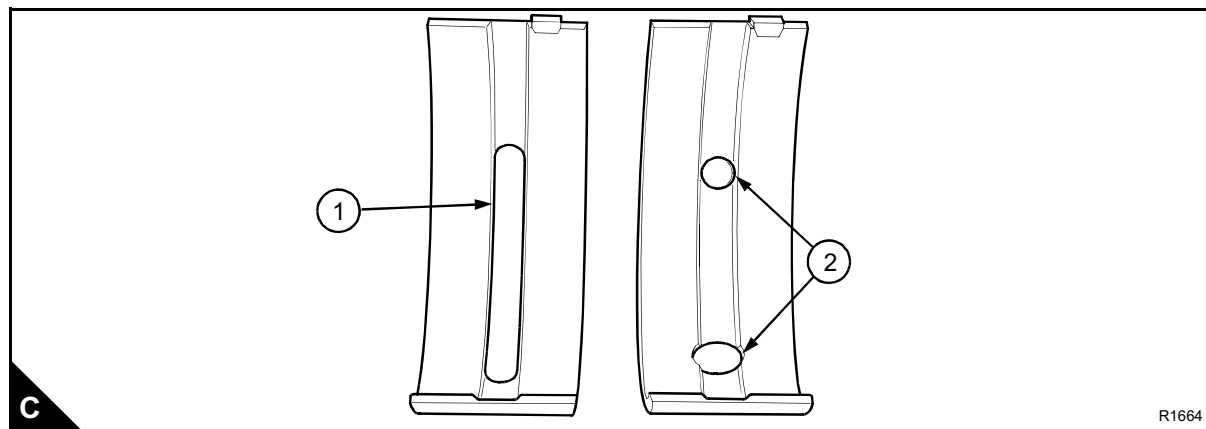
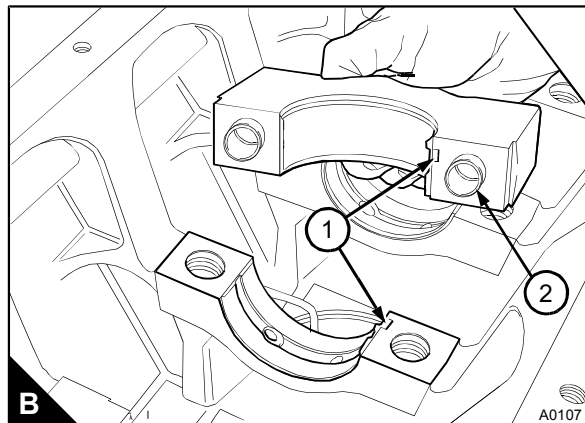
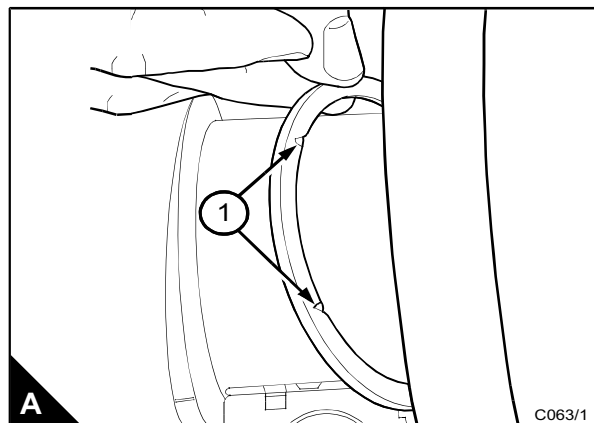
6 Fit the cap with the location tags of both halves of the shell bearings to the same side (B1), ensure that the plain bearing shell is fitted to the lower bearing cap (B).

7 Tighten the main bearing setscrews to 245 Nm (181 lbf ft) 25,0 kgf m.

8 Ensure that the crankshaft turns freely. If the thrust washers have been removed and fitted, check the crankshaft end-float, see Operation 5-4.

9 If necessary, fit the lubricating oil pump, see Operation 10-10, or fit the balancer unit, see Operation 5-15.

10 Fit the lubricating oil sump, see Operation 10-5, and fill the sump to the correct level with lubricating oil of an approved grade, refer to Chapter 5 in the User's Handbook.



Main bearings

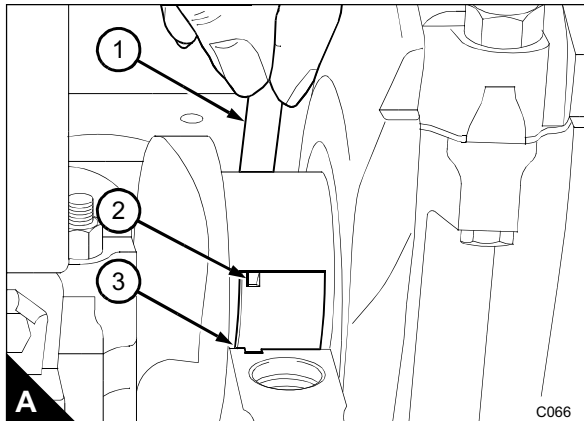
To remove (with the crankshaft in position)

Operation 5-7

Caution: Ensure that the tops of the main bearing caps are stamped with their relevant position number. Keep the bearings with their relevant caps.

Notes:

- If more than one set of main bearings are to be removed then identify, and keep each pair as a set.
 - If the rear main bearing cap is to be removed with the crankshaft in position, the flywheel, the flywheel housing, the rear end oil seal assembly and the bridge piece will have to be removed.
- 1 Drain the lubricating oil and remove the sump, see Operation 10-4.
 - 2 Remove all necessary components to get access to the specific bearing cap.
 - 3 Release the setscrews of the bearing cap and remove the bearing cap. Remove the lower half of the shell bearing from the cap.
 - 4 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 from its recess (A3) in the bearing housing. Carefully rotate the crankshaft to release the bearing from its housing.



To fit (with the crankshaft in position)

Operation 5-8

1 Clean the upper half of the shell bearing and lubricate the bearing surface with clean engine lubricating oil.

Caution: Only the upper half of the bearing has lubrication holes and must be fitted to the cylinder block.

2 Fit the plain end of the upper half of the bearing between the crankshaft journal and the side of the bearing housing which has the recess for the location tag. Slide the bearing into its housing until the tag on the bearing is fitted correctly in its recess in the housing.

3 Clean the lower half of the bearing and the cap, lubricate the bearing surface with clean engine lubricating oil.

4 Fit the bearing into the cap with the tag of the bearing fitted correctly in the recess in the cap.

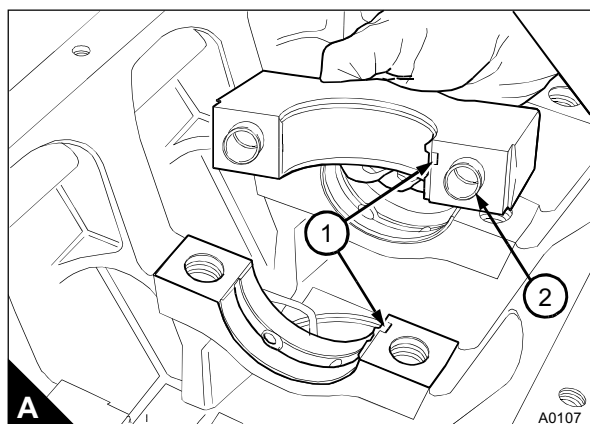
5 Ensure that the location thimbles (A2) are fitted correctly to the cap or to the cylinder block. Fit the bearing cap with the location tags of both bearings on the same side (A1).

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 the setscrews to 245 Nm (181 lbf ft) 25,0 kgf m.

7 Ensure that the crankshaft turns freely. If the thrust washers have been removed and fitted, check the crankshaft end-float, see Operation 5-4.

8 Fit all the components which were removed for access to the main bearing cap.

9 Fit the lubricating oil sump, see Operation 10-5, and fill the sump to the correct level with lubricating oil of an approved grade, refer to Chapter 5 in the User's Handbook.



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

Note: If the crankshaft is to be renewed, it may be necessary to change the grade of the connecting rods, see Operation 4-11. This will occur if the correct piston height above the block face cannot be maintained with the original piston and connecting rod assemblies, see Operation 4-6.

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

- 1 Before the engine is removed from the vehicle or from the machine, drain the lubricating oil and the coolant.
- 2 Remove the lubricating oil sump, see Operation 10-4.
- 3 Remove the fan, see Operation 12-8, the drive belts, see Operation 14-3, the fan drive pulley and housing, see Operation 12-9 and the coolant pump, see Operation 12-4.
- 4 Remove the fuel injection pump:
 - For Bosch VP30 fuel injection pumps, see Operation 11-9.
 - For Bosch EPVE fuel injection pumps, see Operation 11-11.
 - For Delphi DP210 fuel injection pumps, see Operation 11-13.
- 5 Remove the crankshaft pulley, see Operation 5-1.
- 6 Remove the alternator and its mounting bracket, see Operation 14-4.
- 7 Remove the exhauster if fitted, see Operation 15-5.
- 8 Remove the timing case cover, see Operation 6-1.
- 9 Remove the timing gears and the timing case, see Chapter 6, Timing case and drive assembly.
- 10 Remove the flywheel, see Operation 13-1, and the flywheel housing, see Operation 13-3.
- 11 Remove the rear end oil seal housing, see Operation 5-2.
- 12 Remove the lubricating oil pump, see Operation 10-9, or remove the balancer unit, see Operation 5-15.
- 13 Remove the bridge piece.

Warning! The engine should be upside down before the fasteners for the crankshaft are removed. If the engine cannot be turned upside down support the crankshaft before the fasteners are removed.

14 Remove the caps of the connecting rods. Keep the bearings and caps together. Remove the bolts of the connecting rods and carefully push the pistons towards the top their bores, see Operation 4-4.

15 Ensure that the tops of the main bearing caps are stamped with their relevant position number. Remove the main bearing caps, the lower half of the shell bearings and the upper and lower thrust washers. Keep the bearings with their relevant caps, see Operation 5-5 and Operation 5-7.

16 Lift out the crankshaft. Remove the upper half of the bearings and keep each bearing with its relevant lower half and cap.

Caution: If a timing ring is fitted to the crankshaft ensure that it is protected from damage and is correctly stored.

To fit

Operation 5-11

Special requirements

Consumable products	
Description	Part number
POWERPART Silicone adhesive	21826038

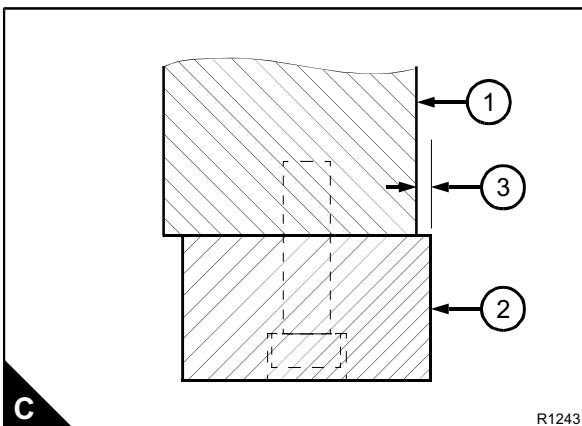
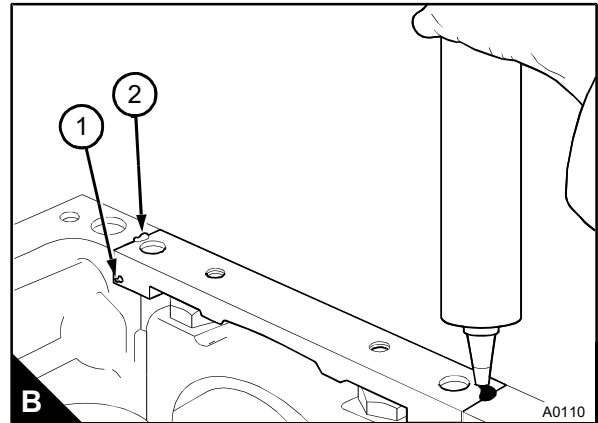
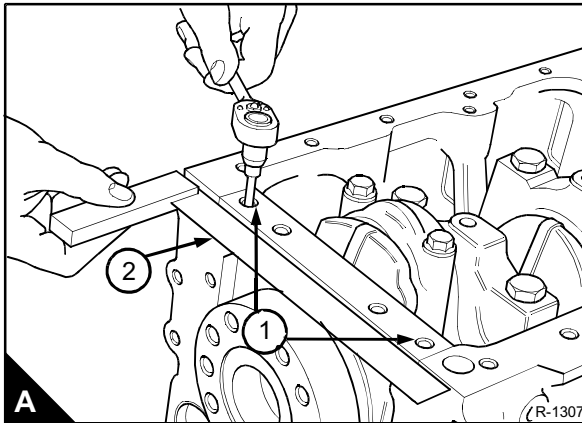
- 1 Ensure that all lubricating oil passages are clean and free from restriction.
- 2 Clean the main bearing housings and the upper half of the bearings. Fit the shell bearings with the location tags fitted correctly in their recesses. Lubricate the bearings with clean engine lubricating oil.
- 3 Ensure that the main journals of the crankshaft are clean. Put the crankshaft in position on the upper bearings.
- 4 Clean and lubricate the upper halves of the thrust washers and slide them into their recesses on both sides of the bearing housing. Ensure that the slotted sides of the thrust washers are towards the crankshaft, see Operation 5-6.
- 5 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.
- 6 Clean the lower halves of the thrust washers and lubricate them with clean engine lubricating oil. Fit the thrust washers on both sides of the bearing cap for the centre main bearing.
- 7 Check that the location thimbles for the main bearing caps are fitted correctly in the caps or in the cylinder block. Fit the bearing caps in their correct positions with the location tags of the bearings on the same side.
- 8 Fit the setscrews to the main bearing caps and tighten them to 265 Nm (196 lbf ft) 27,0 kgf m.

Continued

9 Clean the bridge piece and the location areas for the bridge piece in the cylinder block. Use a straight edge (A2) to ensure that the bridge piece is in line with the rear face of the cylinder block. Tighten the bridge piece cap screws (A1) to 16 Nm (12 lbf ft) 1,6 kgf m.

Note: The maximum protrusion for the bridge piece (C2) to the cylinder block (C1) is 0/-0,075 mm (0/-0.0029 in) (C3).

10 When the bridge piece is in position, inject POWERPART Silicone adhesive into the groove (B2) at each end of the bridge piece. Continue to inject adhesive until the groove is completely full and the adhesive leaves the lower groove (B1) at the front and rear of the bridge piece.



Continued

- 11** Fit the connecting rod caps, see Operation 4-2. Rotate the crankshaft two turns to ensure free movement.
- 12** Fit the lubricating oil pump, see Operation 10-10, or fit the balancer unit, see Operation 5-15.
- 13** Fit the rear end oil seal housing, see Operation 5-2.
- 14** Fit the flywheel housing, see Operation 13-3, and the flywheel, see Operation 13-1.
- 15** Fit the timing case and the timing gears, see Chapter 6, Timing case and drive assembly.
- 16** Fit the timing case cover, see Operation 6-2.
- 17** Fit the exhauster if removed, see Operation 15-5.
- 18** Fit the alternator and its mounting bracket, see Operation 14-4.
- 19** Fit the crankshaft pulley, see Operation 5-1.
- 20** Fit the fuel injection pump:
 - For Bosch VP30 fuel injection pumps, see Operation 11-10.
 - For Bosch EPVE fuel injection pumps, see Operation 11-12.
 - For Delphi DP210 fuel injection pumps, see Operation 11-14.
- 21** Fit the coolant pump, see Operation 12-5, the fan drive pulley and housing, see Operation 12-9, the drive belts, see Operation 14-3, and the fan, see Operation 12-8.
- 22** Fit the lubricating oil sump, see Operation 10-5.
- 23** After the engine has been installed, fill the lubricating oil sump to the correct level with an approved oil, refer to Chapter 5 in the User's Handbook.
- 24** Fill the cooling system.

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, see "Crankshaft overhaul" on page 19. Special undersize bearings are available.

Crankshaft timing ring

To remove

Operation 5-13

Warning! Ensure that suitable protective clothing is worn.

Cautions:

- Apply heat to the timing ring only to reduce the risk of damage to the crankshaft
- Carefully remove the timing ring, do not damage the crankshaft palm oil seal face.

1 Remove the crankshaft from the cylinder block, see Operation 5-10.

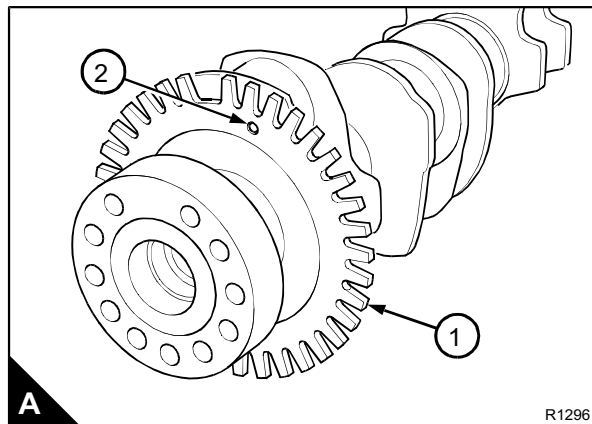
Note: If a "speedi sleeve" (wear sleeve) has been fitted to service the crankshaft palm seal diameter, the shoulder of this sleeve must be removed to give clearance for the timing ring.

2 Support the crankshaft in a vertical position with the crankshaft palm at the bottom.

3 Apply heat to the timing ring (A1) with a flame. The temperature of the timing ring must not exceed 270° C (518° F). When heat is applied to the timing ring, the ring will fall off the crankshaft web.

4 Discard the old timing ring after it has been allowed to cool safely.

5 Do not remove the timing ring locating dowel (A2) from the crankshaft web unless the locating dowel is damaged.



Warning! Ensure that suitable protective clothing is worn.

Cautions:

- Apply heat to the timing ring evenly to reduce the risk of damage and distortion to the timing ring (A1)
- Carefully fit the timing ring, do not damage the crankshaft palm oil seal face.

1 Ensure that the timing ring bore, and the crankshaft timing ring location shoulder, are both clean and free from any rough metal edges.

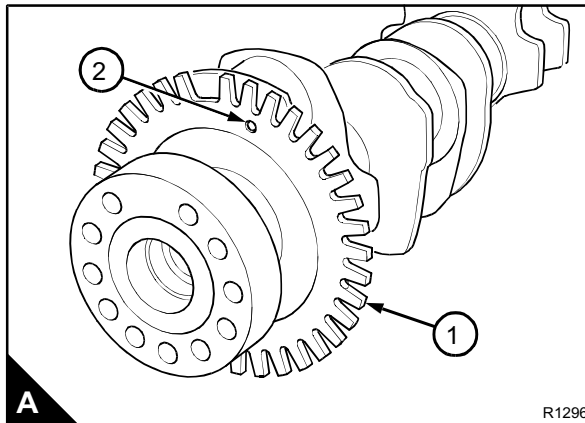
2 If the locating dowel (A2) was removed press a new locating dowel into the hole in the crankshaft web. Ensure that the locating dowel is at the bottom of the hole.

3 Support the crankshaft in a vertical position with the crankshaft palm at the top.

4 Heat the timing ring (A1) in an oven to a temperature of between 207°/250°C (405°/482° F). With the timing ring bore chamfer and relief groove towards the crankshaft web, and the dowel hole aligned with the dowel, immediately fit the timing ring. Ensure that the timing ring is fitted fully against the crankshaft web shoulder.

5 Allow the timing ring to cool safely.

6 Fit the crankshaft to the cylinder block, see Operation 5-11.



Balancer unit

To remove and to fit

Operation 5-15**Special requirements**

Special tools	
Description	Part number
Timing pin	27610225

To remove

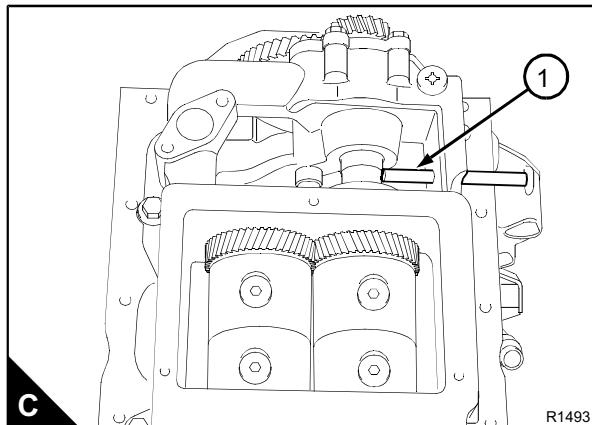
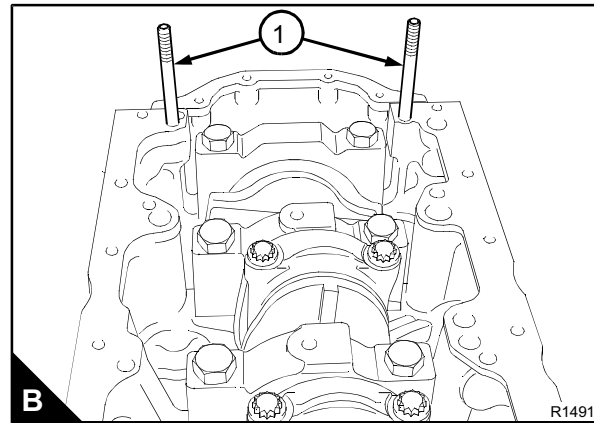
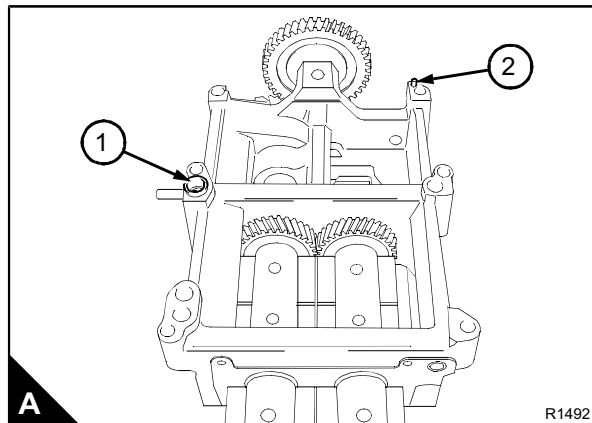
- 1 Drain the lubricating oil from the sump and remove the sump, see Operation 10-4.
- 2 Set the piston of the number 1 cylinder to TDC, see Operation 8-1.
- 3 Insert the timing pin (C1) into the balancer, ensure that the timing pin is fully located in the drive shaft.

Warning! The weight of the unit is approximately 25 kg (55 lb).

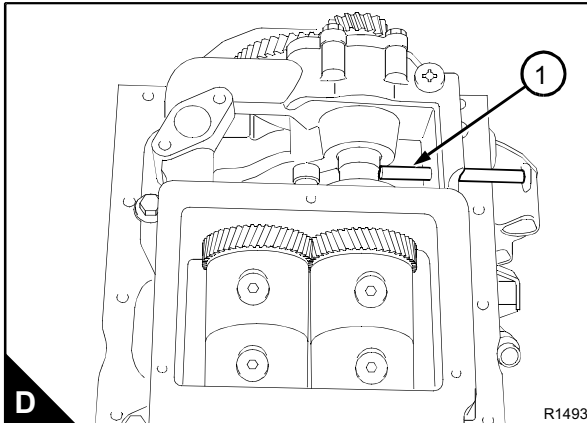
- 4 Provide a support for the balancer unit before release of the setscrews from the engine.
- 5 Release the setscrews and carefully remove the balancer unit.

To fit

- 1 Ensure that the contact faces of the cylinder block and of the balancer unit are clean and that the thimble (A1) and the dowel (A2) are fitted correctly to the cylinder block or to the balancer unit.
- 2 Set the piston of the number 1 cylinder to TDC, see Operation 8-1.
- 3 Fit two suitable M10 guide studs into positions (B1).

*Continued*

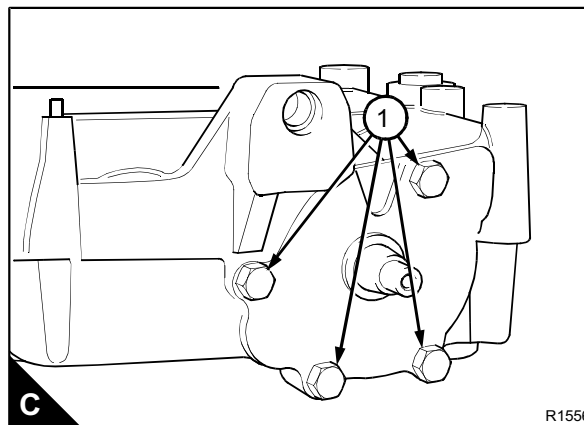
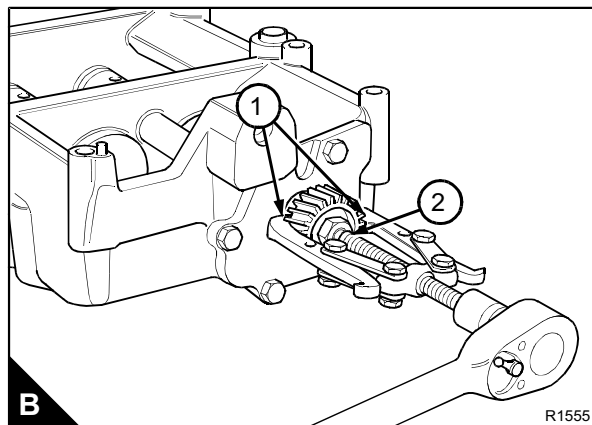
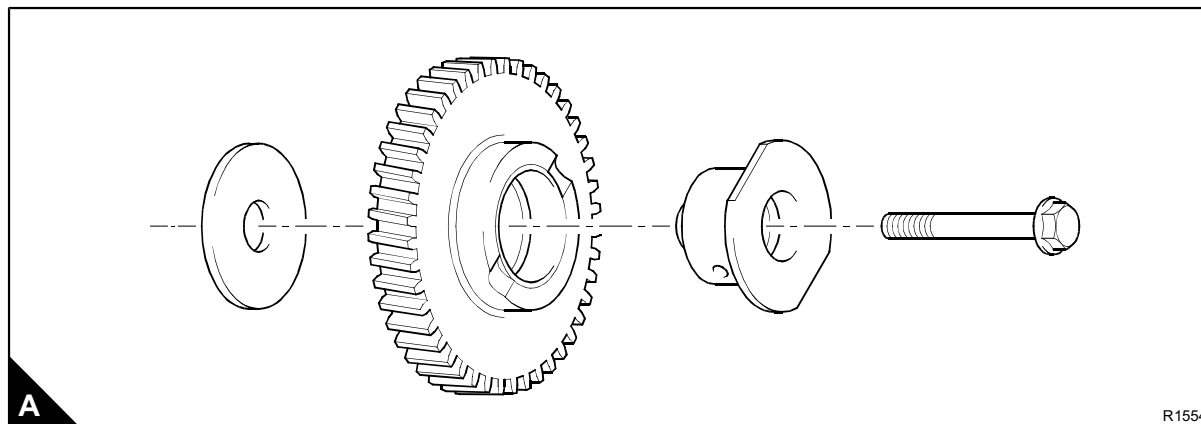
- 4** Insert the timing pin (D1) into balancer, ensure that the timing pin is fully located in the drive shaft and that the balancer weights are pointing away from the cylinder block.
- 5** Carefully fit the balancer unit onto the two M10 guide studs in the cylinder block, check that the balancer unit is fitted correctly on the thimble and the dowel. Ensure that the idler and crankshaft gears are in mesh. Fit two setscrews in the centre positions of the balancer frame, then tighten the setscrews to 54 Nm (40 lbf ft) 5,5 kgf m.
- 6** Remove the two M10 guide studs and fit the four remaining setscrews in their correct position. Tighten the setscrews to 54 Nm (40 lbf ft) 5,5 kgf m.
- 7** Rotate the crankshaft through two turns to ensure that it is free to rotate.
- 8** Fit the lubricating oil sump, see Operation 10-5, and fill the sump to the correct level with lubricating oil of an approved grade, refer to Chapter 5 in the User's Handbook TPD 1477.



To dismantle (oil pump)

Operation 5-16

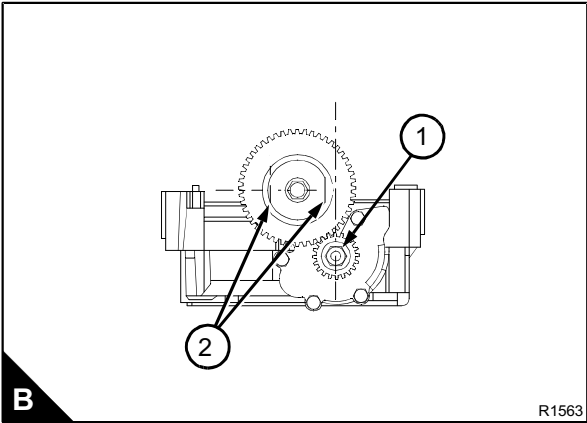
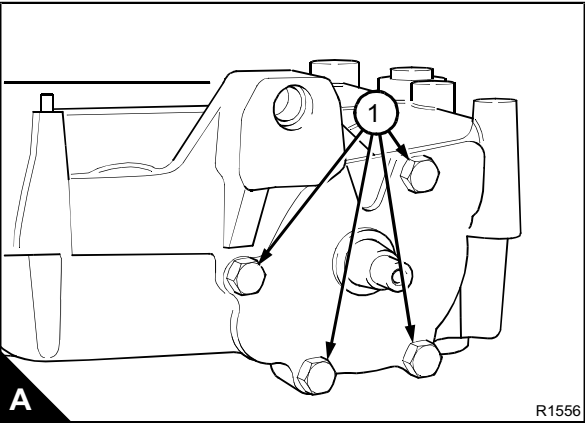
- 1 Remove the balancer from the engine, see Operation 5-15.
 - 2 To prevent movement of the drive shaft. Put a suitable flat distance piece in position between the balancer weights.
 - 3 Release the setscrew and remove the idler gear assembly (A).
- Note:** Keep the components together as an assembly.
- 4 Release the nut of the lubricating oil pump gear and remove the nut. Using a suitable 2 legged puller locate the puller arms on the back of the gear (B1) and remove the lubricating oil pump gear from the shaft.
 - 5 Release the four setscrews (C1) from the lubricating oil pump cover plate and remove the cover.
 - 6 Inspect the lubricating oil pump, see Operation 5-18.
 - 7 Dismantle the lubricating oil relief valve, see Operation 10-12.



Special requirements

Consumable products	
Description	Part number
POWERPART Threadlock and nutlock	21820117

- 1 Assemble the lubricating oil relief valve, see Operation 10-12.
 - 2 Fit the four setscrews (A1) to the lubricating oil pump cover plate and tighten to 26 Nm (19 lbf ft) 2,6 kgf m.
 - 3 Fit the lubricating oil pump gear and nut, gradually tighten to 95 Nm (70 lbf ft) 9,7 kgf m.
- Note:** Ensure that the flats on the thrust washer (B2) are aligned.
- 4 If necessary, renew the idler gear. Lubricate the bush with clean engine lubricating oil. Fit the hub into the bush and fit the thrust washer onto the rear of the hub. Ensure that the threads of the setscrew are clean and dry. Fit the setscrew through the assembly and apply a small amount of POWERPART Threadlock and nutlock to the thread. Fit the assembly to the front of the balancer unit . Tighten the setscrew to 26 Nm (19 lbf ft) 2,6 kgf m.
 - 5 Check the end-float of the idler gear with a feeler gauge between the front face of the idler gear and the hub. Check the backlash between the idler gear and the drive shaft gear. Refer to the Data and dimensions for "Balancer unit" on page 21.
 - 6 Fit the suction tube and the joint and tighten the setscrews, if removed.
 - 7 Remove the distance piece from the balancer weights.
 - 8 Fit the balancer to the engine, see Operation 5-15.

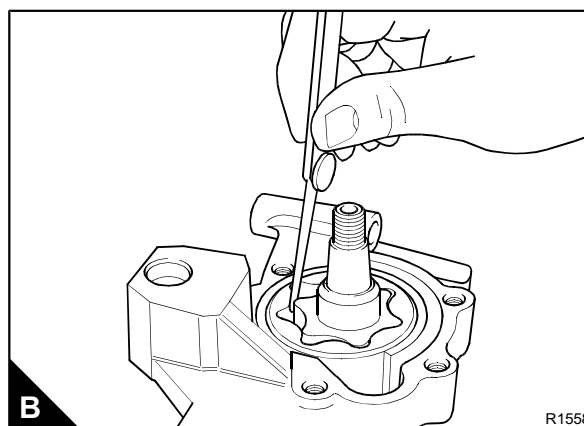
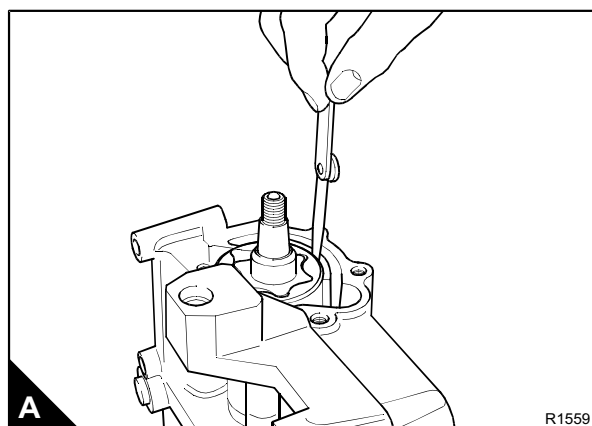


To inspect

Operation 5-18

Note: 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 Remove the setscrews 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 (A), refer to the Data and dimensions for the "Lubricating oil pump" on page 25.
- 4 Check the inner rotor to outer rotor clearance (B), refer to the Data and dimensions for the "Lubricating oil pump" on page 25.
- 5 Check the rotor end-float with a straight edge and a feeler gauge. For all the above clearances, refer to the Data and dimensions for the "Lubricating oil pump" on page 25.
- 6 Lubricate the inner and outer rotor with clean engine lubricating oil. Clean the top face of the oil pump and the inner face of the cover. Fit the cover. Tighten the setscrews to 28 Nm (21 lbf ft) 2,9 kgf m.



6

Timing case and drive assembly

General description

The timing case is made of either aluminium or cast iron.

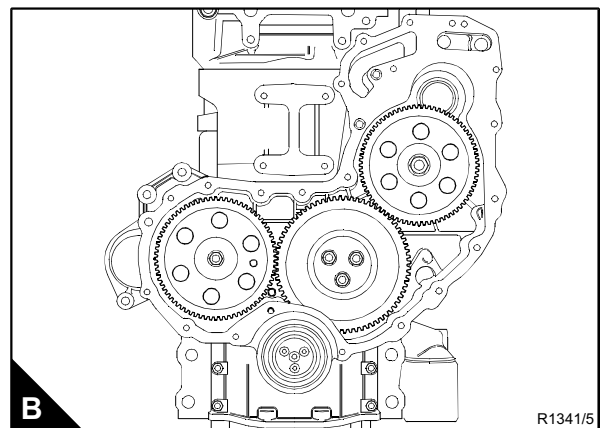
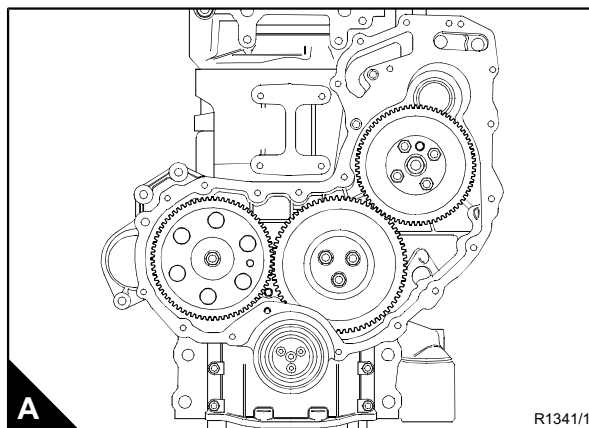
The cast iron timing case is used to mount two power take-off units.

The timing gears are made of steel. There are two different types of steel camshaft gear and upper idler gear. One for heavy duty and one for light duty. A power take-off is available on either the left hand side, or the right hand side or on both sides of the timing case. Some engines have an idler gear with a roller bearing.

The drive from the crankshaft gear passes through an idler gear to the camshaft gear and to the gear of the fuel injection pump. The drive from the crankshaft gear also passes through a lower idler gear to the gear of the lubricating oil pump. The coolant pump is driven by the gear of the fuel injection pump. The camshaft and the fuel injection pump run at half the speed of the crankshaft.

In (A) the electronic fuel pump gear is fitted. In (B) the mechanical fuel pump gear is fitted.

The timing case contains the front oil seal.

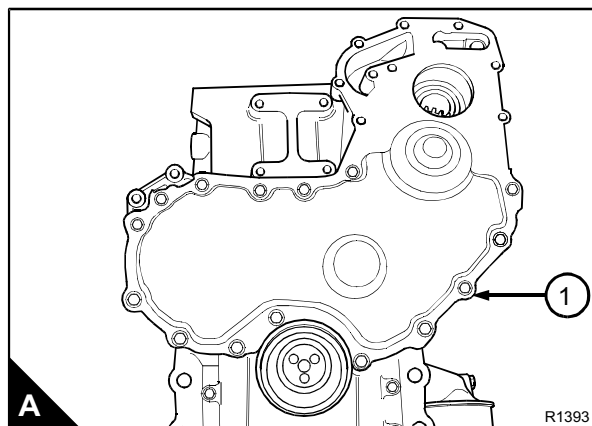


Timing case cover

To remove**Operation 6-1**

Notes:

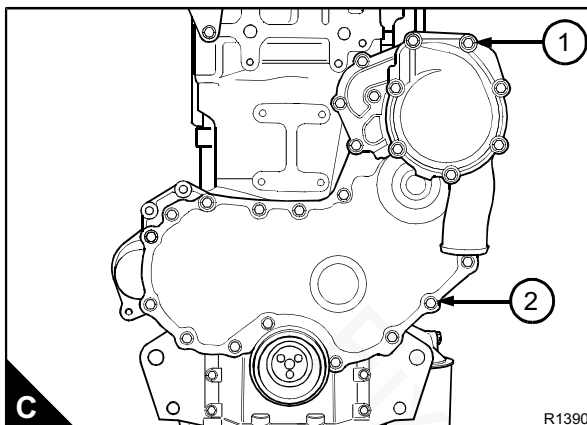
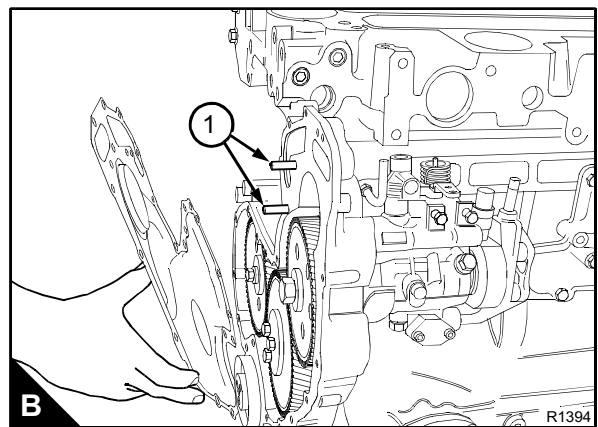
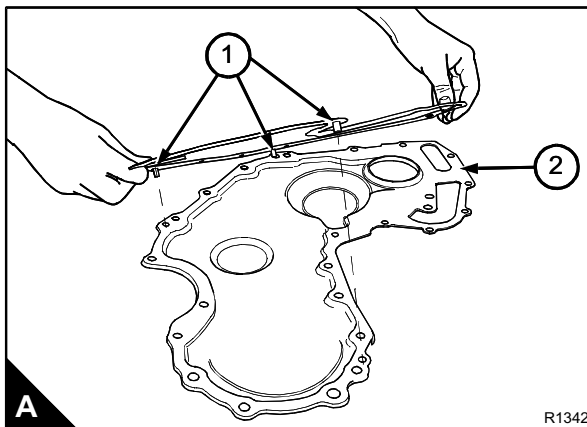
- To assist with access to the timing case cover, the fan drive can be removed, see Operation 12-9.
 - The timing case cover can be removed with the crankshaft pulley fitted.
- 1 Remove the coolant pump, see Operation 12-4.
 - 2 Remove the setscrews and the cover (A1), together with the joint.
 - 3 Remove the joint from the cover and discard the joint.



To fit

Operation 6-2

- 1 Clean the joint faces of the timing case and cover.
- 2 The new joint must be aligned by the three joint dowels (A1). The joint dowels are a push fit into the cover (A2).
- 3 Fit two temporary studs (B1) through the timing case and into the cylinder block.
- 4 Remove the timing pins, if fitted.
- 5 Fit the cover to timing case and loosely fit the setscrews.
- 6 Loosely fit the coolant pump, see Operation 12-5.
- 7 Tighten the cover setscrews (C2) and coolant pump fasteners (C1) together to 22 Nm (16 lbf ft) 2,2 kgf m
- 8 Fill the cooling system, refer to Chapter 4 of User's Handbook, TDP 1477.
- 9 If removed fit the crankshaft pulley, see Operation 5-1.
- 10 Fit the fan drive, see Operation 12-9.



Mechanical fuel pump gear

To remove

Operation 6-3

Special requirements

Special tools			
Description	Part number	Description	Part number
Crankshaft timing pin	27610211	Camshaft timing pin	27610212
Rocker assembly tools	27610227		

Cautions:

- These procedures must only be carried out by a person with the correct training.
- If the Delphi DP210 fuel injection pump nut (A1) is loosened before the fuel pump timing is set and the pump locked, the fuel injection pump timing will be lost and the fuel injection pump will have to be removed and sent to your nearest Perkins Dealer/Distributor to be reset.
- The Delphi DP210 fuel injection pump must remain locked if the fuel pump gear is removed. The fuel injection pump timing will be lost and the fuel injection pump will have to be removed and sent to your nearest Perkins Dealer/Distributor to be reset.
- If the Bosch EPVE fuel injection pump timing is lost, the pump timing can be reset on the engine, see Operation 8-4.
- The timing pins are a push fit. Do not use excessive force to fit the pins.
- The engine is pin timed at TDC, do not use the pins as a locking device when repairs are carried out on the engine.

Notes:

- The fuel pump gear can be removed with the crankshaft pulley fitted.
- It is recommend to help rotate the crankshaft, that the glow plugs are removed, see Operation 14-10.

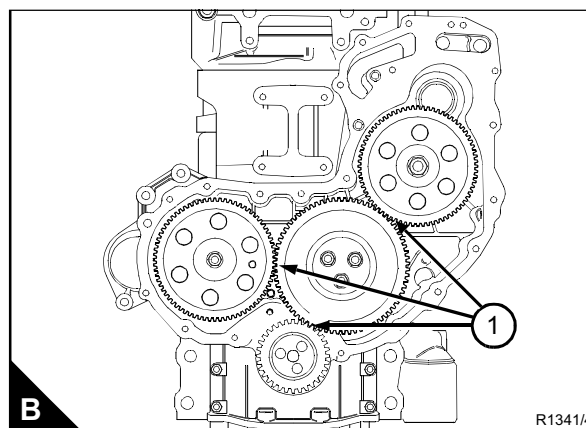
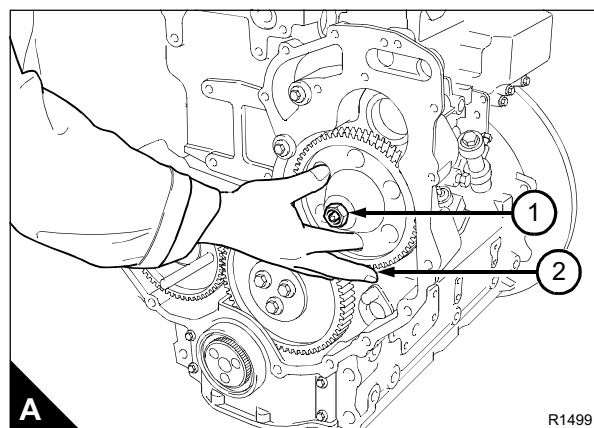
1 Rotate the crankshaft to TDC, see Operation 8-1.

2 Remove the rocker assembly, see Operation 3-4.

Caution: The backlash must be removed from all the gears before the fuel injection pump is locked. Failure to do so will make the fuel pump timing incorrect.

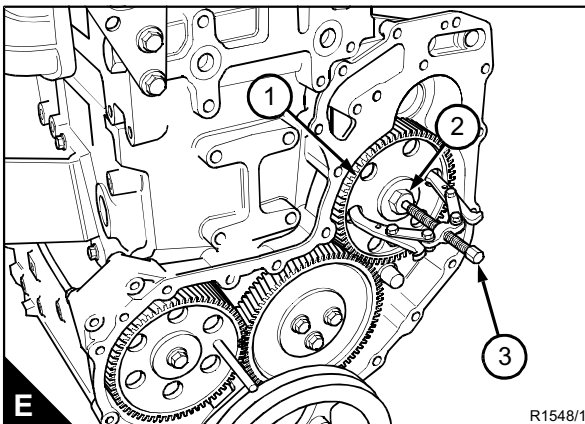
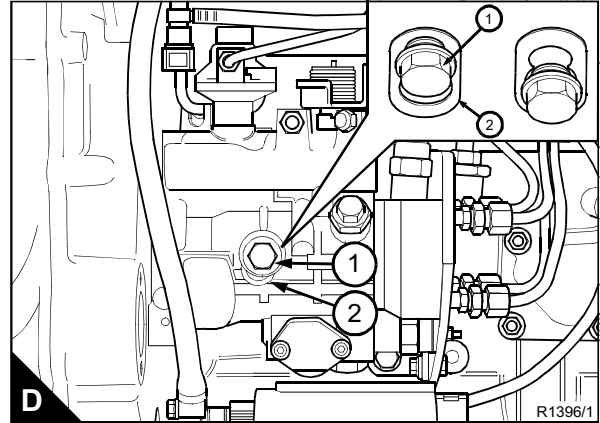
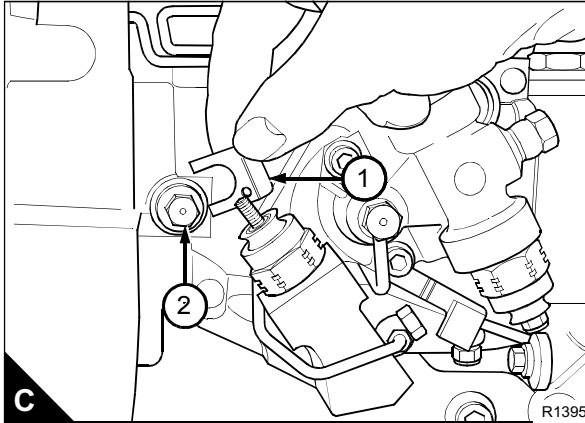
3 Apply pressure counter clockwise by hand to the fuel pump gear (A2), to remove back lash from the gears (B1), then lock the fuel injection pump.

4 There are two types of mechanical injection pump the Bosch EPVE and Delphi DP210. Both have different locking screws and require a different method to lock the pump.



Continued

- To lock the Bosch EPVE pump shaft, ensure the backlash is removed. Loosen the locking screw (C2) and remove the washer (C1). Tighten the locking screw (C2) to 31 Nm (23 lbf ft) 3,1 kgf m.
 - To lock the Delphi DP210 pump shaft, ensure the backlash is removed. Loosen the locking screw (D1) and move the washer (D2). Tighten the locking screw (D1) to 17 Nm (12 lbf ft) 1,7 kgf m. The washer (D2) can now rotate around the locking screw (D1) with the pump shaft locked.
- 5 Release the nut (E2) and fit a suitable two legged puller (E3). Tighten the puller until the gear is released.
- 6 Remove the puller (E3) and the nut (E2). Remove the gear (E1).



To fit

Operation 6-4

Special requirements

Special tools			
Description	Part number	Description	Part number
Crankshaft timing pin	27610211	Camshaft timing pin	27610212

Cautions:

- These procedures must only be carried out by a person with the correct training.
- The drive shaft of the pump must not be turned without the locking screw released, as this will damage the drive shaft.
- The engine is pin timed at TDC, do not use the pins as a locking device when repairs are carried out on the engine.

1 Clean and check the fuel pump gear and renew if damaged. Clean the fuel injection pump tapered shaft (A1).

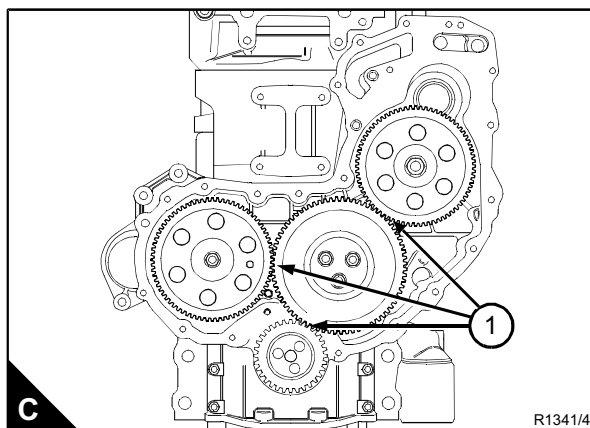
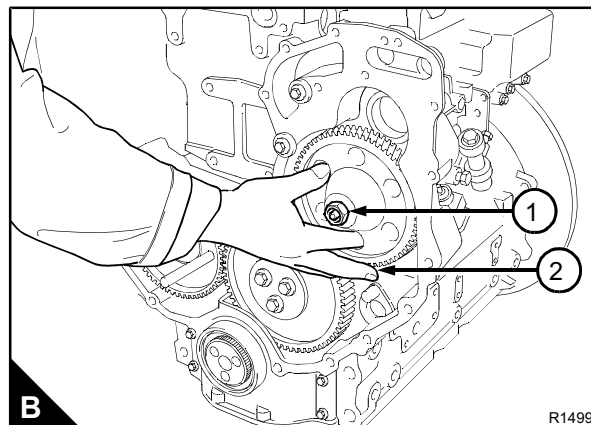
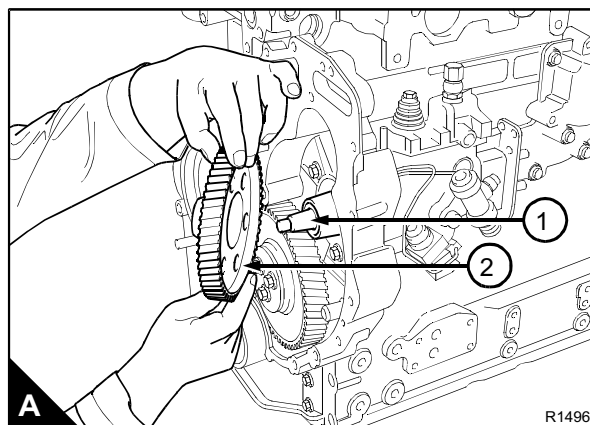
2 Check the engine is set to TDC, see Operation 8-1.

3 Fit the gear (A2) onto the tapered shaft (A1). Check that the fuel pump gear is correctly in mesh with the idler gear.

4 Fit the washer and nut (B1) and tighten by hand.

Caution: The backlash must be removed before the fuel injection pump is released. Failure to do so will make the fuel pump timing incorrect.

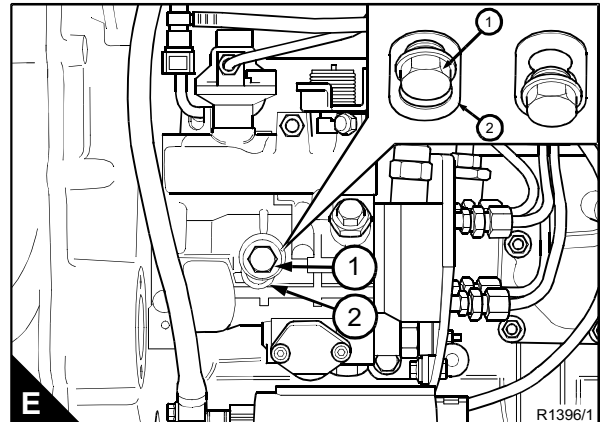
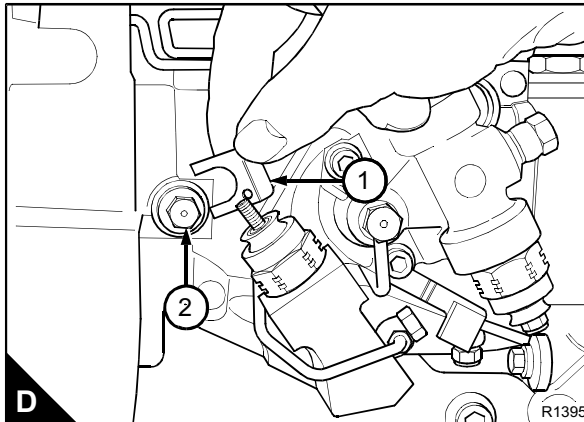
5 Apply pressure counter clockwise by hand (B2) to the fuel pump gear to remove the backlash from all the gears (C1). Tighten the nut (B1) to 24 Nm (18 lbf ft) 2,4 kgf m.



Continued

6 Release the locked fuel pump shaft.

- To release the Bosch EPVE pump shaft, ensure the backlash is removed. Loosen the locking screw (D2) and fit the washer (D1). Tighten the locking screw (D2) to 12 Nm (9 lbf ft) 1,2 kgf m.
- To release the Delphi DP210 pump shaft, ensure the backlash is removed. Loosen the locking screw (E1) and move the washer (E2). Tighten the locking screw (E1) onto the washer to 12 Nm (9 lbf ft) 1,2 kgf m.



7 Tighten the nut (B1) to 88 Nm (65 lbf ft) 9,0 kgf m.

8 Remove the two timing pins.

9 Check the fuel injection pump gear end-float (F1) and the backlash (G1), see "Timing case and drive assembly" on page 22.

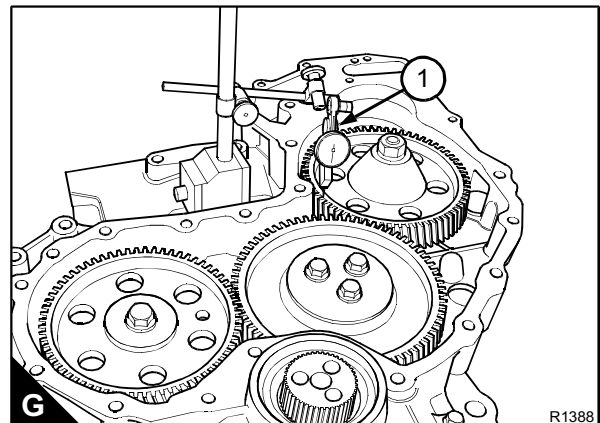
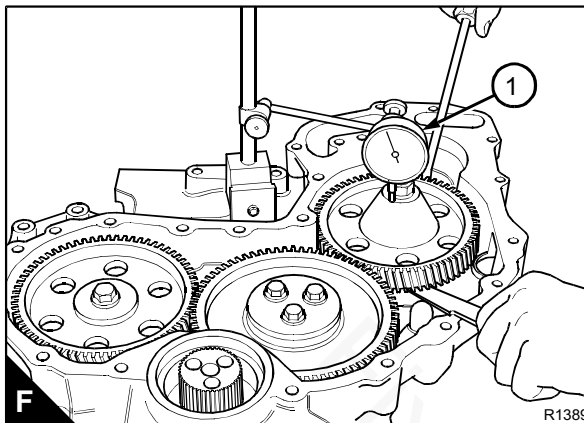
10 Lightly lubricate each gear with clean engine lubricating oil.

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

12 Fit the glow plugs, see Operation 14-10.

13 Fit the rocker assembly, see Operation 3-4.

14 Fit the rocker cover, see Operation 3-3.



Electronic fuel pump gear

To remove

Operation 6-5

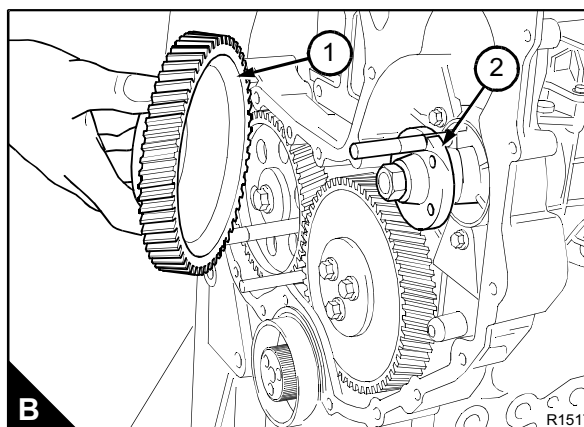
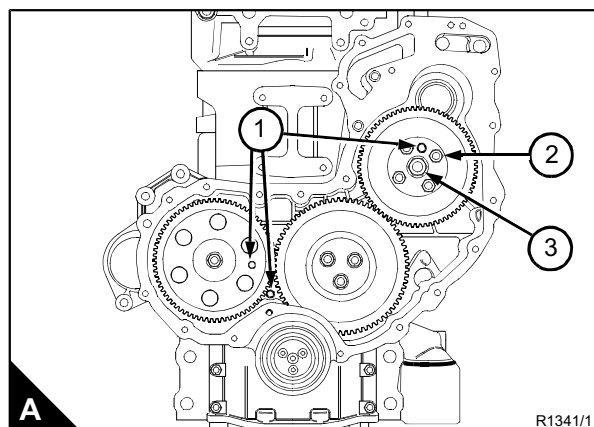
Special tools			
Description	Part number	Description	Part number
Crankshaft timing pin	27610211	Fuel pump timing pin	27610032
Camshaft timing pin	27610212		

Cautions:

- These procedures must only be carried out by a person with the correct training.
- If the hub nut (A3) is loosened the fuel injection pump timing will be lost and the fuel injection pump will have to be removed and sent to your nearest Perkins Dealer/Distributor to be reset.
- The timing pins are a push fit and must not be forced into place.
- The engine is pin timed at TDC, do not use the pins as a locking device when repairs are carried out on the engine.

Note: The fuel pump gear can be removed with the crankshaft pulley fitted.

- 1 Rotate the crankshaft to obtain TDC see, Operation 8-1.
- 2 Set the Bosch VP30 fuel injection pump timing, see Operation 8-2.
- 3 With all three timing pins fitted (A1), remove the setscrews (A2) and the hardened washers from the gear.
- 4 Remove the gear (B1) from the hub (B2).



Cautions:

- These procedures must only be carried out by a person with the correct training.
- The engine is pin timed at TDC, do not use the pins as a locking device when repairs are carried out on the engine.

Note: The fuel pump gear will only fit correctly in one position.

1 Clean and check the fuel pump gear (A1) for damage and renew if necessary. Clean the fuel injection pump hub (A3).

2 If the timing pin (A2) has been removed, rotate the hub (A3) until the slot in the hub is aligned with the hole in the pump body. Insert the timing pin through the slot into the hub (A3) and fully into the body of the fuel injection pump.

3 With all three timing pins fitted, fit the fuel pump gear (A1) over the timing pin (A2) and onto the hub (A3).

4 Loosely fit the flat hardened washers and setscrews (B3).

Caution: To ensure that the engine is correctly timed, backlash must be removed from all the gears.

5 Apply pressure counter clockwise by hand (B1) to the fuel pump gear (B2), to remove the backlash.

6 Tighten the setscrews (B3) to 22 Nm (16 lbf ft) 2,2 kgf m.

7 Remove the timing pins.

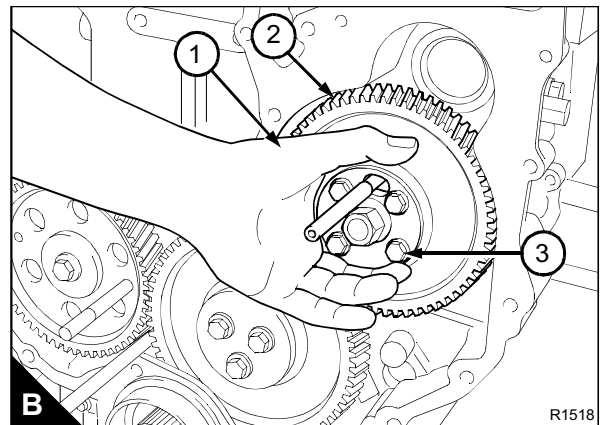
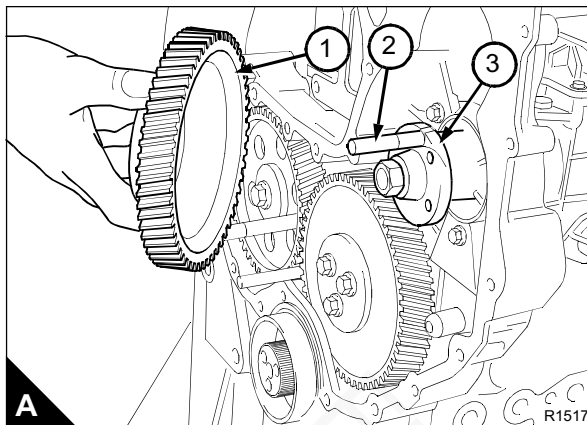
8 Check the fuel pump gear end-float and backlash, see "Timing case and drive assembly" on page 22.

9 Lightly lubricate each gear with clean engine lubricating oil.

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

11 Fit the glow plugs, see Operation 14-10.

12 Fit the rocker cover, see Operation 3-3.



Idler gear and hub

To remove

Operation 6-7

Notes:

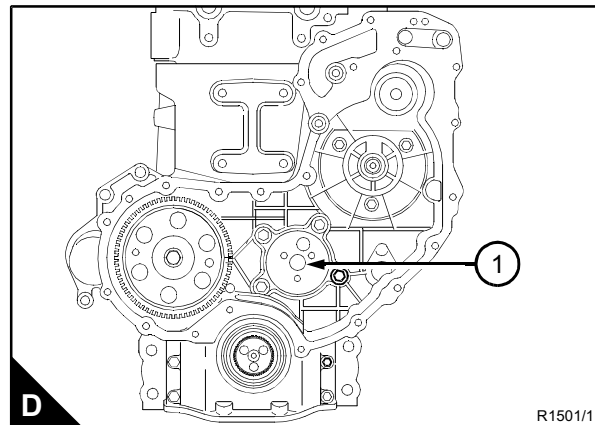
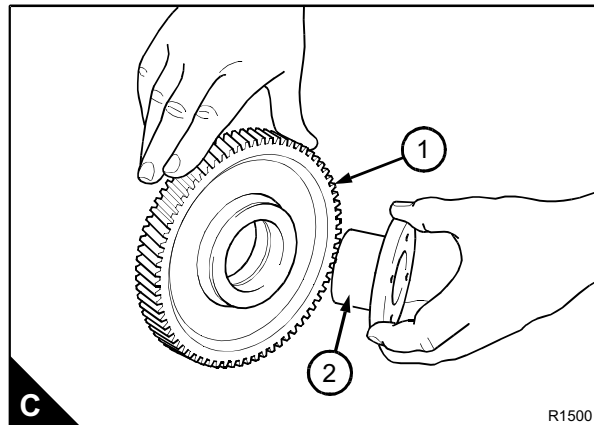
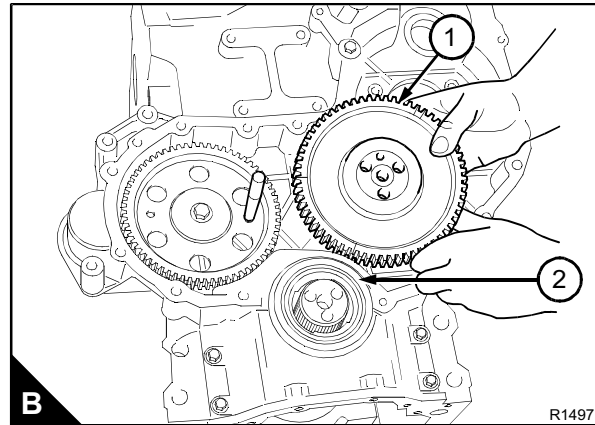
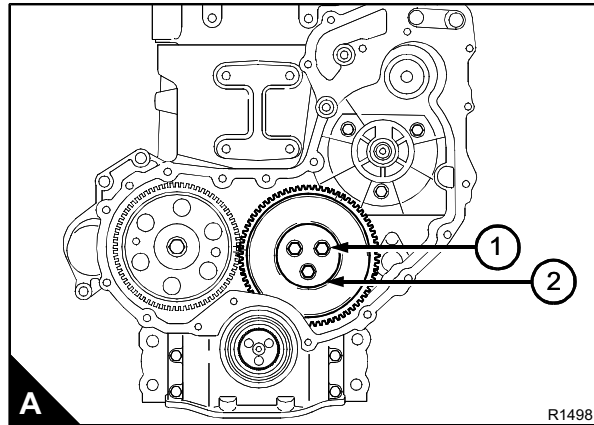
- There are two types of idler gear and hub. One gear is bushed and the other is fitted with roller bearings. This gear is the heavy duty idler gear. To remove the heavy duty idler gear assembly, the plate (A2) is removed and fitted as part of the gear assembly. To dismantle the assembly, see Operation 6-10.
- When the idler gear is to be removed, it is good practice to mark the plate (A2) and the idler gear, to help align the parts when they are to be assembled.

1 Remove the fuel pump gear; for the mechanical fuel pump gear, see Operation 6-3, and for the electronic fuel pump gear, see Operation 6-5.

2 Remove the rocker assembly, see Operation 3-4.

3 Remove the three setscrews (A1) and the plate (A2) from the idler gear. Remove the gear and the hub assembly (B1) from the recess (D1) in the cylinder block. The hub assembly (B1) must be moved forward and lifted over the front oil seal housing (B2).

4 Slide the hub (C2) out of the gear (C1).



To fit

Operation 6-8

Special requirements

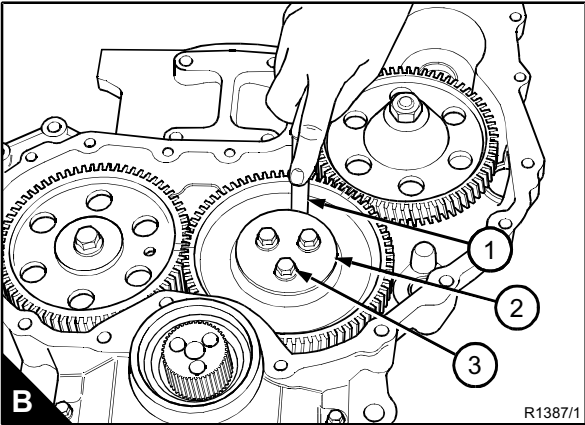
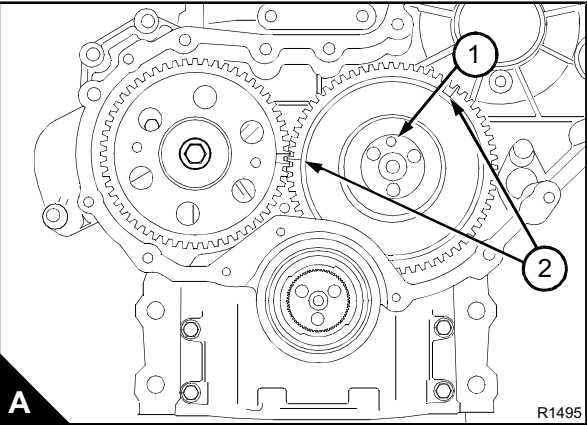
Special tools			
Description	Part number	Description	Part number
Crankshaft timing pin	27610211	Fuel pump timing pin	27610032
Camshaft timing pin	27610212		

Cautions:

- The hub assembly must be aligned correctly to the plate (B2) and the cylinder block to allow the gear to be lubricated.
- The marked teeth (A2) on the idler gear must be assembled to the hub so that they face to the front.
- The marked teeth (A2) on the idler gear must not be used as timing marks.
- The engine is pin timed at TDC, do not use the pins as a locking device when repairs are carried out on the engine.

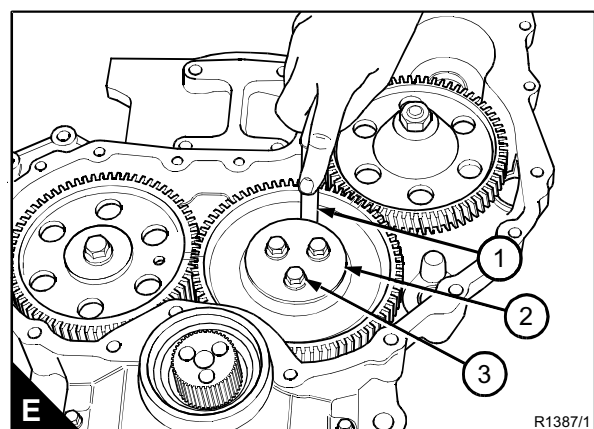
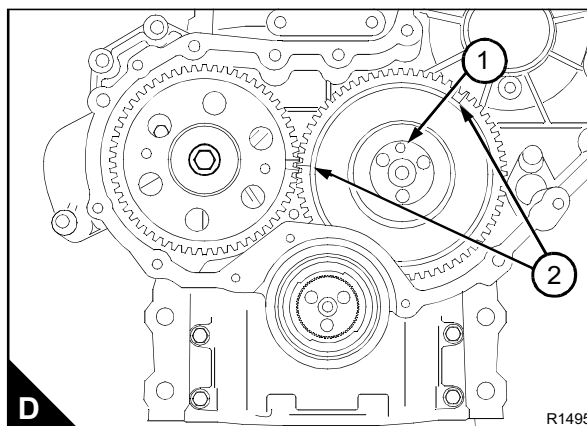
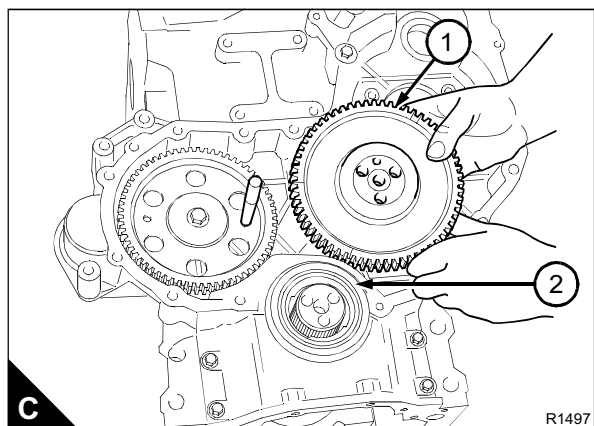
Note: To fit the heavy duty idler gear assembly the plate (B2) is fitted as part of the gear assembly. The plate will be marked with the word TOP, ensure this is facing the front of the engine this is to allow the gear assembly to be fitted correctly. To assemble the heavy duty idler gear, see Operation 6-11.

- 1 Clean and check the hub and gear for damage, renew if necessary.
- 2 Check the engine timing, see Operation 8-1.



Continued

- 3 Lubricate the hub with clean lubricating engine oil and fit the gear to the hub. Rotate the hub in the gear to align the oil way to the top.
- 4 Fit the hub assembly (C1) over the front oil seal housing (C2) and into mesh with crankshaft gear and camshaft gear. Check that the hole (D1) is towards the cylinder head.
- 5 Align the plate (E2) to the three holes in the hub. Fit the setscrew (E3).
- 6 With the hub assembly fitted, tighten evenly the three setscrews (E3) to 44 Nm (32 lbf) 4,5 kgf m.
- 7 Check the end float (E1) and back lash, see "Timing case and drive assembly" on page 22.
- 8 Fit the mechanical fuel pump gear, see Operation 6-4, or the electronic fuel pump gear, see Operation 6-6.
- 9 Fit the rocker assembly, see Operation 3-4.



To remove and fit idler gear bushes

Operation 6-9

Caution: *If the bushes in the idler gear are to be renewed, the backlash between the camshaft gear and the idler gear, and between the idler gear and the fuel pump gear must be accurate.*

If the bushes are to be changed, remove them with a suitable puller. If a puller is not available, machine off the face of one of the bushes and press them out. Press in new bushes and machine the bores to get the correct clearance on the hub. The gear must have the correct backlash. Machine the faces to get the correct end clearance.

When assembled, the idler gear backlash between the crank gear and idler gear must be checked in four positions. Rotate the crankshaft clockwise viewed from the front, and check the backlash between the two gears every 90°, see "Timing case and drive assembly" on page 22.

Heavy duty idler gear assembly

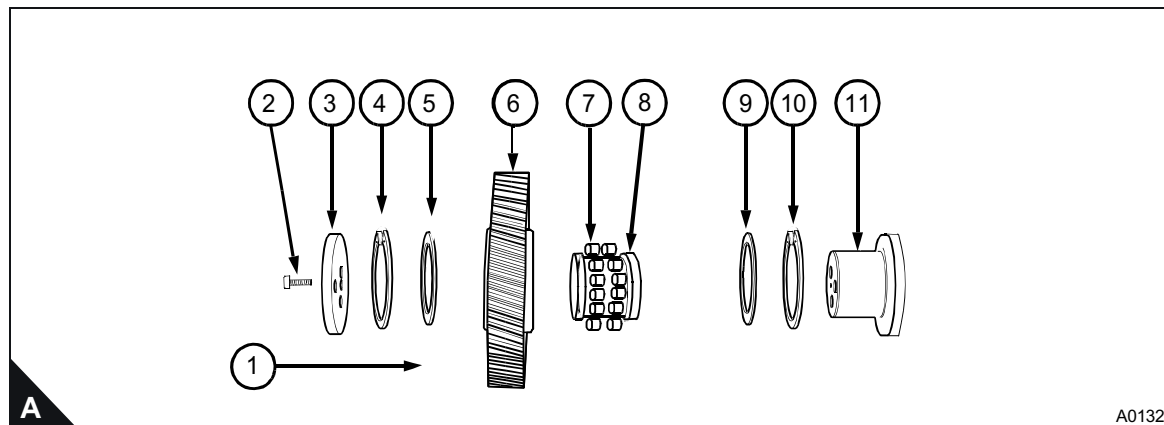
To dismantle

Operation 6-10

- 1 Remove the setscrew (A2), and the plate (A3) from the assembly.
- 2 Press the hub (A11) out of the bearing housing (A8).
- 3 Remove the circlip (A4) and the thrust washer (A5) from the gear (A6). Slide the bearing housing (A8) with the rollers (A7) out of the gear (A6).

Note: With the removal of the bearing from the gear, the rollers (A7) will become loose.

- 4 Remove the circlip (A10) and the thrust washer (A9).



To assemble

Operation 6-11

Special requirements

Consumable products	
Description	Part number
POWERPART Threadlock and nutlock	21820117

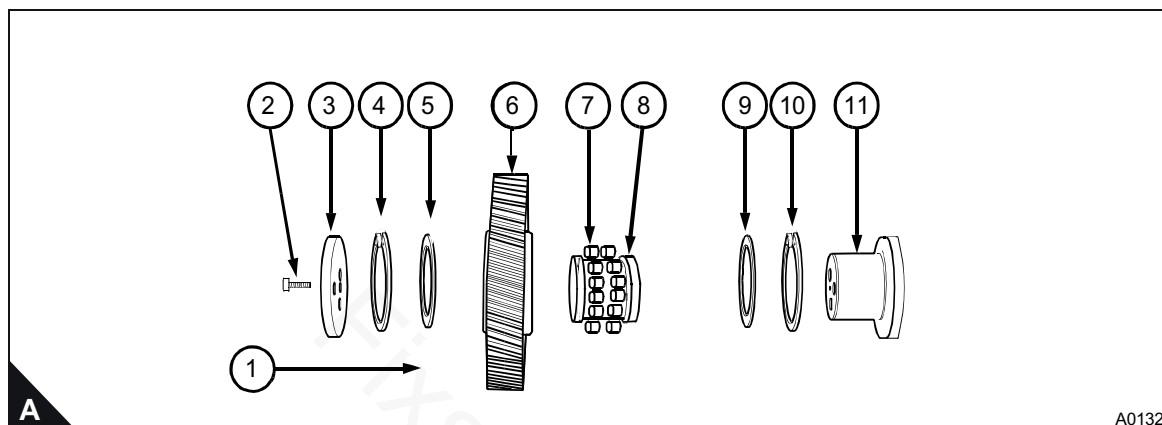
Cautions:

- The bearing and the hub must be fitted so that the marked teeth of the heavy duty idler gear are to the front.
- The new bearing assembly has a sleeve fitted, to hold the needle roller bearing securely. The sleeve must not be removed before the bearing assembly is fitted into the gear. If the sleeve is removed from the bearing assembly before the bearing is fitted, the bearing rollers will become loose.
- The hub assembly must be aligned correctly to the plate (A3) and the cylinder block to allow the gear to be lubricated.
- If a used bearing assembly is dismantled and the rollers become loose, a new bearing assembly must be fitted.

- 1 Clean all parts and check for wear and damage, renew as necessary.
- 2 Fit the circlip (A10) into the back face of the gear (A6), slide the thrust washer (A9) into the front face of the gear bore (A1).
- 3 Align the new bearing assembly with the sleeve to the front face (A1) of the gear bore, push the bearing assembly out of the sleeve and into the gear bore.
- 4 Fit the thrust washer (A5) and the circlip (A4). Lightly lubricate the bearing with clean engine lubricating oil.
- 5 Press the gear assembly onto the hub (A11).

Note: If the old setscrew (A2) is to be used, apply POWERPART Threadlock and nutlock.

- 6 Fit the plate (A3) and the setscrew (A2) to the gear assembly. Rotate the plate (A3) until the three holes in the plate are aligned correctly to the three holes in the hub (A11). The plate (A3) will be marked with the word TOP, ensure this is facing the front of the engine. Tighten the setscrew (A2) to 9 Nm (7 lbf ft) 0,9 kgf m.



Camshaft gear

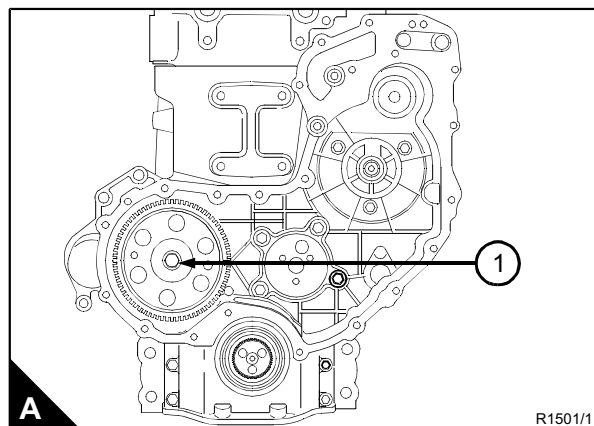
To remove and to fit

Operation 6-12

To remove

Caution: The engine is pin timed at TDC, do not use the pins as a locking device when repairs are carried out on the engine.

- 1 Remove the idler gear, see Operation 6-7.
- 2 Remove the camshaft timing pin.
- 3 Remove the setscrew (A1), with its washer, and remove the gear from the camshaft. Ensure that the key in the camshaft is not lost.



To fit

Note: The camshaft timing pin is a push fit into the timing case. The camshaft gear will rotate a small amount when the pin is fitted. This is to allow the assembly of the gears and removal of the backlash from the gears when needed, with the timing pin fitted.

- 1 Clean and check the camshaft gear and camshaft key for wear and damage, renew if necessary.
- 2 Ensure that the camshaft key is fitted correctly.
- 3 Fit the camshaft gear to the camshaft with the marked teeth towards the front and the keyway correctly aligned with the key. If necessary, lightly hit the gear with a soft face hammer to engage the key into the keyway. Fit the camshaft timing pin. If the camshaft needs to be rotated, remove the rocker assembly, see Operation 3-4.
- 4 Fit the washer and setscrew (A1) to the gear and tighten the setscrew to 95 Nm (70 lbf ft) 9,7 kgf m.
- 5 Fit the idler gear, see Operation 6-8.

Front oil seal

To remove

Operation 6-13**Special requirements**

Special tools	
Description	Part number
Three legged puller	27610230

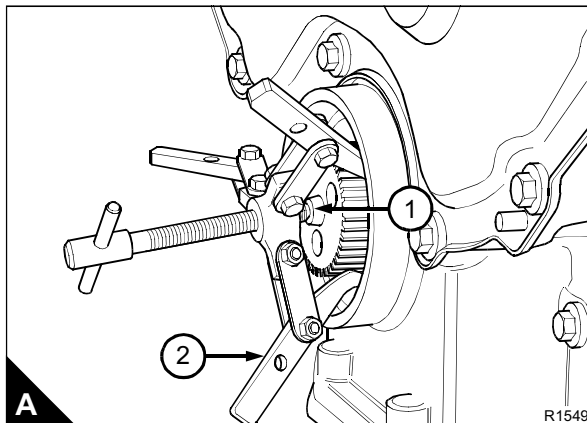
To remove the oil seal from the timing case fitted to the engine

Warning! The oil seal is made of "Viton", see the safety precautions for "Viton seals" on page 8.

Caution: The oil seal housing must not be damaged when the oil seal is removed.

- 1 Remove the crankshaft pulley, see Operation 5-1.
- 2 Thoroughly clean the area around the oil seal housing.
- 3 Fit the legs (A2) of the puller under the oil seal and lock into position.
- 4 Fit a suitable distance piece (A1) between the crankshaft and the puller.
- 5 Remove the oil seal from the housing.
- 6 Discard the oil seal.

Note: If the timing case is removed from the engine, the seal can be removed from the timing case. Use a suitable adaptor to press the seal out of the timing case. Ensure that the timing case is supported correctly, and that excessive pressure is not used to remove the seal, this can damage or distort the case.



To fit

Operation 6-14

Special requirements

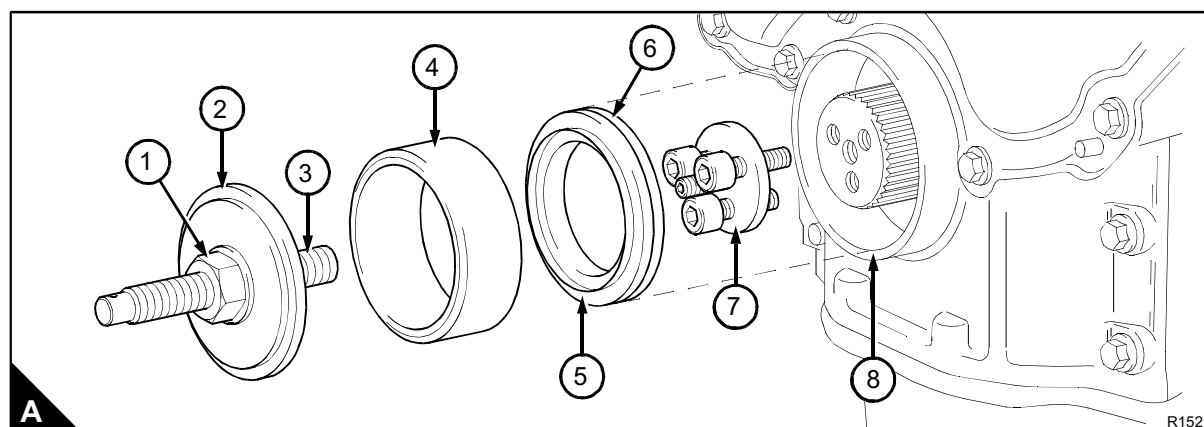
Special tools			
Description	Part number	Description	Part number
Crankshaft front oil seal replacer	21825577	Pressure plate for use with 21825577	21825578
Fastener plate for use with 21825577	21825580	Adaptor for use with 21825577	27610217

To fit the oil seal with the timing case fitted

Warning! The oil seal (A6) is made of "Viton", see the safety precautions for "Viton seals" on page 8.

Cautions:

- New timing case oil seals have a sleeve (A5) fitted to protect the oil seal. Do not remove the sleeve until the crankshaft pulley is to be fitted. Discard the new oil seal if the sleeve (A5) is not fitted.
 - Damage may be done to the seal if the correct tool is not used.
 - It is important that only genuine Perkins parts are used. The use of a seal that is not a genuine Perkins part may damage the engine and will affect the warranty.
 - Do not lubricate the oil seal or the oil seal housing.
- 1 Clean the oil seal housing and check for damage, renew if necessary.
 - 2 Check the crankshaft pulley seal face for wear. To repair the pulley, see Operation 6-15.
 - 3 Assemble the oil seal tool. Fit the fastener plate (A7) to the front of the crankshaft.
 - 4 Assemble the nut (A1) and the pressure plate (A2) onto the threaded bar (A3).
 - 5 Align the seal (A6) and the sleeve (A5) to the front of the oil seal housing (A8).
 - 6 Fit the adaptor (A4) onto the sleeve (A5).
 - 7 Put the pressure plate assembly onto the adaptor (A4) and tighten the threaded bar (A3) onto the fastener plate (A7). Check the alignment of the assembly and the oil seal to the oil seal housing.
 - 8 Fit a rod through the hole in the end of the threaded bar to prevent movement of the bar when the nut is tightened. Tighten the nut (A1) to push the seal into the housing. Tighten until contact is made with the bottom face of the oil seal housing.
 - 9 Remove the replacer tool.
 - 10 Turn and pull the sleeve (A5) counter clockwise, to remove the sleeve from the oil seal.
 - 11 Fit the crankshaft pulley immediately see, see Operation 5-1.



Continued

To fit the oil seal with the timing case removed

- 1 Clean the oil seal housing and check for damage, renew if necessary.
- 2 Check the crankshaft pulley for damaged. To repair the pulley, see Operation 6-15.
- 3 Check that the new oil seal has the sleeve protector fitted.
- 4 Align the oil seal to the oil seal housing. Do not lubricate the oil seal or the housing.
- 5 With a suitable tool, press the oil seal into the housing until contact is made with the bottom face of the housing.
- 6 Fit the timing case, see Operation 6-17.
- 7 When the front timing case cover is fitted, turn and pull the sleeve protector counter clockwise, to remove the sleeve from the seal.
- 8 Fit the crankshaft pulley immediately, see Operation 5-1.

To fit a wear sleeve

Operation 6-15

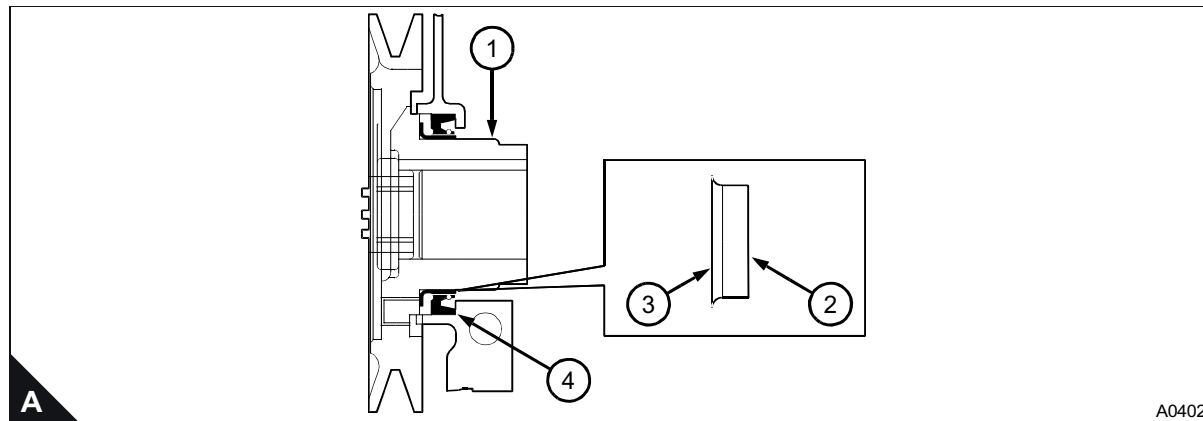
To renew a worn or damaged crankshaft pulley, a wear sleeve (A2) is fitted over the spigot (A1).

1 Remove the crankshaft pulley, see Operation 5-1.

Note: Full instructions and a special tool to fit the wear sleeve are in each service kit.

2 Fit the wear sleeve, in accordance with the manufacturer's instructions. It is not necessary to remove the flange (A3) of the wear sleeve after it has been fitted. A new front oil seal (A4) must be used when a wear sleeve is fitted.

3 Fit the crankshaft pulley, see Operation 5-1.

**A**

A0402

Timing case

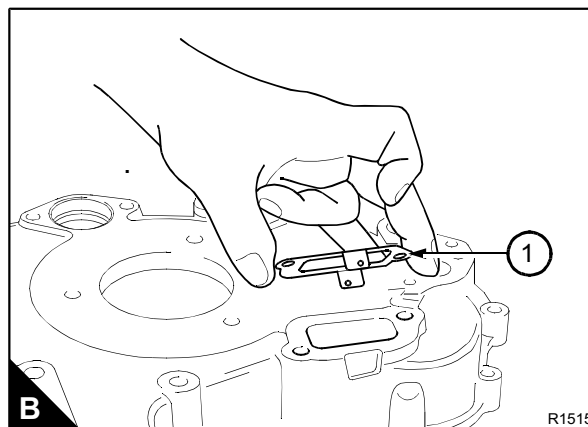
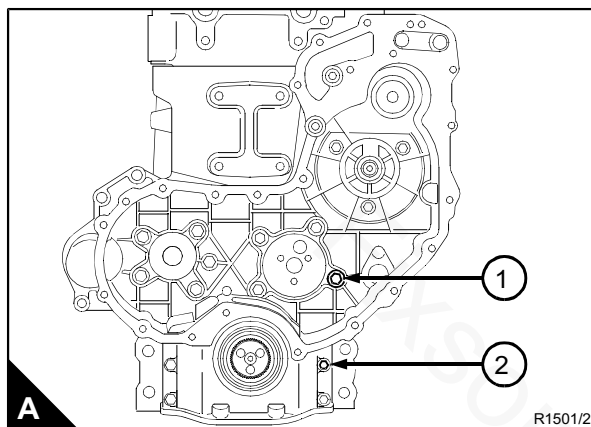
To remove

Operation 6-16**Special requirements**

Special tools			
Description	Part number	Description	Part number
Crankshaft timing pin	27610211	Fuel pump timing pin	27610032
Camshaft timing pin	27610212		

Note: It is not necessary to remove the alternator, if the belts and the link setscrew are removed. The alternator can be rotated away from the timing case.

- 1 Drain the lubricating oil and coolant.
- 2 Remove the fan drive, see Operation 12-9.
- 3 If not previously removed, remove the crankshaft pulley, see Operation 5-1.
- 4 If required remove the alternator, see Operation 14-4.
- 5 Remove the lubricating oil sump, see Operation 10-4.
- 6 Remove the fuel injection pump:
 - For Bosch fuel injection pumps, see Operation 11-9 or Operation 11-11.
 - For the Delphi DP210 fuel injection pump, see Operation 11-13.
- 7 Remove the coolant by-pass, see Operation 12-13.
- 8 Remove the PTO, if fitted see Operation 15-2.
- 9 Remove the crankshaft timing pin and the camshaft timing pin.
- 10 Remove the camshaft gear, see Operation 6-12.
- 11 Remove the timing case oil seal if a new oil seal is to be fitted, see Operation 6-13.
- 12 Remove the internal setscrews (A1) and the outer setscrews (A2) of the timing case.
- 13 Remove the timing case from the cylinder block. Remove the upper joint (B1) from the timing case, and the lower joint from the cylinder block.
- 14 Discard all old joints.



To fit

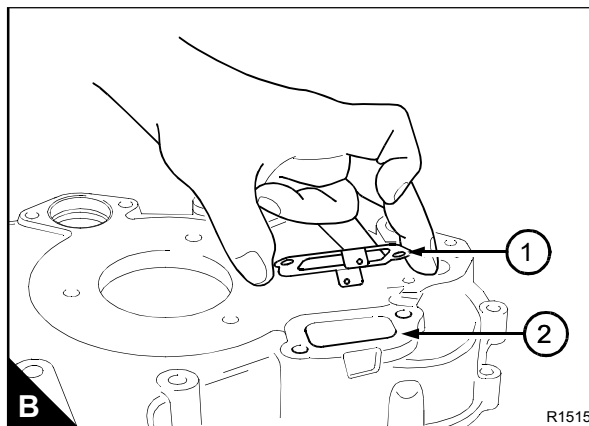
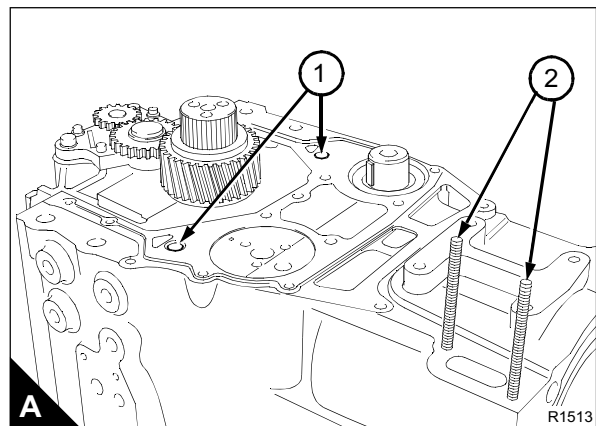
Operation 6-17

Special requirements

Special tools		Consumable products	
Description	Part number	Description	Part number
Crankshaft timing pin	27610211	POWERPART Retainer	21820608
Camshaft timing pin	27610212		
Fuel pump timing pin	27610032		
Alignment tool	27610216		

Note: If a new timing case is to be fitted, it may be necessary to fit blanking plugs. Apply POWERPART retainer, part number 21820608, to the blanking plug bore. This plug must be fitted into the timing case before the case is fitted to the engine.

- 1 Clean and check the timing case for damage, renew if necessary.
- 2 Check that the camshaft thrust washer is fitted correctly. Fit the lower timing case joint (A1) onto the cylinder block.
- 3 Fit two temporary studs (A2) to the cylinder block.
- 4 Fit the upper timing case joint (B1) to the timing case (B2).

*Continued*

5 Fit the alignment tool (C2) into the block, and secure in place.

6 Fit the timing case (C1) over the alignment tool (C2) and onto the cylinder block. Fit the setscrews into the timing case and tighten by hand.

7 Align the timing case (D2) to the cylinder block (D1).

Note: To seal the lubricating oil sump joint, ensure that the bottom of the timing case is correctly aligned with the bottom of the cylinder block before the setscrews are tightened. The alignment of the bottom face of the timing case (D2) and the cylinder block (D1) must not exceed $\pm 0,05$ mm (0.002 in).

8 Tighten the setscrews to 22 Nm (16 lbf ft) 2,2 kgf m, and check the alignment (C3) of the timing case face to the cylinder block face, adjust if necessary.

9 Fit the coolant by-pass, see Operation 12-13.

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

11 Fit the camshaft gear, see Operation 6-12.

12 Fit the idler gear, see Operation 6-8.

13 Fit the fuel injection pump:

- For Bosch fuel injection pumps, see Operation 11-10 or, see Operation 11-12.
- For the Delphi DP210 fuel injection pump, see Operation 11-14.

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

15 Fit the coolant pump, see Operation 12-5.

Note: The coolant pump setscrews should be tightened together with the timing case cover setscrews.

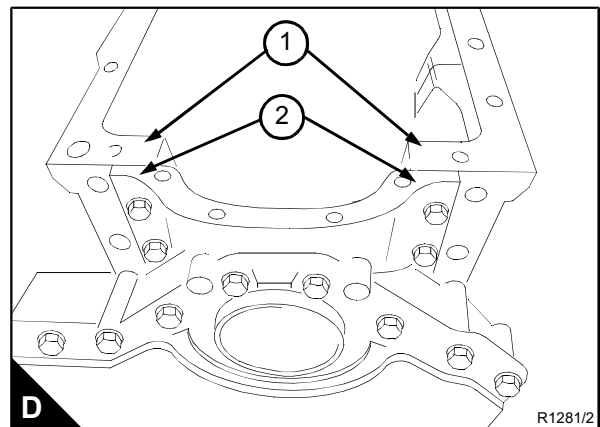
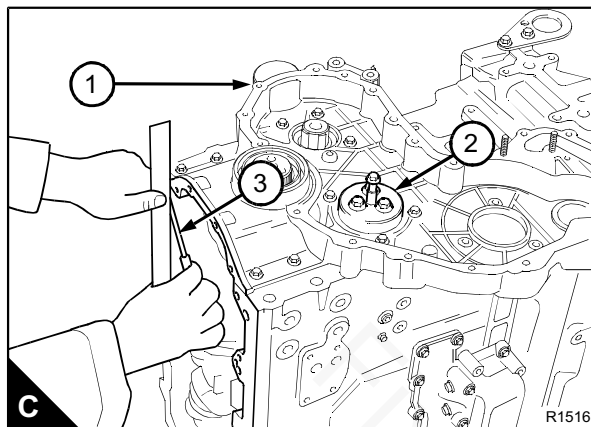
16 Fit a new oil seal to the timing case, see Operation 6-14.

17 Fit the crankshaft pulley, see Operation 5-1.

18 If removed fit the alternator, see Operation 14-4.

19 Fit the fan drive, see Operation 12-9.

20 When the engine is fitted into the application, fill the lubricating oil sump to the correct level and with the correct grade of engine lubricating oil, see Operation 10-5. Fill the cooling system to the correct level, and with the recommended POWERPART Antifreeze, see User's Handbook TPD 1477.



Crankshaft gear

To remove and to fit

Operation 6-18

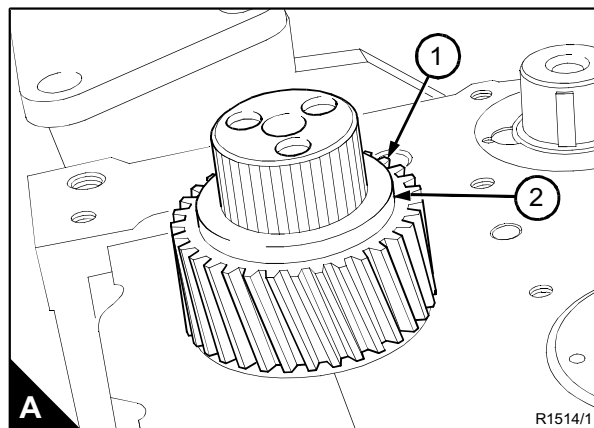
To remove

- 1 Remove the timing case, see Operation 6-16.
- 2 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, to remove the gear safely, see Operation 5-10.

To fit

Caution: Do not use a flame to heat the gear, as this can cause local damage.

- 1 The gear (A1) 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 the gear in an oven to not more than 200 °C (392 °F). If an oven is not available, heat the gear in coolant which is at its boiling point.
- 2 Align the keyway in the gear to the key in the crankshaft.
- 3 Fit the gear (A1) with the shoulder (A2) facing outwards.
- 4 Fit the timing case, see Operation 6-17.

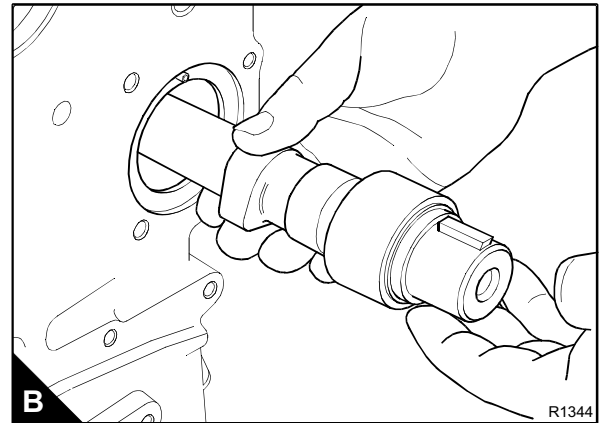
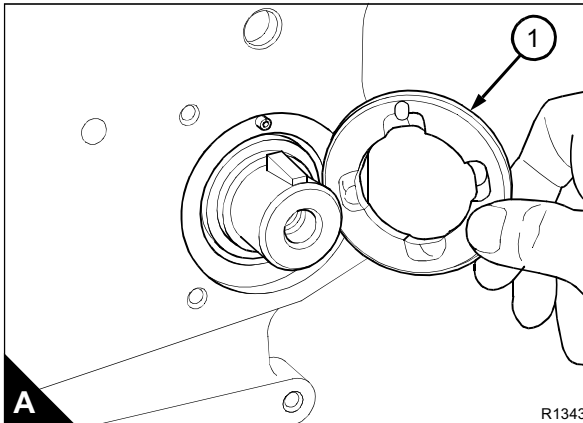


Camshaft and tappets

To remove

Operation 6-19

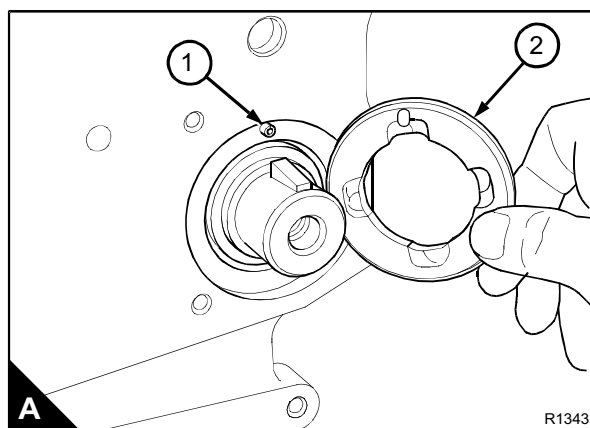
- 1 Remove the timing case, see Operation 6-16.
- 2 Remove the rocker cover, see Operation 3-2.
- 3 Remove the rocker assembly and the push rods, see Operation 3-4.
- 4 With the engine upside down, remove the camshaft thrust washer (A1) and carefully remove the camshaft (B).
- 5 Remove the tappets.
- 6 Inspect the camshaft and the tappets for wear and other damage, also inspect the camshaft bush. Renew the components as necessary.



To fit

Operation 6-20

- 1 Ensure that all components are clean and are lubricated with clean engine lubricating oil.
- 2 With the engine upside down, fit the tappets into position.
- 3 Carefully fit the camshaft.
- 4 Fit the camshaft thrust washer (A2). Ensure that it is fitted correctly onto the hollow dowel (A1).
- 5 Turn the engine the right way up.
- 6 Fit the timing case, see Operation 6-17.
- 7 Check that the camshaft end-float is within the limits, see "Camshaft" on page 22.
- 8 Fit the push rods.
- 9 Fit the rocker assembly, see Operation 3-4.
- 10 Adjust the valve tip clearance, see Operation 3-7.
- 11 Fit the rocker cover, see Operation 3-3.



Fixsomething

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7

Cylinder block assembly

General description

The cylinder block is made of high duty cast iron with an integral crankcase. The sides of the cylinder block extend below the crankshaft centre line to give added strength. The cylinder block provides full length support for the cylinder bores.

All bores are honed with silicon carbide tools to a controlled finish to ensure long life and low oil consumption. A bush is fitted in the cylinder block for the front camshaft journal and the other camshaft journals run directly in the block.

Note: Your Perkins Dealer/Distributor has specialist equipment and personnel with the correct training to repair worn cylinder bores.

Fixsomething

Cylinder block

To dismantle

Operation 7-1

Notes:

- If the cylinder block is to be renewed, it may be necessary to change the grade of the connecting rods, see the table in Operation 4-11. This will occur if the correct piston height above the block face cannot be maintained with the original piston and connecting rod assemblies, see Operation 4-6.
 - All of the components that need to be removed for access to the cylinder block are referred to in the procedure below. As a result some of the stages within operations may be repeated.
- 1** Ensure that all engine fluids are drained.
 - 2** Remove the ECM, if fitted, see Operation 14-13, the wiring harness, and the speed and timing sensor, if fitted, see Operation 14-16.
 - 3** Remove the VLPM, if fitted, see Operation 14-14.
 - 4** Remove the lubricating oil cooler, see Operation 12-10.
 - 5** Remove the lubricating oil filter head, see Operation 10-3.
 - 6** Remove the cylinder head, see Operation 3-9.
 - 7** Remove the crankshaft, see Operation 5-10.
 - 8** Remove the piston and the connecting rod assemblies, see Operation 4-4.
 - 9** Remove the camshaft, see Operation 6-19.
 - 10** Remove the piston cooling jets, if fitted, see Operation 4-15.

To assemble

Operation 7-2

Special requirements

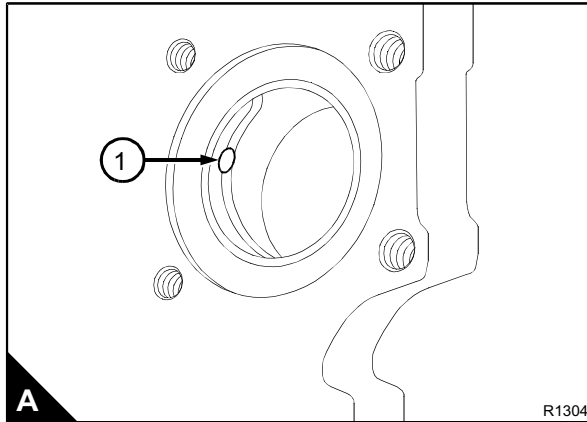
Consumable products	
Description	Part number
POWERPART Threadlock and nutlock	21820117

- 1 Clean thoroughly the new cylinder block. Ensure that all the oil passages are clean and free from debris.
- 2 Remove the threaded plugs from the old cylinder block and clean the threads. Seal the threads with POWERPART Threadlock and nutlock, and fit the threaded plugs into the new cylinder block.
- 3 Fit the piston cooling jets, see Operation 4-15.
- 4 Fit the crankshaft, see Operation 5-11. Do not fit the lubrication oil sump at this time.
- 5 Fit the piston and connecting rod assemblies, see Operation 4-5.
- 6 Fit the camshaft, see Operation 6-20.
- 7 Fit the lubricating oil filter housing, see Operation 10-3.
- 8 Fit the lubricating oil cooler, see Operation 12-11.
- 9 Fit the ECM, if removed, see Operation 14-13, the wiring harness, and the speed and timing sensor, if removed, see Operation 14-16.
- 10 Fit the VLPM, if removed, see Operation 14-14.
- 11 Install the engine into the vehicle or machine.
- 12 Fill the cooling system.
- 13 Fill the lubricating oil sump to the correct level with an approved lubricating oil.
- 14 Eliminate air from the fuel system, see Operation 11-8.

To inspect

Operation 7-3

- 1 Clean the internal passages for the coolant and the oil.
- 2 Check the cylinder block for cracks and for other damage.
- 3 Check the camshaft bush for wear. If the bush is to be renewed, use a suitable adaptor to press it out of the bore. Ensure that the lubricating oil hole in the new bush (A1) will be towards the front of the engine when fitted. Press in the new bush with the oil hole on the same side and aligned with the oil hole in the block until the front end of the bush is aligned with the face of the recess.



Cylinder bore

To inspect**Operation 7-4**

To ensure the best performance during the life of the engine it is important that worn or damaged cylinder bores are re-bored and re-honed.

The condition of a cylinder bore is decided by:

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

Note: It will not be necessary to re-bore/re-hone if:

- The honed finish can still be clearly seen.
- The engine performance and oil consumption are acceptable.

To check the condition of a cylinder bore

1 Inspect the bore surface for cracks and deep scratches.

2 Check the bore wall 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.

Cautions:

- *Do not use "Flex-hone" to repair cylinder bores.*
- *New oversized piston and rings must be fitted when the cylinder bore is re-bored/re-honed.*
- *An engine can have high oil consumption with very little wear of the bores, if the surfaces of the bores are glazed.*
- *Specialist training and equipment are needed to machine the finish of a cylinder bore.*

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8

Engine timing

General description

To ensure that the 1100 Series 4 cylinder engines have an accurate system of timing, the engines are pin timed.

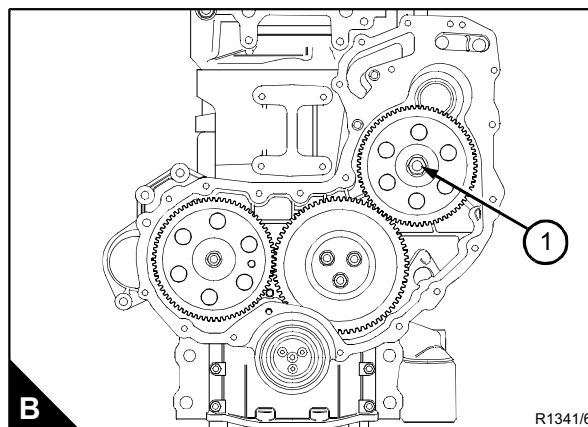
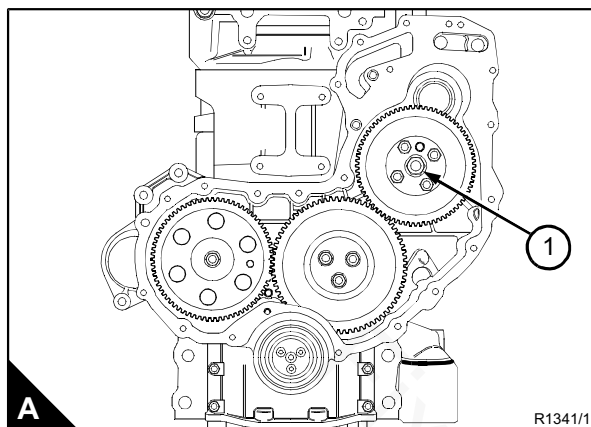
This system will set the engine so that number one piston is at top dead centre (TDC) on the compression stroke.

To reach the accurate fuel injection needed for engines to conform to emissions legislation, the latest fuel injection pumps operate at a static timing of TDC.

It is important that fuel injection timing is accurate to conform to emissions legislation. Always use Operation 8-1 to obtain TDC on the compression stroke of number one cylinder.

Cautions:

- If the hub nut (A1) is loosened the Bosch VP30 fuel injection pump timing will be lost and the fuel injection pump will have to be removed and sent to your nearest Perkins Dealer/Distributor to be reset.
- The Delphi DP210 nut (B1) must not be released until TDC on the compression stroke is set, the backlash is removed from the fuel injection pump gear and the fuel pump shaft is locked. If the nut (B1) is loosened before TDC on the compression stroke is set and the fuel pump shaft is locked the fuel pump timing will be lost. The pump will have to be removed and sent to your nearest Perkins Dealer/Distributor to be reset.
- The Bosch EPVE nut (B1) must not be released until TDC on the compression stroke is set, the backlash is removed from the fuel injection pump gear and the fuel pump shaft is locked. If the nut (B1) is loosened before TDC on the compression stroke is set and the fuel pump shaft is locked, the fuel pump timing will be lost. To adjust the fuel pump timing see, Operation 8-4.



Engine timing

To set number 1 piston to TDC on the compression stroke

Operation 8-1

Special requirements

Special tools			
Description	Part number	Description	Part number
Crankshaft timing pin	27610211	Camshaft timing pin	27610212

Cautions:

- This procedure must only be carried out by a person with the correct training.
- The timing pins are a push fit. Do not use excessive force to fit the pins.
- Do not use the pins as a locking device when repairs are carried out on the engine.
- The timing pins must be removed before the timing case cover is fitted. Failure to do so will damage the engine.
- The marks on the timing gears are not to be use as timing marks. The marks indicate the front of the gear only.

- 1 Remove the rocker cover, see Operation 3-2.
- 2 Remove the glow plugs, see Operation 14-10.
- 3 Remove the timing case cover see, Operation 6-1.

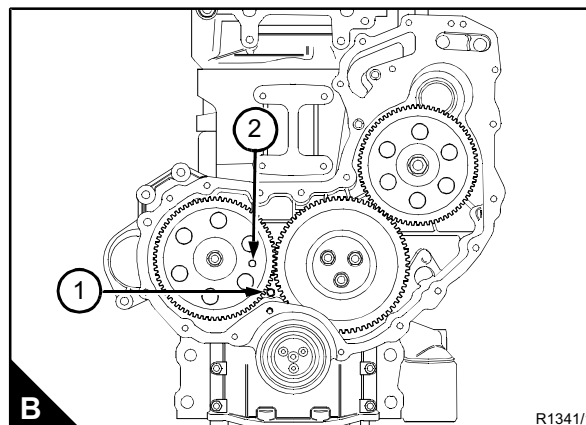
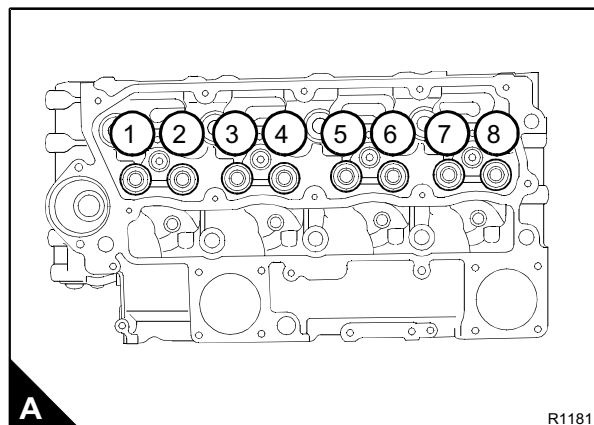
Note: The crankshaft timing pin can be inserted with the crankshaft pulley still fitted.

4 To set the No 1 piston to TDC on the correct stroke, rotate the crankshaft in the normal direction of rotation until the intake valve (A7) of number 4 cylinder has just opened and the exhaust valve (A8) of the same cylinder has not closed completely.

5 Carefully rotate the crankshaft in the normal direction of rotation. Align the hole in the crankshaft with the hole in the cylinder block and the timing case (B1). Insert the crankshaft timing pin through the timing case and the cylinder block. Push the pin fully into the hole in the crankshaft web.

6 Insert the camshaft timing pin, through the hole in the camshaft gear (B2) and into the body of the timing case. With the two timing pins fitted the engine is set at TDC number one on the compression stroke.

Note: The camshaft timing pin is a push fit into the timing case. The camshaft gear can rotate a small amount when the pin is fitted. This is to allow the assembly of the gears and removal of the backlash from the gears, with the timing pins fitted.



- 7 Remove the timing pin from each gear.
- 8 Fit the timing case cover, see Operation 6-2.
- 9 Fit the glow plugs, see Operation 14-10.
- 10 Fit the rocker cover, see Operation 3-3.

To check the timing of the Bosch VP30 fuel injection pump

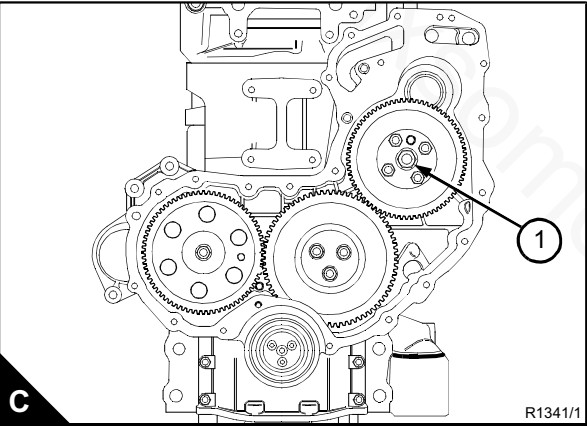
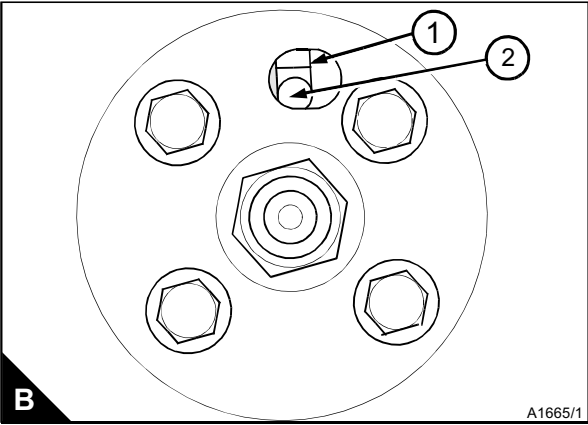
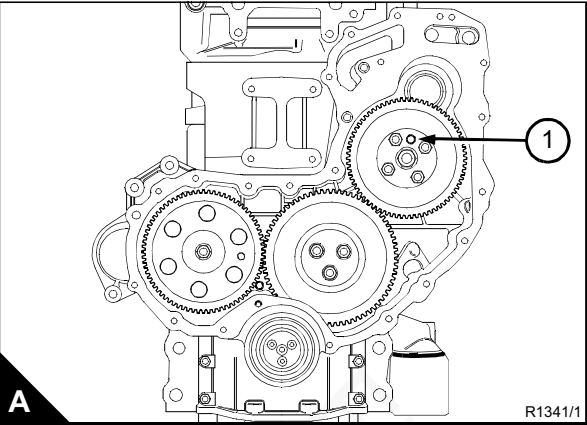
Operation 8-2

Special requirements

Special tools			
Description	Part number	Description	Part number
Crankshaft timing pin	27610211	Fuel pump timing pin	27610032
Camshaft timing pin	27610212		

Cautions:

- This procedure must only be carried out by a person with the correct training.
 - If the hub nut (C1) is loosened the fuel injection pump timing will be lost and the fuel injection pump will have to be removed and sent to your nearest Perkins Dealer/Distributor to be reset.
 - Do not use the pins as a locking device when repairs are carried out on the engine.
 - The fuel pump timing pin is a push fit. Do not use excessive force to fit the pin.
- 1 Rotate the crankshaft to obtain TDC, see Operation 8-1.
- Note:** Do not remove the timing pins from the engine after TDC is set.
- 2 Insert the fuel pump timing pin through the gear (A1) and through the slot in the hub (B1). Push the pin fully into the hole (B2) in the body of the fuel injection pump.
- 3 With all three timing pins fitted, the engine is set at TDC No 1 piston and the fuel injection pump timing is correct.
- 4 If the timing pin cannot be pushed into the fuel injection pump body, and the engine is correctly set at TDC, see Operation 8-1, the fuel injection pump must be removed, see Operation 11-9, and sent to your nearest Perkins Dealer/Distributor to be reset.
- 5 Remove all timing pins from the engine.



To check the timing of the Bosch EPVE fuel injection pump

Operation 8-3

Special requirements

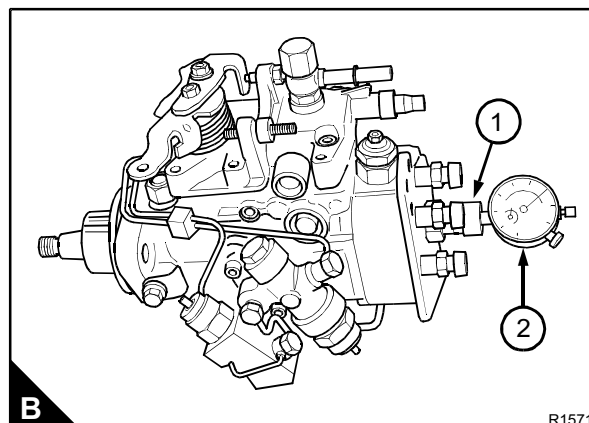
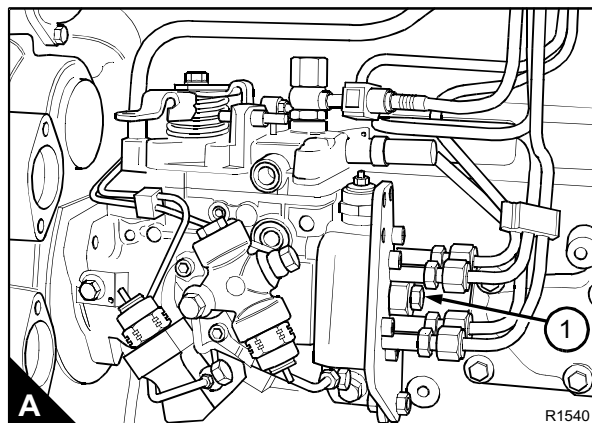
Special tools	
Description	Part number
Bosch EPVE fuel pump timing adaptor	27610248

Caution: This procedure must only be carried out by a person with the correct training.

- 1 Rotate the crankshaft to obtain TDC, see Operation 8-1.
- 2 Remove the high pressure fuel pipes from the fuel injection pump.
- 3 Remove the plug (A1) and washer from the rear of the fuel pump and fit the Bosch EPVE fuel pump timing adaptor (B1), and a suitable dial gauge (B2). Set the dial gauge to indicate approximately 3,0 mm.
- 4 Slowly rotate the crankshaft, counter-clockwise from the front of the engine, until the dial gauge indicates that the plunger of the fuel injection pump is at the bottom of its stroke. Set the dial to zero.
- 5 Slowly rotate the crankshaft clockwise, until the crankshaft timing pin can be pushed into the crankshaft web. With the engine set at TDC, check the reading on the dial gauge.

Fuel injection pump with the code ER has a plunger lift of 1,55 mm (0.061in).

- 6 If the fuel pump timing is correct, remove the dial gauge and the Bosch EPVE fuel pump timing adaptor. Fit a new washer and the plug. Tighten the plug to 29 Nm (21 lbft) 2,9 kgf m.
- 7 If the fuel injection pump timing is to be adjusted, see Operation 8-4.
- 8 Fit the high pressure fuel pipes to the fuel injection pump.
- 9 Eliminate the air from the fuel system, see Operation 11-8.



To adjust the timing of the Bosch EPVE fuel injection pump

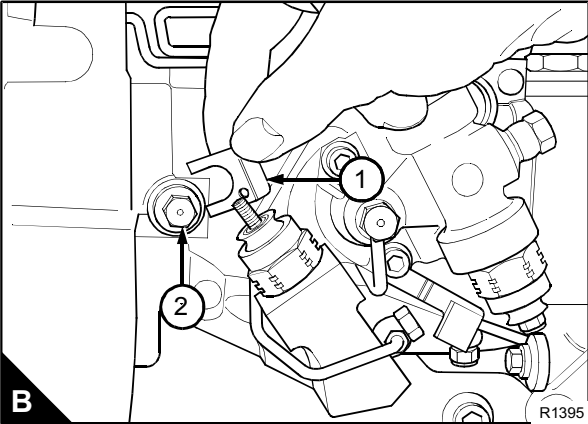
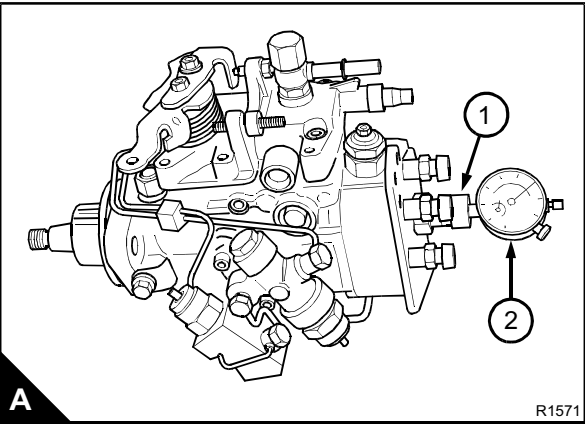
Operation 8-4

Special requirements

Special tools	
Description	Part number
Bosch EPVE fuel pump timing adaptor	27610248

Cautions:

- This procedure must only be carried out by a person with the correct training.
 - Do not turn the fuel injection pump with the pump shaft locked.
- 1 Rotate the crankshaft to obtain TDC, see Operation 8-1.
 - 2 Remove the rocker assembly, see Operation 3-4.
 - 3 Remove the high-pressure fuel pipes from the fuel injection pump.
 - 4 Remove the plug and washer from the rear of the fuel pump and fit the Bosch EPVE fuel pump timing adaptor (A1) and a suitable dial gauge (A2). Set the dial gauge to indicate approximately 3,0 mm.
 - 5 Remove the timing pins.
 - 6 Rotate the crankshaft slowly counter-clockwise and then clockwise, until the needle of the dial gauge indicates that the plunger of the fuel injection pump is at the bottom of its stroke. Set the dial to zero.
 - 7 Rotate the crankshaft slowly clockwise, until the needle of the dial gauge indicates the required plunger lift, see Operation 8-3.
 - 8 To lock the Bosch EPVE pump shaft, loosen the locking screw (B2) and remove the washer (B1). Tighten the locking screw (B2) to 31 Nm (23 lbf ft) 3,1 kgf m. Ensure that the needle of the dial gauge has not moved.

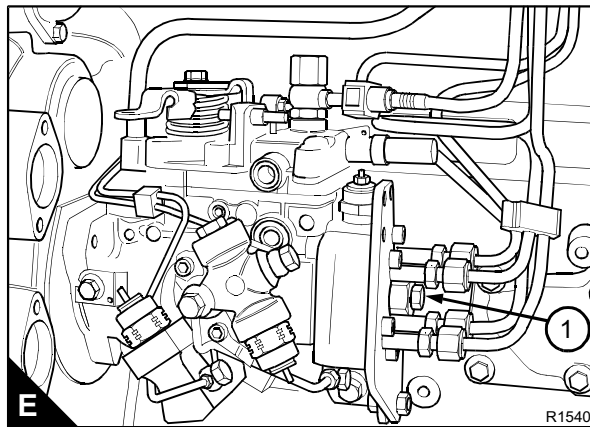
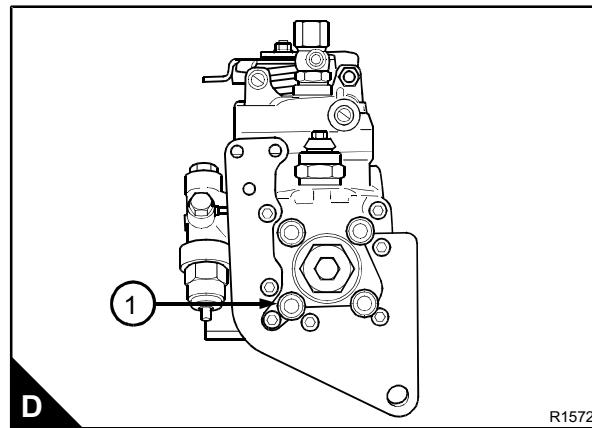
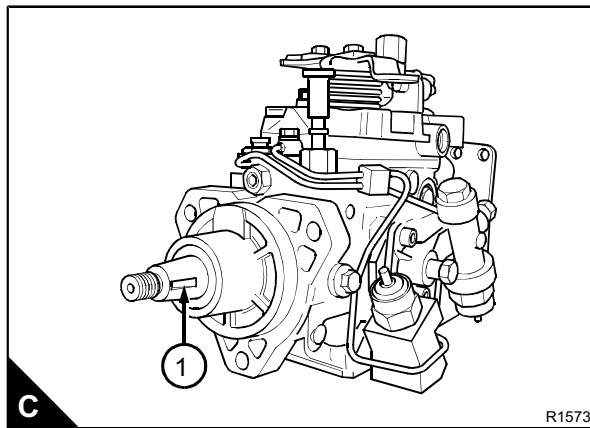


Continued

9 Remove the Bosch mechanical fuel pump gear, see Operation 6-3.

Notes:

- There no key fitted into the keyway (C1).
 - If the fuel injection pump is on the correct stroke, the keyway (C1) is towards the outlet (D1).
- 10 Rotate the crankshaft to obtain TDC, see Operation 8-1.
- 11 Fit the fuel pump gear, see Operation 6-4.
- 12 Ensure that the needle of the dial gauge has not moved. Remove the dial gauge and the Bosch EPVE fuel pump timing adaptor (A1). Fit a new washer and tighten the plug (E1) to 29 Nm (21 lbf ft) 2,9 kgf m.
- 13 Fit the glow plugs, see Operation 14-10.
- 14 Fit the high pressure fuel pipes.
- 15 Fit the timing case cover, see Operation 6-2.
- 16 Fit the rocker assembly, see Operation 3-4.
- 17 Fit the rocker cover, see Operation 3-3.



To check the timing of the Delphi DP210 fuel injection pump

Operation 8-5

Caution: *The fuel pump timing of the Delphi DP210 fuel injection pump must not be checked or adjusted. If the fuel pump timing is lost, the pump must be removed and sent to your nearest Perkins Dealer/Distributor to be reset.*

Note: To remove the Delphi DP210 fuel injection pump, see Operation 11-13.

To check the valve timing

Operation 8-6

Note: Do not fit the timing case cover, the glow plugs or the rocker cover at this stage.

- 1 Set the piston of number 1 cylinder to TDC on the compression stroke, see Operation 8-1.
- 2 Mark the pulley at TDC, set a temporary pointer to the mark.
- 3 For naturally aspirated engines:
 - Set the valve tip clearance of number 1 cylinder intake valve to 0,589 mm (0,023 in) and No 1 exhaust valve to 0,698 mm (0.027 in).
- 4 For turbocharged engines:
 - Set the valve tip clearance of number 1 cylinder intake valve to 1,220 mm (0.048 in) and No 1 exhaust valve to 1,302 mm (0.051 in).
- 5 Rotate the crankshaft, clockwise from the front, until the push rod of number 1 cylinder intake valve is just loose and the push rod for number 1 exhaust valve is equally loose. In this position, check if the mark on the crankshaft pulley or damper is within +/- 2.5° of the temporary pointer. Use the formula below to find the measurement which is equal to 2.5° on the pulley or damper.

$$\frac{C \times P}{360}$$

C = circumference of pulley or damper

P = 2.5 degrees

- 6 If the timing is more than 2.5° out of position, the timing gears are likely not to be in correct mesh.

Notes:

- One tooth on the camshaft gear is equivalent to 18 mm (0.62in) at the circumference of a pulley of 200 mm (7.87 in) diameter.
 - One tooth on the camshaft gear is equivalent to 16 mm (0.70 in) at the circumference of a pulley of 170 mm (6.69 in) diameter.
- 7 Rotate the crankshaft, clockwise from the front, until the intake valve of the rear cylinder has just opened, and the exhaust valve has just closed. Set the valve tip clearance of the intake valve of No 1 cylinder to 0,20 mm (0.008 in). Set the valve tip clearance of the exhaust valve of No 1 cylinder to 0,45 mm (0.018 in).
 - 8 Fit the timing case front cover, see Operation 6-2.
 - 9 Fit the glow plugs, see Operation 14-10.
 - 10 Fit the rocker cover, see Operation 3-3.
 - 11 Remove the temporary pointer from the timing case and the timing mark from the pulley.

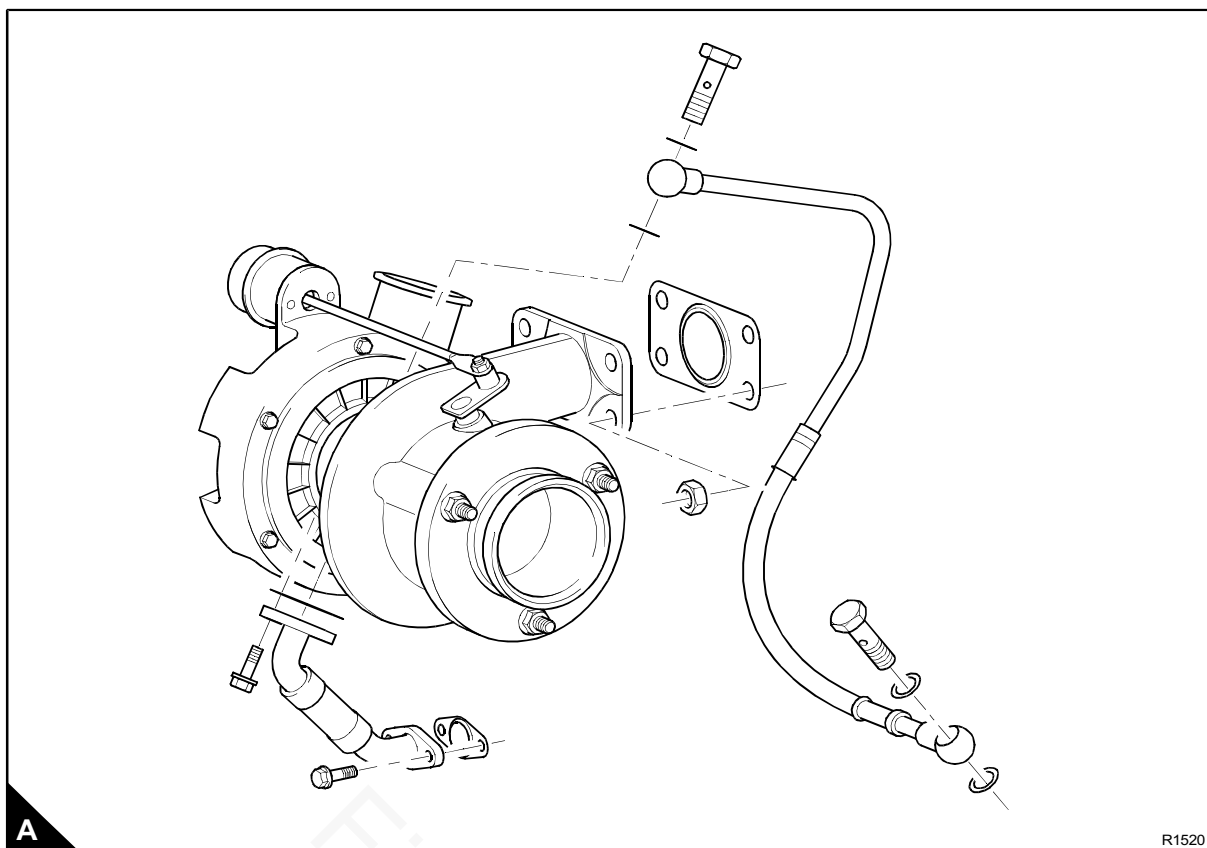
9

Aspiration system

General description

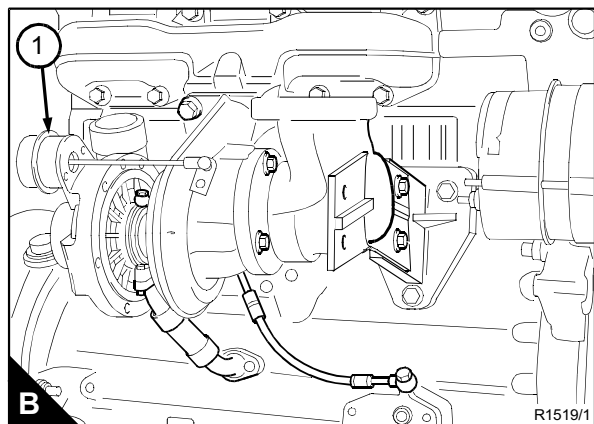
Warning! Turbochargers operate at high speed and at high temperatures. Keep fingers, tools and debris away from the inlet and outlet ports of the turbocharger and prevent contact with hot surfaces.

The turbocharger is fitted between the exhaust and intake manifold and is driven by exhaust gas. The turbocharger passes air to the engine at more than atmospheric pressure. It is lubricated by oil from the main gallery. The oil enters through the bearing housing of the turbocharger and returns to the cylinder block. From there it is returned to the lubricating oil sump.



Continued

All turbochargers that are fitted with a waste-gate unit (B1). The waste-gate, which is controlled by boost pressure from the inlet manifold, will allow some of the exhaust gases to by-pass the turbine rotor at higher engine speeds. With this arrangement the turbocharger can be designed to be more effective at lower engine speeds.



Aspiration system**To remove and to fit an exhaust elbow****Operation 9-1****To remove**

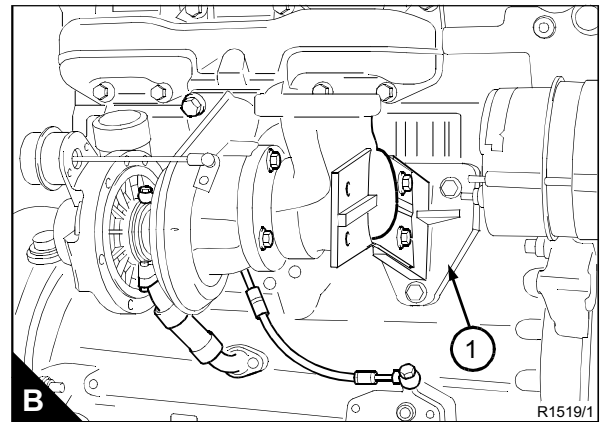
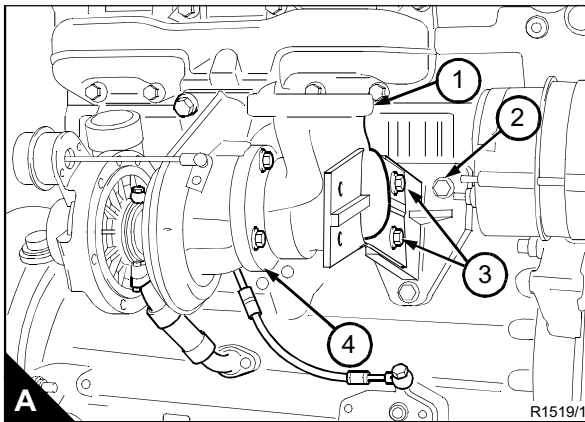
- 1 Remove the two setscrews (A3) from the exhaust elbow (A1).
- 2 Pull the exhaust elbow (A1) away from the adaptor (A4).

To fit

- 1 Ensure that all the component faces are clean and free from damage, renew if necessary.
- 2 Push the exhaust elbow (A1) onto the adaptor (A4).
- 3 Align the exhaust elbow (A1) to the support bracket (B1) and the exhaust pipe of the application.
- 4 Fit the setscrews (A3) and tighten to 44 Nm (33 lbf ft) 4,5 kgf m.

Note: If the support bracket (B1) is to be removed and fitted, remove the exhaust elbow, and remove the three setscrews that hold the support bracket. To fit the bracket, align the support bracket to the cylinder block. Fit the top setscrew (A2) to align the bracket, then fit the two remaining setscrews. Tighten to 44 Nm (33 lbf ft) 4,5 kgf m.

- 5 Connect the exhaust elbow to the application.



Turbocharger side mounted

Warnings!

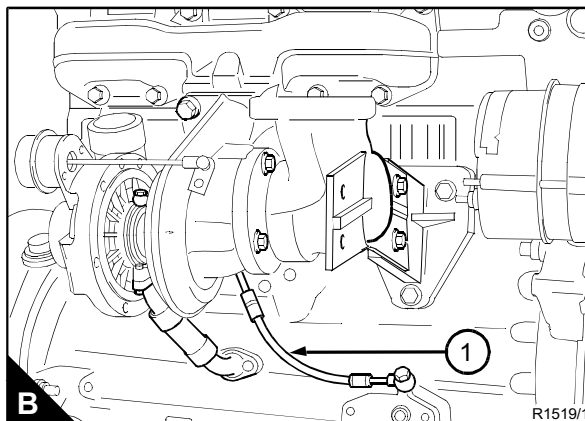
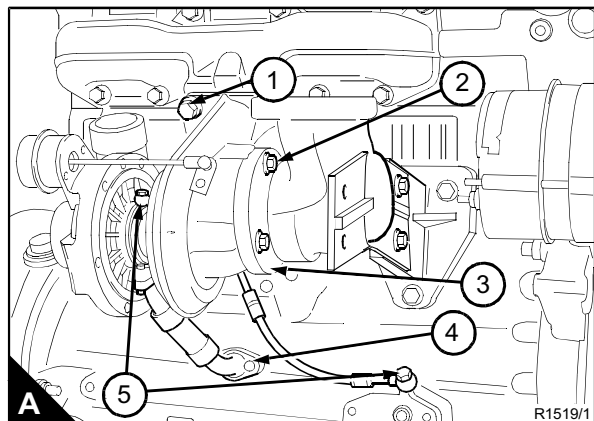
- The sealing washers used on the lubricating oil pipe (B1) contain Viton. Read the safety precautions on page 8.
- Discard old lubricating oil in a safe place and in accordance with local regulations.

Caution: Ensure that the turbocharger waste-gate and the actuator rod of the waste-gate are not used to lift or move the turbocharger. This could damage the waste-gate and affect the calibration.

To remove

Operation 9-2

- 1 Thoroughly clean the turbocharger.
- 2 Remove the air cleaner hose at the compressor inlet.
- 3 Put a suitable container under the oil drain pipe.
- 4 Disconnect the exhaust pipe for the application and remove the exhaust elbow from the turbocharger, see Operation 9-1.
- 5 Remove the three nuts (A2) of the adaptor plate and remove the adaptor plate (A3).
- 6 Release the hose clip of the compressor outlet. Remove the setscrews of the crossover pipe. Remove the crossover pipe complete with the old gasket and hose. Discard the gasket.
- 7 Remove the banjo bolts (A5) and the sealing washers. Remove the pipe and discard the old sealing washers.
- 8 Remove the setscrews (A4) from the bottom flange of the oil drain pipe.
- 9 Remove the nuts (A1) at the turbocharger to exhaust manifold flange. Remove the turbocharger and the gasket with the drain pipe. Remove the bottom joint of the drain pipe.
- 10 Remove the setscrews from the top of the oil drain pipe and remove the pipe and joint from the turbocharger. Discard all old joints and gaskets. Cover the open ports in the manifold, the turbocharger and the pipes to ensure that dirt will not enter.
- 11 Check the air hoses and the oil drain pipe for damage, renew if necessary.



Warning! The sealing washers used on the lubricating oil pipe (B1) contain Viton. Read the safety precautions on page 8.

Cautions:

- The compressor inlet hose has a heat shield material that partly covers the hose. When a new hose is fitted, the hose must be correctly aligned to the exhaust to protect the hose from the heat.
- When a new compressor inlet hose is to be fitted, use a water and 5% soap solution to fit the hose into position. Do not use oil or grease.
- The reflective heat shield of the inlet hose must be kept clean and free from dust, oil or paint. If the surface of the heat shield is not shiny, the part that is protected by the heat shield could be damaged.

1 Remove the covers from the pipes, manifold and turbocharger.

2 Check that the turbocharger inlet and outlet ports are clean and free from restriction and that the turbocharger shaft rotates freely. Also check that the open ports in the intake crossover pipe and the exhaust pipe are clean and free from restriction.

3 Fit loosely the drain pipe (A2) and its new joint to the turbocharger (A1).

Note: The turbocharger drain pipe has different size setscrews. The top flange has 6 mm setscrews and the bottom flange has 8 mm setscrews.

4 Fit a new gasket (A4) to the exhaust manifold flange. If the original nuts are to be used, ensure that the threads of the studs are clean. Apply a suitable compound to the studs to prevent seizure.

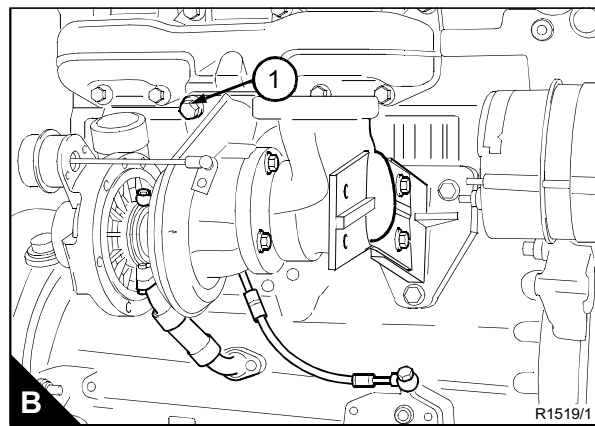
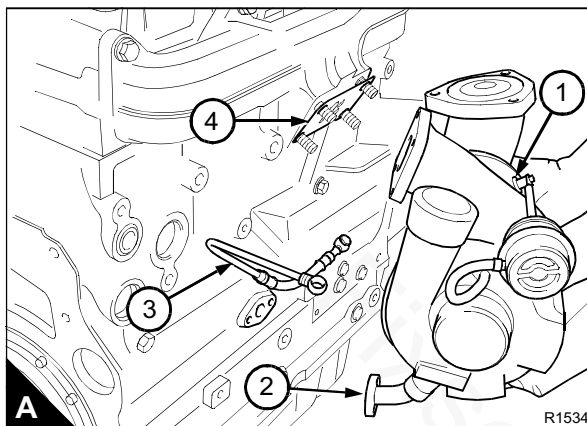
Note: The threads of new nuts are phosphated to prevent seizure.

5 Fit the turbocharger (A1). Fit the nuts (B1) and tighten them to 47 Nm (34 lbf ft) 4,8 kgf m.

6 Fit the bottom flange of the pipe (A2) together with a new joint and tighten the flange setscrews to 22 Nm (16 lbf ft) 2,2 kgf m. Tighten the top flange setscrews to 9 Nm (7 lbf ft) 0,9 kgf m.

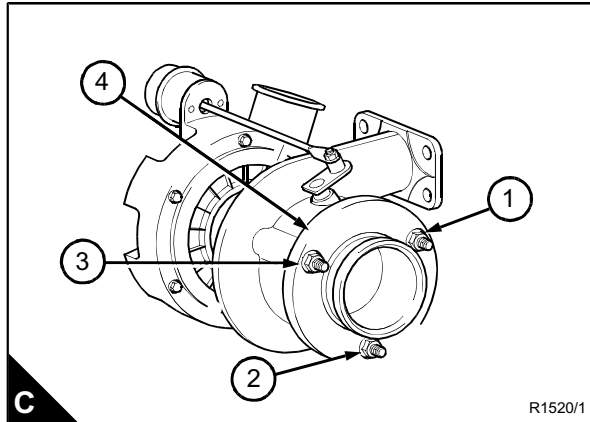
7 Lubricate the bearing housing of the turbocharger with clean engine lubricating oil. Fit loosely the pipe (A3) and new sealing washers. Tighten both banjo bolts to 22 Nm (16 lbf ft) 2,2 kgf m.

Note: Ensure that the lubricating oil pipe (A3) does not come in contact with other components.



Continued

- 8 Fit the adaptor plate (C4) to the turbocharger and fit loosely the three nuts.
- 9 Fit the exhaust elbow to the adaptor, see Operation 9-1.
- 10 With the elbow secure, tighten the nut (C1) by hand, then (C2) and (C3). Tighten the nuts in the same sequence to 25 Nm (18 lbf ft) 2,5 kgf m.
- 11 Connect the exhaust pipe for the application to the exhaust elbow.
- 12 Fit the crossover pipe and hose to the turbocharger. Tighten the setscrews to 22 Nm (16 lbf ft) 2,2 kgf m. Tighten the hose clip to 5 Nm (4 lbf ft) 0,5 kgf m.
- 13 Check that there is no restriction in the hose from the air filter to the turbocharger. Fit the hose and tighten the clip to 5 Nm (4 lbf ft) 0,5 kgf m.



To check the operation of the waste-gate

Operation 9-4

If the waste-gate valve does not operate at the correct pressure, it can affect the engine performance.

If the valve opens at a low pressure, this can cause black exhaust smoke and loss of power at lower engine speeds.

1 Disconnect the actuator hose (A2) at the actuator. Connect to the actuator an air supply which can be adjusted accurately and is fitted with an accurate gauge.

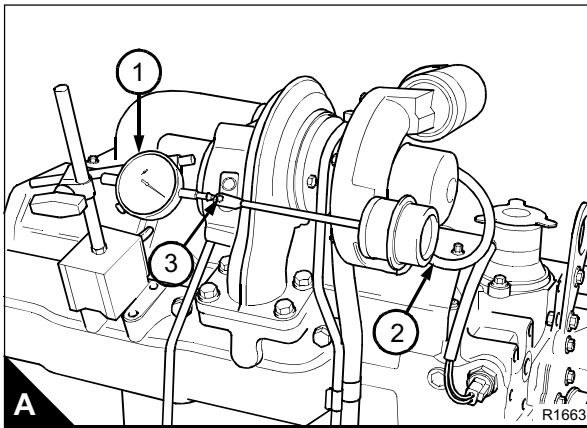
2 Fasten a dial test indicator (A1) to the turbocharger with its plunger in contact with the end of the actuator rod (A3) to measure the axial movement of the rod.

Caution: Do not apply an air pressure of more than 205 kPa (30 lbf/in²) 2,1 kgf/cm² to the actuator. Higher pressures may damage the actuator.

3 Slowly apply air pressure. Check that the pressure necessary to move the rod 1,00 mm (0.039 in), is within limits, refer to the Data and dimensions for "Turbocharger" on page 24. Ensure that the pointer returns to zero when the pressure is released. Repeat the test several times to ensure that an accurate reading is obtained. It may be necessary to lightly hit the turbine housing with a soft hammer during the test operation.

4 Consult your nearest Perkins Dealer/Distributor if the operation of the waste-gate is not correct.

5 If the air pressure is correct, release the air pressure, remove the test equipment and connect the actuator hose.



Turbocharger faults

Caution: If the turbocharger or waste-gate is found to be damaged or faulty, a new turbocharger must be fitted.

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

Problems	Possible causes code numbers
Not enough power	1, 4, 5, 6, 7, 8, 9, 10, 11, 18, 20, 21, 22, 25, 26, 27, 28, 34, 35, 36
Black smoke	1, 4, 5, 6, 7, 8, 9, 10, 11, 18, 20, 21, 22, 25, 26, 27, 28, 34, 35, 36
Blue smoke	1, 2, 4, 6, 8, 9, 17, 19, 20, 21, 22, 30, 31, 32, 34
High 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 intake manifold wet	1, 2, 3, 4, 5, 6, 8, 10, 11, 17, 18, 19, 20, 21, 28, 32, 34,
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

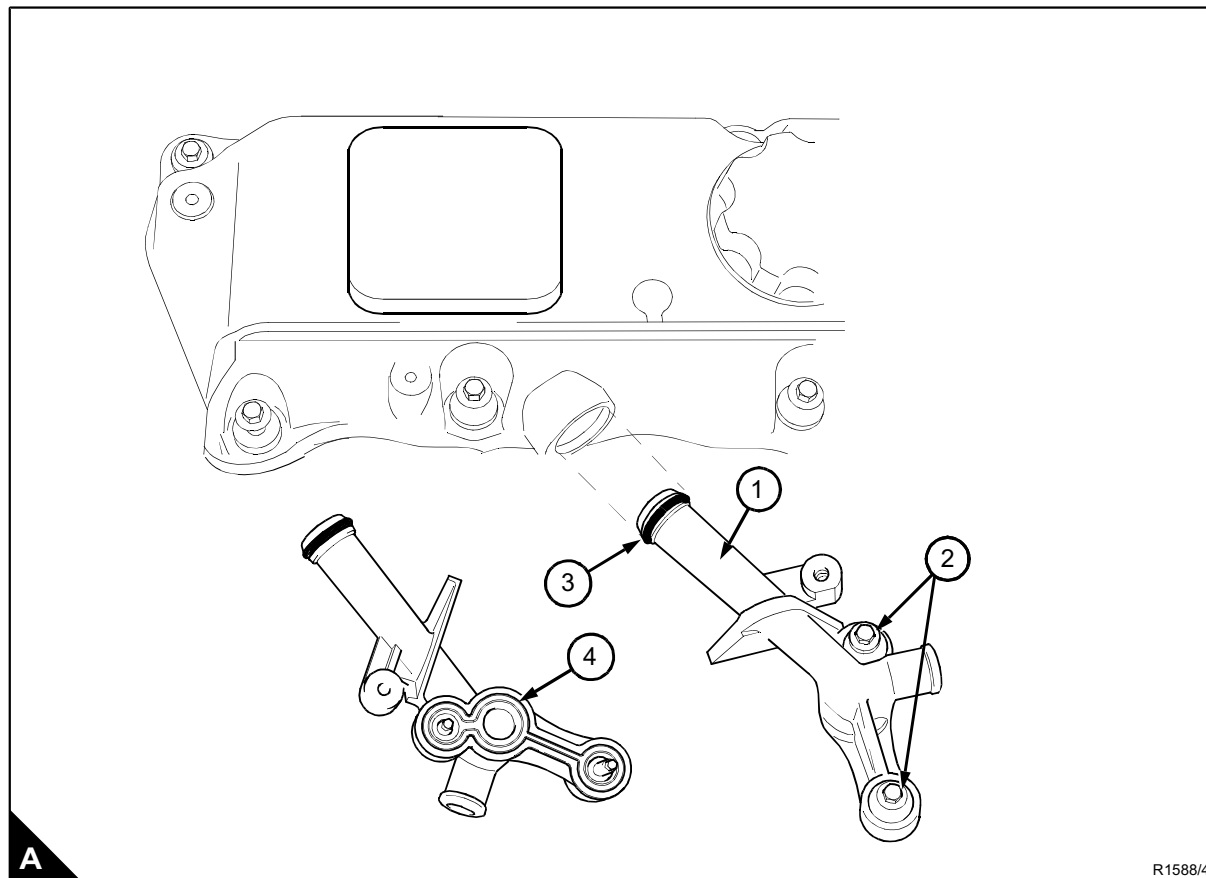
- 1 Element of the air filter dirty.
- 2 Restricted crankcase breather.
- 3 Element of the air filter not fitted, or not sealing correctly. Loose connection to turbocharger.
- 4 Internal distortion or restriction in pipe from air filter to turbocharger.
- 5 Damaged/restricted crossover pipe, turbocharger to intake manifold.
- 6 Restriction between air filter and turbocharger.
- 7 Restriction in exhaust system.
- 8 Turbocharger loose or clamps/setscrews loose.
- 9 Intake manifold crossover pipe 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 Waste-gate actuator faulty or damaged.
- 36 Waste-gate valve not free.
- 37 Engine stopped too soon from high load.
- 38 Insufficient lubricating oil.

Open engine breather

To remove and to fit the breather pipe

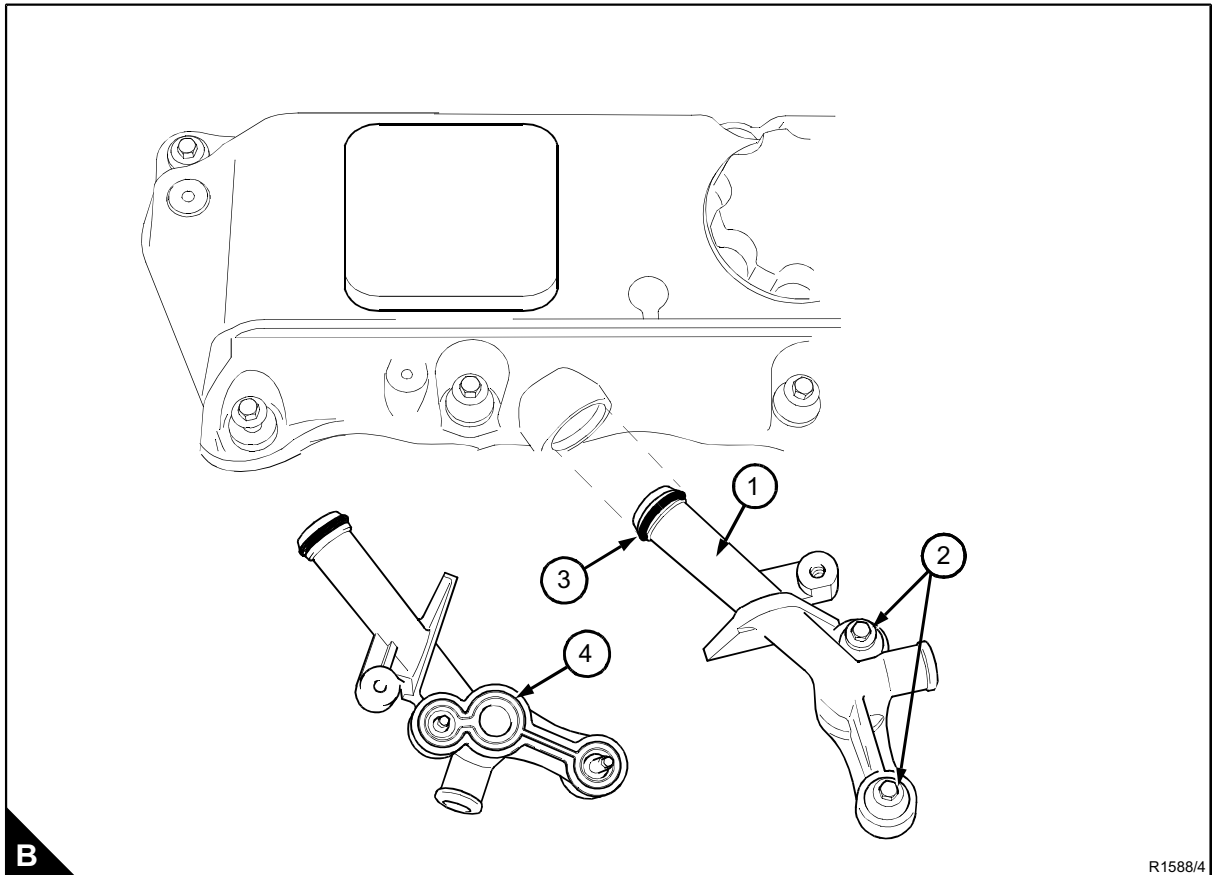
Operation 9-5**To remove**

- 1 Release the hose clip and remove the hose from the breather pipe assembly.
- 2 Release the two fasteners (A2) and pull the breather pipe assembly (A1) out of the rocker cover.
- 3 Remove the "O" ring (A3).
- 4 Remove the joint (A4) and the two fasteners (A2) from the breather pipe assembly.
- 5 Clean all the components and discard all joints and "O" rings.

*Continued*

To fit

- 1 Fit the new joint (B4) into the breather pipe housing.
- 2 Push the two fasteners (B2) into the breather pipe assembly.
- 3 Fit a new "O" ring (B3) to the breather pipe assembly and lubricate the "O" ring with clean lubricating engine oil.
- 4 Push the breather pipe assembly into the rocker cover and tighten the fasteners to 9 Nm (7 lbf ft) 0,9 kgf m.
- 5 Fit the breather hose and tighten the clip to 5 Nm (4 lbf ft) 0,5 kgf m.

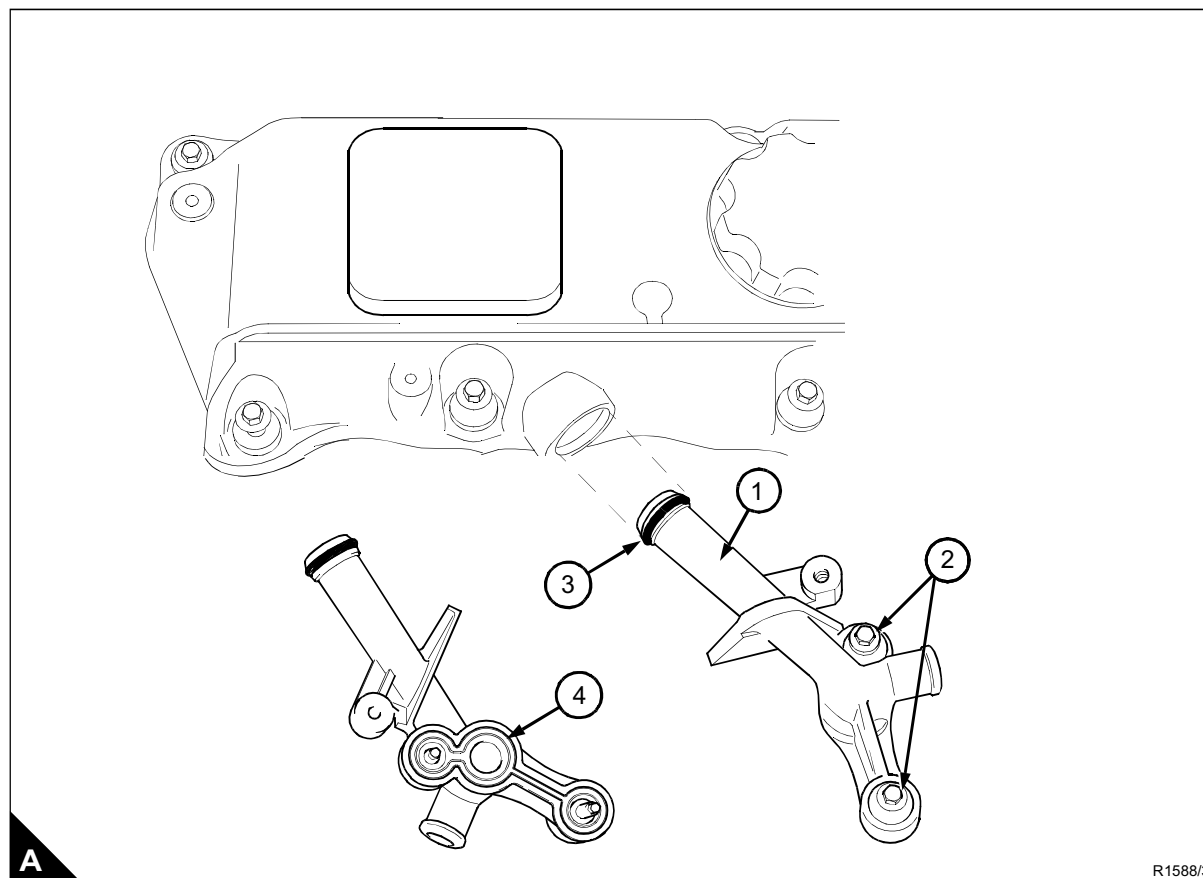


Naturally aspirated engine breather

To remove and fit the breather pipe

Operation 9-6**To remove**

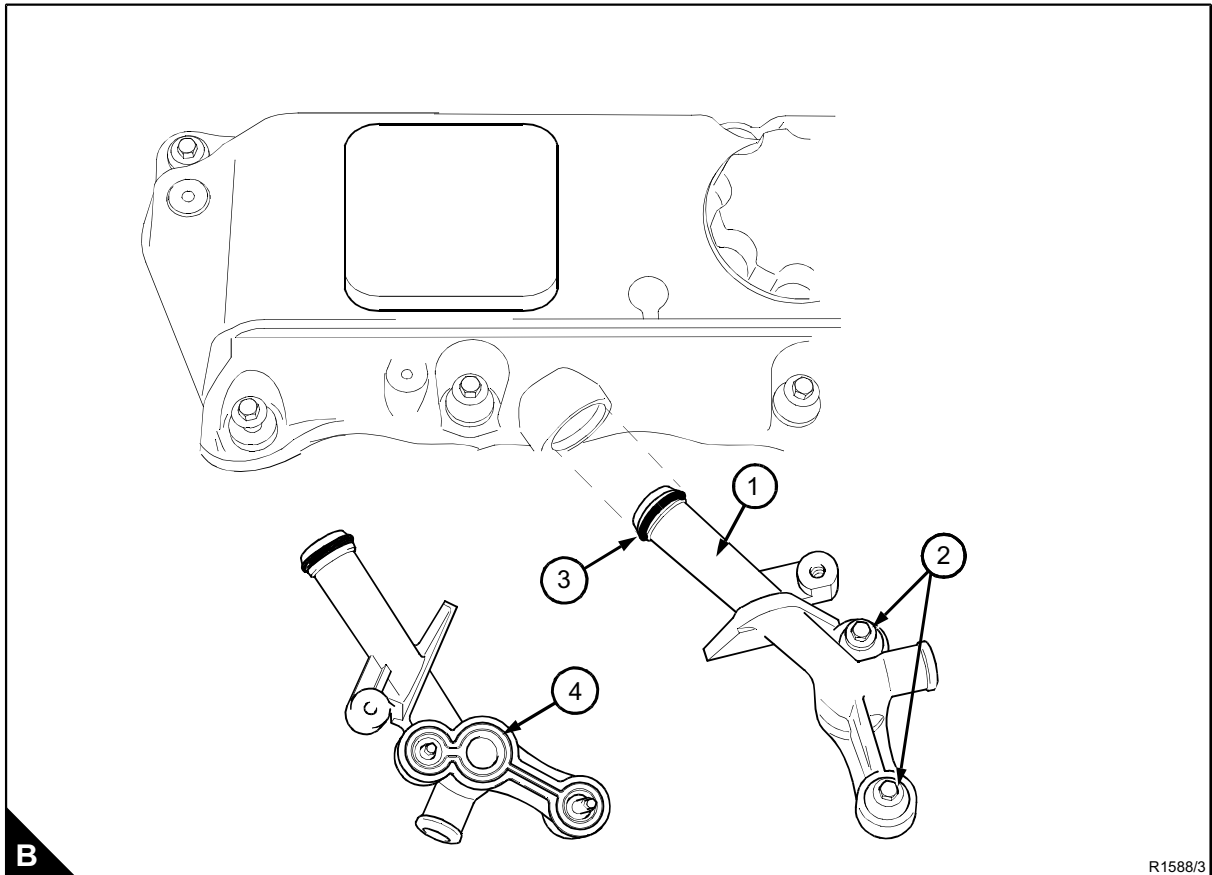
- 1 Release the two fasteners (A2) and pull the breather pipe assembly (A1) out of the rocker cover.
- 2 Remove the "O" ring (A3).
- 3 Remove the joint (A4) and the two fasteners (A2) from the breather pipe assembly.
- 4 Clean all the components and discard all joints and "O" rings.



Continued

To fit

- 1 Fit the new joint (B4) into the breather pipe housing.
- 2 Push the two fasteners (B2) into the breather pipe assembly.
- 3 Fit a new "O" ring (B3) to the breather pipe assembly and lubricate the "O" ring with clean lubricating engine oil.
- 4 Push the breather pipe assembly into the rocker cover and tighten the fasteners to 9 Nm (7 lbf ft) 0,9 kgf m.
- 5 Fit the breather hose and tighten the clip to 5 Nm (4 lbf ft) 0,5 kgf m.



Closed engine breather

To clean and to renew**Operation 9-7**

Note: For details on how to change the closed crankcase breather and element, contact your nearest Perkins Dealer/Distributor for advice.

10

Lubrication system

General description

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 which are off-set to each other. There is an interference fit between the inner rotor and the drive shaft. When the pump rotates, the space between the lobes which are in mesh increases to cause a suction to fill the space and then a decrease to create a pressure increase.

Lubricating oil from the sump passes through a strainer and pipe into the suction side of the pump. The pump delivers the oil to the cylinder block. If an oil cooler is fitted the oil is transferred to and from the oil cooler by an internal passage in the cylinder block. The oil is transferred by the oil pump frame to the oil filter passage in the cylinder block. If an oil cooler is not fitted the oil is transferred directly to the oil filter passage.

A relief valve is integral with the pump and re-circulates the excess oil directly back to oil pump inlet.

The lubricating oil passes through the oil filter and directly back to the main pressure rail which drilled the full length of the left side of the cylinder block.

From the pressure rail, lubricating oil passes to the main bearings of the crankshaft and through passages in the crankshaft to the big end bearings. The pistons and the cylinder bores by the oil jets which are attached to the main pressure rail.

Lubricating oil passes from the main bearings through passages in the cylinder block to the journals of the camshaft. The front camshaft bearings feed oil through a drilling in the cylinder block and cylinder head to the rocker shaft. The oil passes through the centre of the rocker shaft to the rocker levers. The rocker pads, valve stems, cam lobes and the tappets are splash lubricated.

The hub of the idler gear is lubricated by oil from the end pressure rail and the timing gears are splash lubricated.

The lubricating oil for turbochargers is delivered by an external pipe from a tapping on the side of the cylinder block above the right hand side of filter face. The oil returns from the turbocharger down another extended drain pipe into the side of the cylinder block from a connection on the right side of the cylinder block, or filter head, through an external pipe to the turbocharger. The oil passes through the turbocharger and returns through a pipe to the sump.

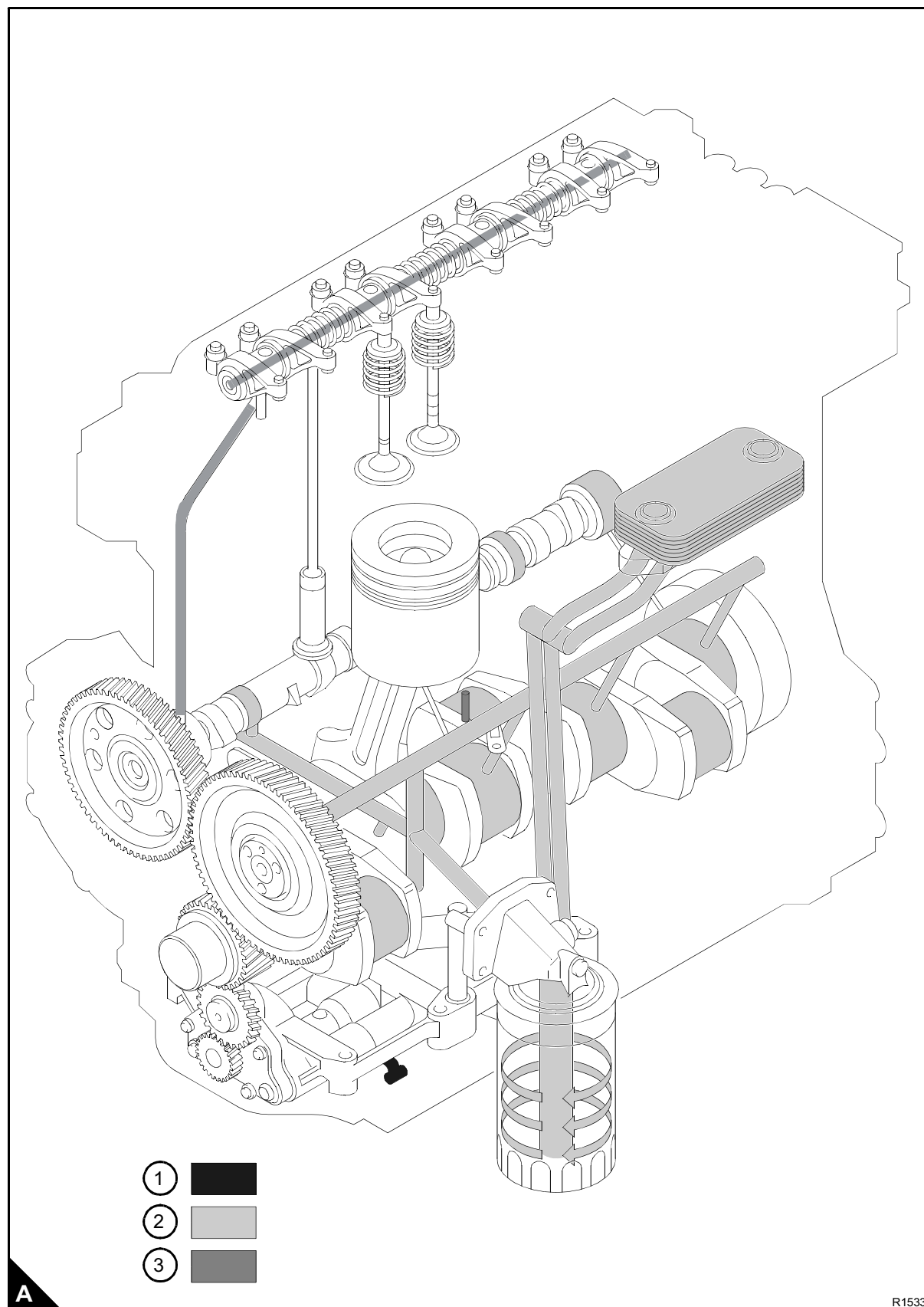
Top mounted turbochargers are fed from the filter head, or from a connection on the right hand side of the engine.

These engines are fitted with piston cooling jets that are connected to the oil pressure rail and spray lubricating oil inside the pistons to keep them cool.

Key to the oil flow diagram on page 158.

- 1 Suction pressure to the lubrication oil pump.
- 2 Main engine lubrication oil pressure.
- 3 Reduced engine lubrication oil pressure.

Lubrication system flow diagram



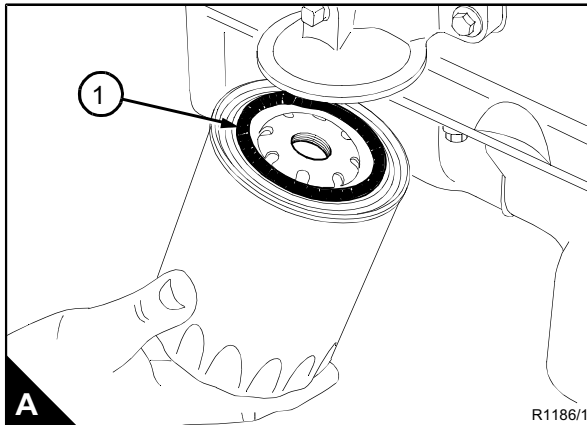
Filter canister**To renew (canister type oil filter)****Operation 10-1**

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

Cautions:

- The canister contains a valve and a special tube to ensure that lubricating oil does not drain from the filter, when the lubricating oil is changed. Ensure that the correct perkins POWERPART canister is used.
- Ensure that the application is on a level surface to ensure an accurate reading on the dipstick.

- 1 Put a suitable container below the lubricating oil filter.
- 2 Remove the filter canister with a strap wrench. Ensure that the adaptor is secure in the filter head. Discard the canister.
- 3 Clean the filter head.
- 4 If the filter canister is mounted vertically position (A) add clean engine lubricating oil to the new canister. Allow the oil enough time to pass through the filter element.
- 5 Lubricate the top of the canister seal (A1) with clean engine lubricating oil.
- 6 Fit the new canister and tighten by hand only. Do not use a strap wrench.
- 7 Remove the container and discard the old lubricating oil.
- 8 Operate the engine and check for leakage from the filter. When the engine has cooled, check the oil level on the dipstick and add more oil into the sump, as necessary.



To renew (element type oil filter)

Operation 10-2

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

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

1 Put a suitable container below the lubricating oil filter.

Note: On the horizontal filter assembly the drain plug (A2) is in the filter head and should not be removed.

2 Remove the drain plug (A2) together with the seal and drain the lubricating oil.

3 Fit a 1/2" square drive ratchet into the recess (A1) and remove the filter casing (A3). Discard the old filter element.

4 Clean the filter casing and replace the seal (B2). Fit a new seal to the drain plug and fit the plug finger tight.

5 Fit the new filter element (B1) into the casing and rotate the element to locate it into position.

6 If the filter casing is in vertically mounted position (A), add clean engine lubricating oil to the filter casing. Allow the oil enough time to pass through the filter element.

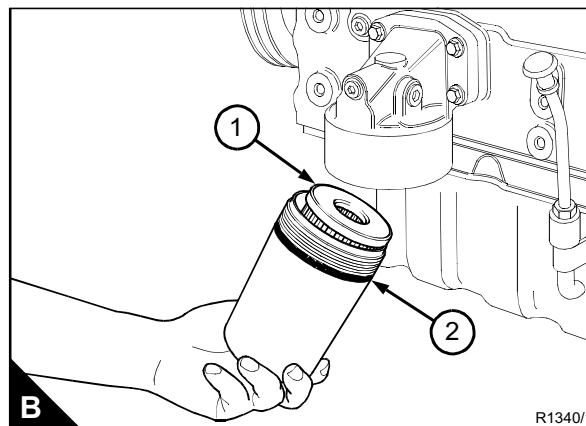
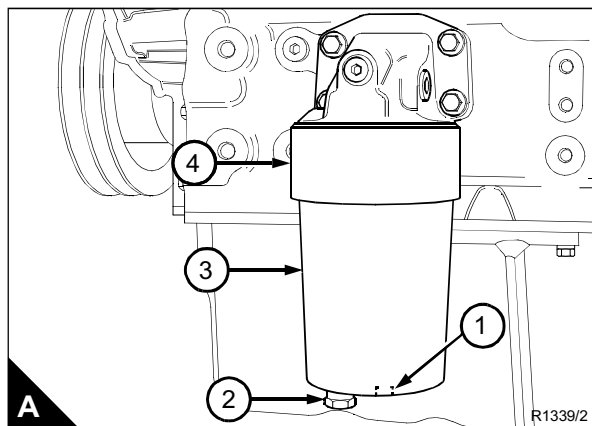
7 Lubricate the seal (B2) with clean engine lubricating oil. Fit the casing (A3) into the filter head (A4).

8 Tighten the casing (A3) to 25 Nm (18 lbf ft) 2,5 kgf m.

9 Tighten the drain plug to 12 Nm (9 lbf ft) 1,2 kgf m.

10 Remove the container and discard the old lubricating oil.

11 Operate the engine and check for leakage from the filter. When the engine has cooled, check the oil level on the dipstick and add more oil into the sump, as necessary.



Filter head

To remove and to fit

Operation 10-3**Special requirements**

Consumable products	
Description	Part number
POWERPART Threadlock and nutlock	21820117

To remove

Caution: If a balancer is fitted, the oil filter head must only be mounted on the left hand of the engine.

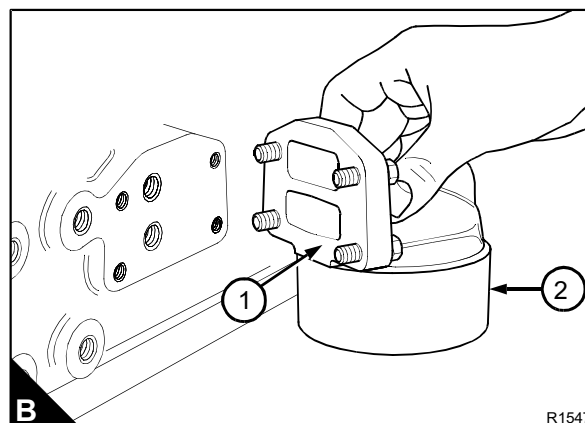
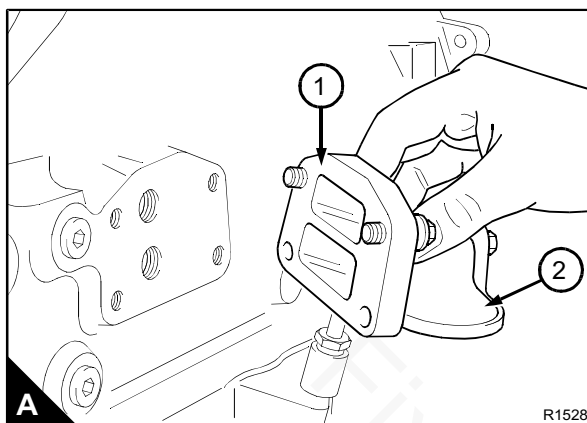
- 1 Put a tray under the filter head to contain spilt lubricating oil.
- 2 Remove the filter canister, see Operation 10-1 or Operation 10-2.
- 3 Remove the setscrews and remove the filter head (A2) (B2) from the cylinder block. Discard the joint (A1) (B1).
- 4 Clean the joint face (A1) (B1) of the filter head and the cylinder block.

To fit

- 1 Ensure that all joint surfaces are clean and free from damage.
- 2 Fit a new joint to the filter head, the joint is fitted dry.

Note: The setscrews for securing the filter head have a sealant (MEAS) applied by the manufacturer to the first 13,0 mm (0.50 in) of the threads. If the setscrews are used again, the sealant must be removed from the male and female threads and POWERPART Threadlock and nutlock applied to the first 13,0 mm (0.50 in) of the setscrew threads.

- 3 Fit the filter head to the cylinder block. Gradually and evenly tighten the setscrews.
- 4 Fit the new filter canisters, see Operation 10-1 or Operation 10-2.



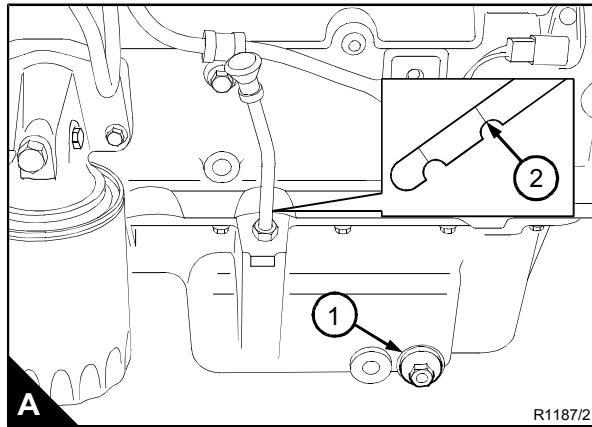
Sump

To remove**Operation 10-4**

Warnings!

- *Discard the used lubricating oil in a safe place and in accordance with local regulations.*
- *Before the sump is removed, especially with the cast iron version, ensure that the sump is fully supported before the setscrews are removed.*

- 1 Operate the engine until it is warm.
- 2 Stop the engine, remove the sump drain plug (A1) and its 'O' ring, and drain the oil. Where necessary, remove the dipstick and the dipstick tube, see Operation 10-6.
- 3 Provide a support for the sump and remove the setscrews and, if relevant, the two nuts which fasten the sump to the timing case. Lower the sump and remove and discard the joint.
- 4 Wash the sump with an approved cleaning fluid, ensure all the cleaning fluid is removed. Clean the flange face of the sump and of the cylinder block.



To fit

Operation 10-5

Special requirements

Consumable products			
Description	Part number	Description	Part number
POWERPART Threadlock and nutlock	21820117	POWERPART Silicone rubber sealant	1861108

Notes:

- If either the cylinder block bridge piece, and / or the timing case, have just been fitted then fit the sump before any bridge piece / timing case sealant has been allowed to cure.
 - If the sump only is to be fitted, then any old surface sealant from either the cylinder block bridge piece, and / or the timing case, should be removed and renewed.
- 1 Remove any old sealant from the cylinder block bridge piece, timing case, and cylinder block joint surfaces.
 - 2 Ensure that the joint faces of the cylinder block and the sump are both free from dirt and damage.

Continued

3 Insert four alignment studs into holes (A1).

4 Apply a bead of POWERPART Silicone rubber sealant to the joints between the cylinder block and the timing case (C1), and the cylinder block and the bridge piece (B2).

Note: Handle the sump joint with care as rubber-sealing bead can be easily damaged.

5 Place the joint onto the cylinder block over the alignment studs and ensure that all of the fixing holes align correctly.

6 Place the sump onto the cylinder block over the alignment studs.

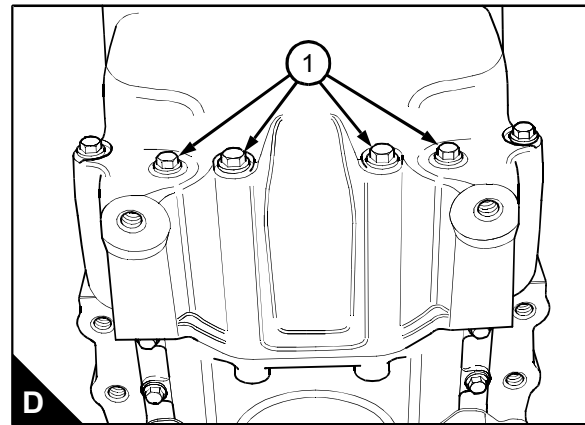
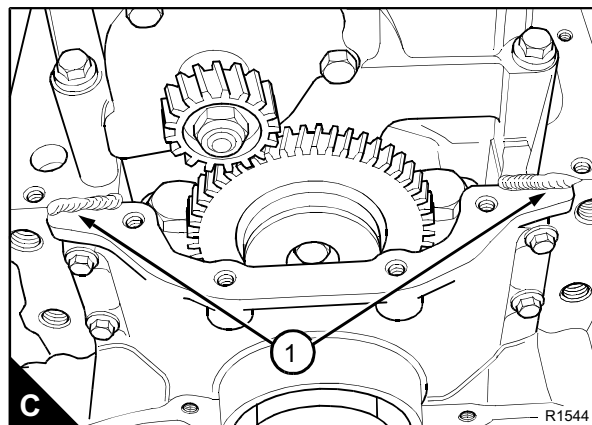
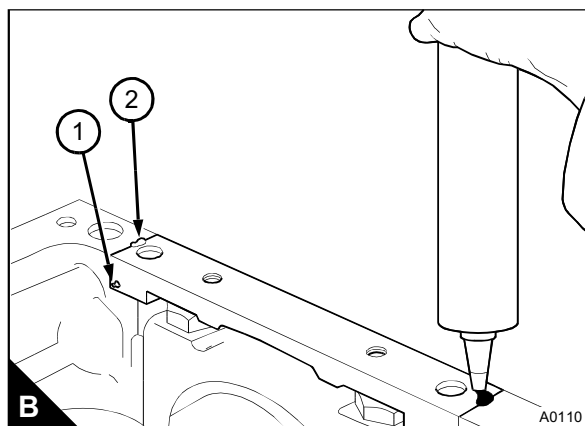
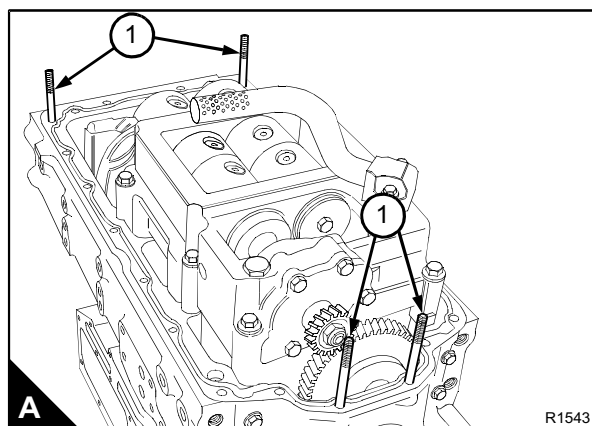
Note: The setscrews for securing the sump have a sealant (MEAS) applied by the manufacturer to the first 13,0 mm (0.50 in) of the threads. If the setscrews are used again, the sealant must be removed from the male and female threads and POWERPART Threadlock and nutlock applied to the first 13,0 mm (0.50 in) of the setscrew threads.

7 Loosely fit the setscrews into all of the available holes by hand.

8 Remove the alignment studs and fit the remainder of the setscrews.

9 Tighten the four setscrews (D1) to 22 Nm (16 lbf ft) 2,2 kgf m.

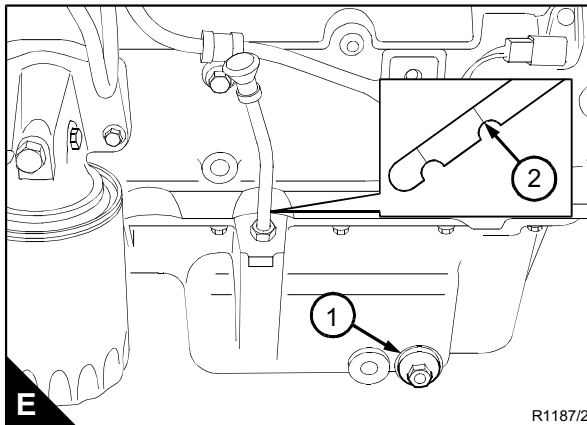
10 Tighten the remaining setscrews to 22 Nm (16 lbf ft) 2,2 kgf m.



Continued

11 Fit the drain plug, if necessary fit a new 'O' ring, and tighten to 34 Nm (25 lbf ft) 3,5 kgf m.

12 Fill the sump to the mark (E2) on the dipstick with new engine lubricating oil of an approved grade, see User's Handbook TPD 1477.



Dipstick tube

To remove and to fit

Operation 10-6

Special requirements

Consumable products	
Description	Part number
POWERPART Threadlock and Nutlock	21820117

- 1 Remove the dipstick tube M16 gland nut and remove the tube from the sump.
- 2 Clean the gland nut and the thread in the sump of all old sealant.
- 3 Ensure that the rubber seal is fitted to the dipstick tube assembly.
- 4 Apply POWERPART Threadlock and Nutlock to the threads of the gland nut.
- 5 Fit the dipstick tube to the sump in the correct position, tighten the gland nut to 18 Nm (14 lbf ft) 1,8 kgf m.

Oil strainer and suction pipe**To remove and to fit****Operation 10-7**

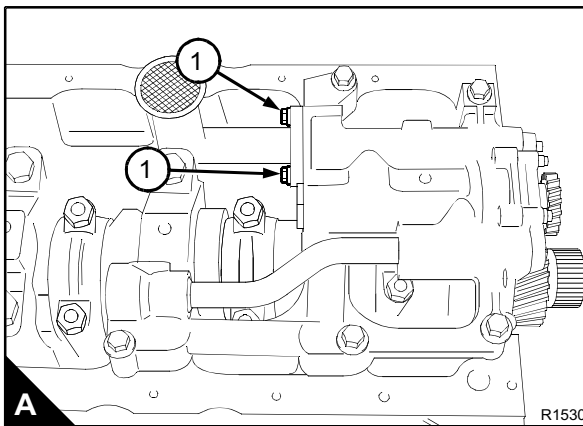
The oil strainer is an integral part of the suction pipe. No regular service is necessary but wash the strainer when it is removed.

To remove

- 1 If not already removed; remove the lubricating oil sump, see Operation 10-4.
- 2 Remove the setscrews from the flange of the suction pipe. Remove the suction pipe and strainer. Remove the old joint. Clean the flange face of the oil pump and the suction pipe.

To fit

- 1 Fit the suction pipe to the oil pump together with a new joint. Tighten the setscrews (A1).
- 2 Fit the lubricating oil sump, see Operation 10-5.

**To inspect and to correct****Operation 10-8**

- 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.
- 3 If a component is damaged, renew as necessary.

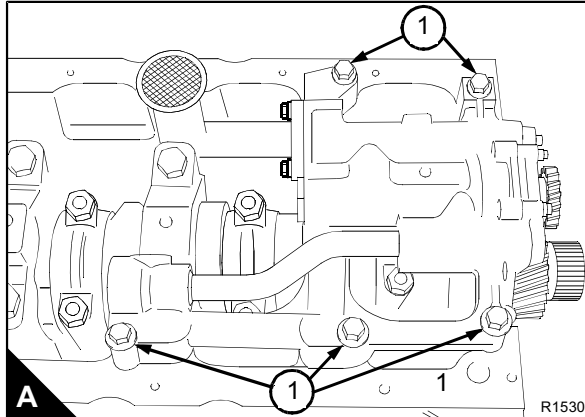
Lubricating oil pump assembly

To remove

Operation 10-9

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

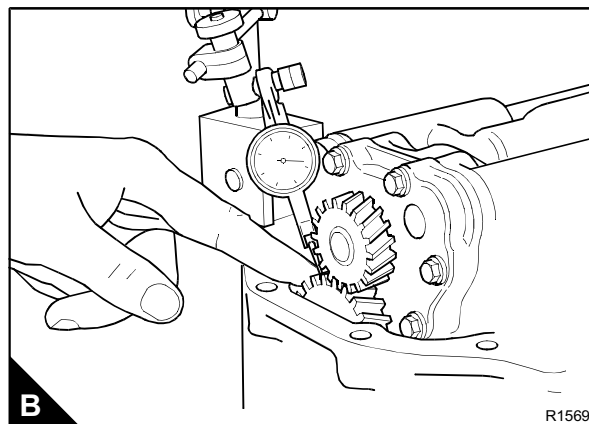
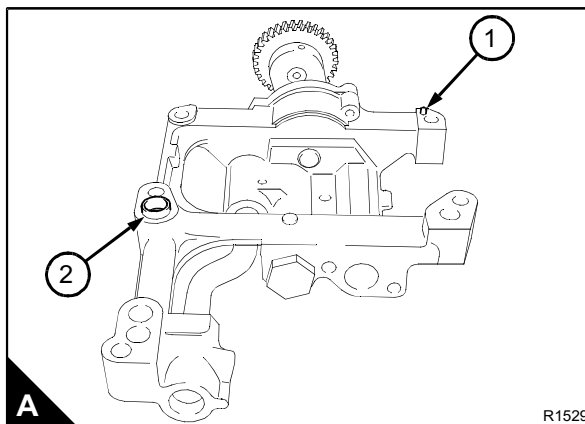
- 1 If not already removed; remove the lubricating oil sump, see Operation 10-4.
- 2 Remove the setscrews (A1) and remove the oil pump assembly.



To fit

Operation 10-10

- 1 Fill the oil pump assembly with clean engine lubricating oil. Fit the oil pump assembly to the cylinder block, ensure that the dowel (A1) and the thimble (A2) are correctly located, then tighten the setscrews to 22 Nm (16 lbf ft) 2,2 kgf m.
- 2 Check the idler gear for wear and other damage. If the gear is damaged, it must only be renewed as an assembly. The assembly consists of an idler gear, an idler shaft and a front plate.
- 3 Check that there is backlash between the oil pump idler gear and the crankshaft gear (B).

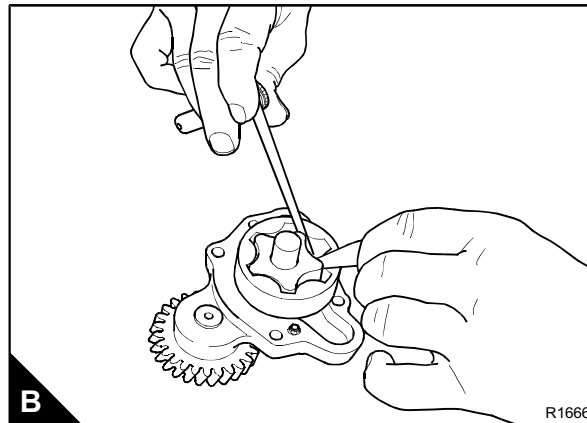
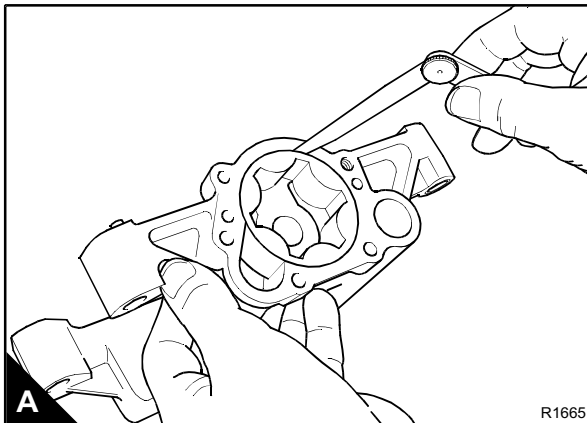


To inspect

Operation 10-11

Note: For all the clearances, refer to the Data and dimensions for the "Lubrication system" on page 25.

- 1 Remove the setscrews and remove the cover of the oil pump.
- 2 Remove the outer rotor and clean all the parts. Check for cracks and any other damage.
- 3 Fit the outer rotor, and check the outer rotor to body clearance (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.
- 6 Lubricate the inner and outer rotor with clean engine lubricating oil. Clean the top face of the oil pump and the inner face of the cover. Fit the cover. Tighten the setscrews to 28 Nm (21 lbf ft) 2,9 kgf m.



Relief valve

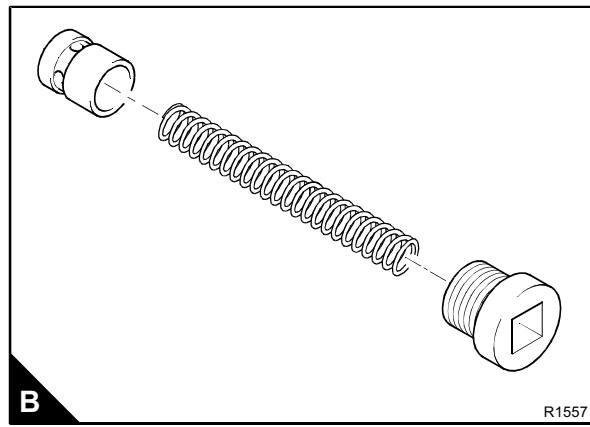
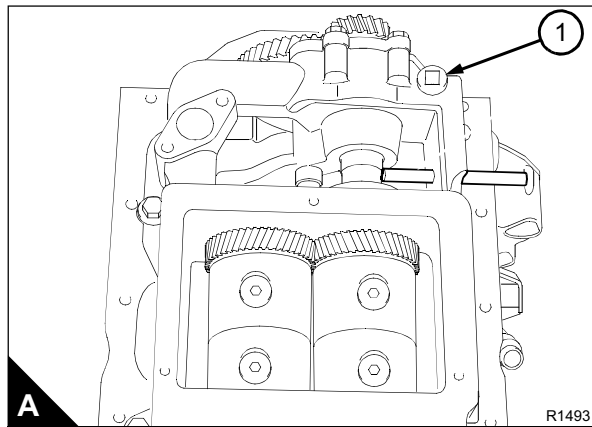
To remove and to fit the relief valve of the balancer

Operation 10-12**To remove**

- 1 Remove the plug that retains the relief valve (A1). Remove the spring and valve (B).

To fit

- 1 Ensure the relief valve is clean.
- 2 Place the relief valve and spring into the balancer.
- 3 Tighten the plug for the relief valve (A1) to 22 Nm (16 lbf ft) 2,2 kgf m.



To remove and to fit the relief valve of the lubricating oil pump

Operation 10-13

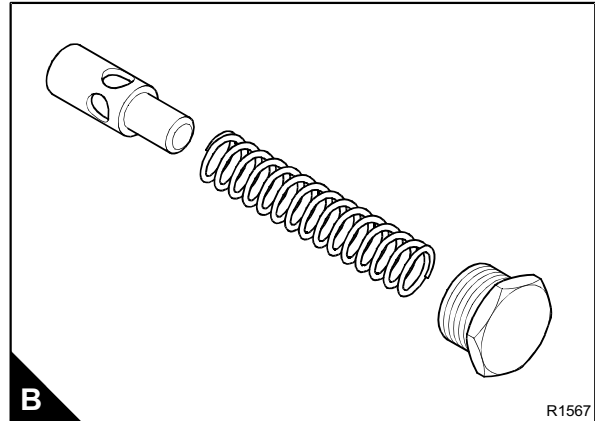
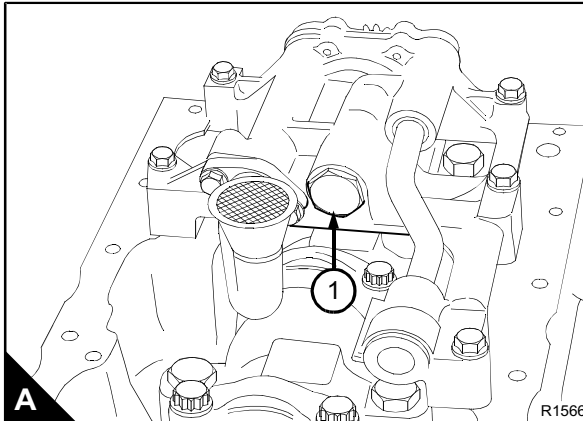
Caution: Do not change the operation pressure of the relief valve by a method other than the installation of new components.

To remove

- 1 Remove the plug which fastens the relief valve (A1), and remove the spring and valve (B).

To fit

- 1 Ensure the relief valve is clean.
- 2 Place the valve spring and relief valve into the lubricating oil pump.
- 3 Tighten the plug for the relief valve (A1) to 22 Nm (16 lbf ft) 2,2 kgf m.



To inspect the relief valve of the lubricating oil pump/balancer

Operation 10-14

Caution: Do not change the operation pressure of the relief valve by a method other than the installation of 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 Data and dimensions for "Oil pressure relief valve (oil pump)" on page 25 or "Oil pressure relief valve (balancer)" on page 25.
- 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 plug for wear and other damage.
- 4 Renew worn or damaged components.

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11

Fuel system

General description

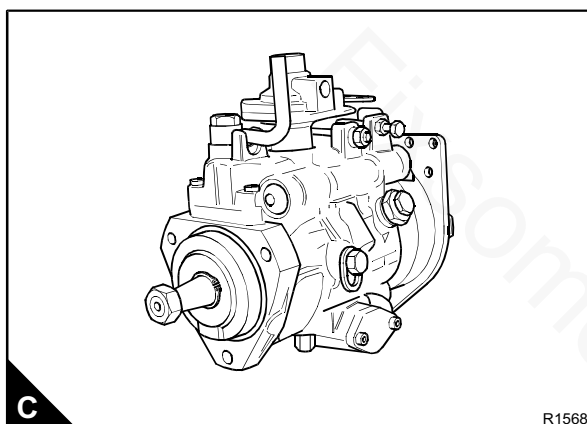
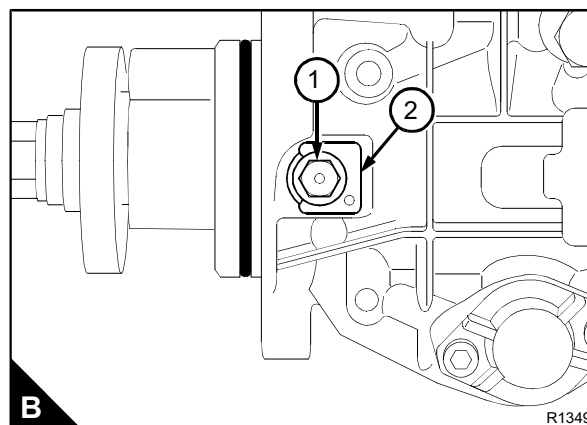
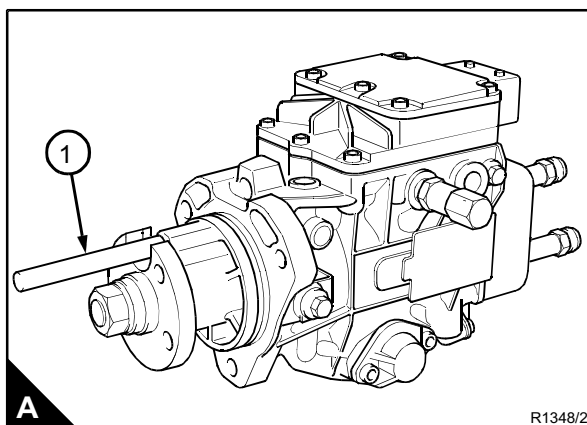
Cautions:

- There are no adjustments that can be carried out on the Bosch VP30 and Delphi DP210 fuel pumps. The fuel injection equipment must only be checked by personnel who have had the correct training.
- If a fuel injection pump is returned for repair, or under warranty, then all of the fuel ports must be closed with a plastic blanking cap to prevent the entry of water and dirt into the pump. If these blanking caps are not fitted then the warranty will be affected.
- A new fuel injection pump will be supplied with the pump shaft in the locked position. The drive shaft of the pump must not be turned without the spacer (B2) in position under the locking screw (B1).

The 1100 Series four cylinder engines are used for industrial, construction and agricultural applications and use three different types of fuel injection pump:

- Bosch VP30 (A)
- Bosch EPVE (B)
- Delphi DP210 (C).

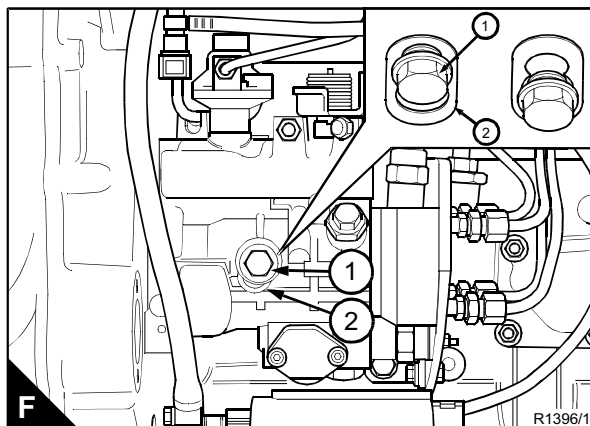
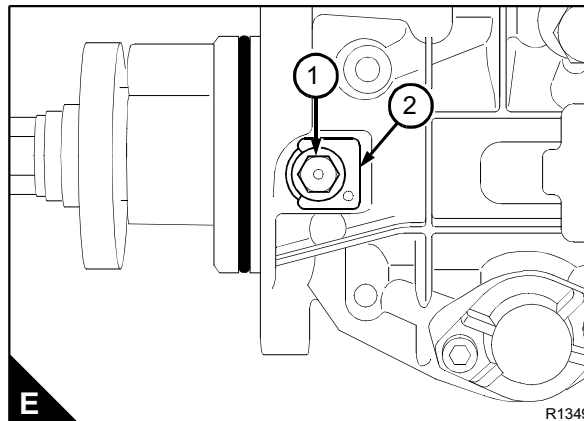
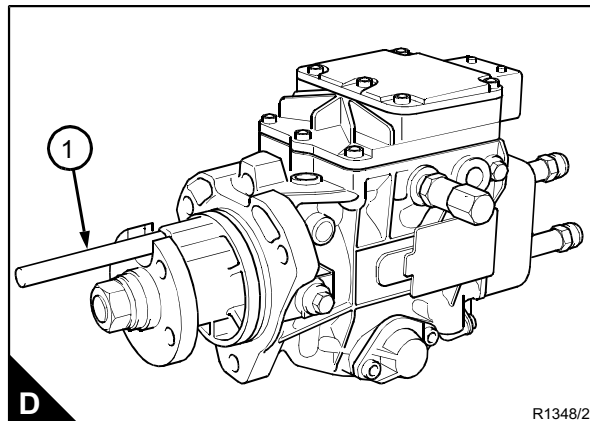
These fuel injection pumps conform to emissions legislation.



Continued

On the Bosch VP30 the pump timing, the speed adjustment and amount of fuel supplied are all controlled electronically by the ECM. The fuel injection pump timing is by a pin (D1) that is fitted through the fuel pump gear, the pump flange and into the pump body.

Bosch EPVE (E) and Delphi DP210 (F) fuel injection pumps have locking screws which lock the shaft. It is important that the locking screw is released and the pump shaft is free to turn when the pump is fitted to the engine.



The electronic fuel lift pump and fuel filter are a single assembly.

The maximum no-load speed is shown on the emissions data plate fitted to various positions on the side of the cylinder block, see "Engine identification" on page 3.

The atomisers, which are of the valve covered orifice (VCO) 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.

The atomisers are set in the factory and are not serviceable, they must be checked in accordance with the preventive maintenance schedules in the User's Handbook.

Cold start advance unit (KSB)

Delphi DP210 and Bosch EPVE (A) fuel injection pumps have a cold start advance unit that holds the timing of the pump in an advanced position when the engine is cold.

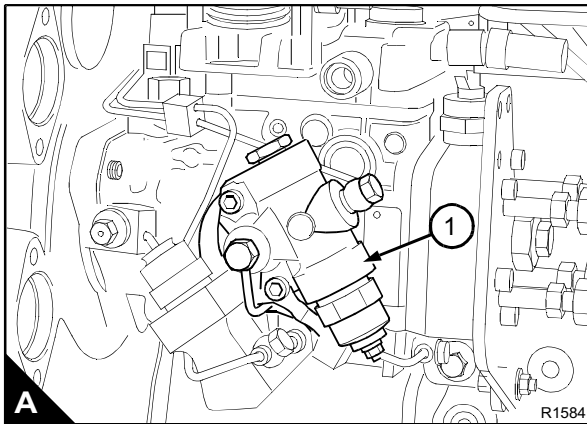
Caution: *It is important that the electrical connections to the sender unit are connected correctly. Failure of the KSB to operate correctly could result in damage to the engine as the timing will be fully advanced for normal operation.*

The sender unit, is on the rear of the timing case on the left side of the engine.

With the engine cold, the sender unit energises to advance the pump timing for the cold start operation of the Delphi and Bosch fuel injection pumps.

Note: The wiring diagrams on the following page show the sender unit position when the engine is cold.

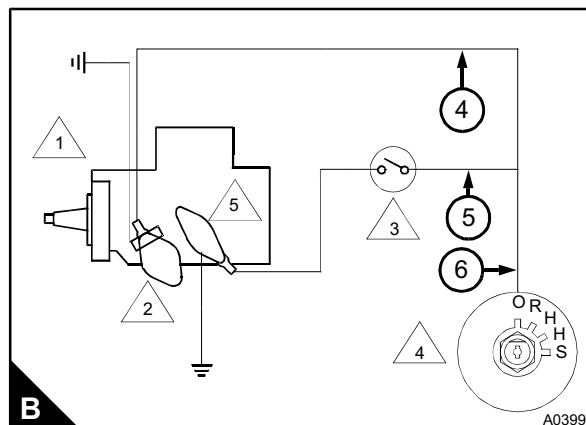
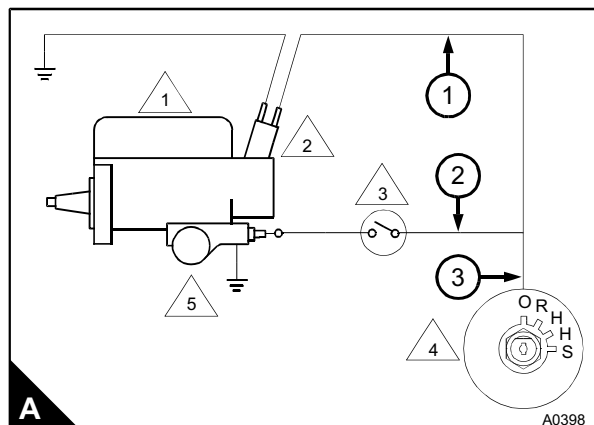
To ensure that the engine conforms to emissions legislation, it is important that the electrical connections of the engine cold start advance unit are fitted correctly before the engine is operated.



Continued

Wiring diagrams for the cold start advance unit fitted to some Delphi DP210 Series and Bosch EPVE injection pumps are shown in the illustrations (A), and (B) respectively. For easy identification the cables are shown in circles on the illustrations.

The amperage of each of the cables is listed in the cable identification table below. The identification numbers for the electrical components are shown in triangles. Refer to the component identification list to find a component.



Cable identification ⁽¹⁾		Component identification ⁽²⁾	
Cable (Number)	Current (Amperes)	Component	Description
1	3	1	Fuel injection pump
2	3	2	Engine stop solenoid
3	6	3	Sender unit
4	3	4	Start switch
5	3	5	Cold start advance unit

(1) For numbers shown in circles

(2) For numbers shown in triangles

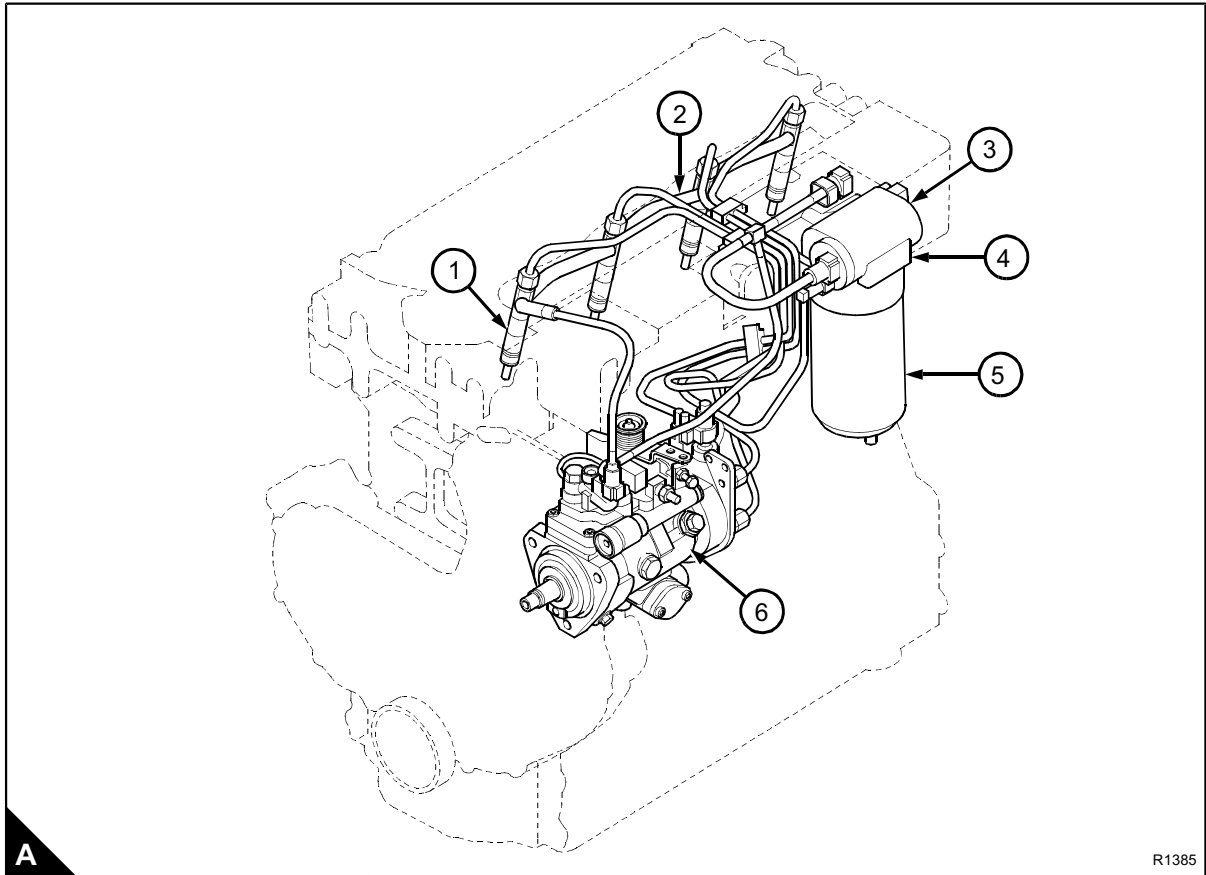
Typical fuel system

The position of the fuel system components may vary from application to application, this information is provided for training purposes only.

Fuel from the tank passes to the electric lift pump/filter (A4). Fuel leaves the lift pump (A3) under pressure to the fuel injection pump (A6).

The fuel injection pump has a self-vent pipe to remove air from the fuel system back into the fuel tank through a connection on the connector block. The fuel in the injection pump also lubricates and cools the pump. The amount of fuel and the fuel injection timing is controlled by the Engine Control Module (ECM).

The fuel injection pump increases the fuel pressure and injects high-pressure fuel at the correct time and sequence through pipes to the atomisers (A1).



Fuel filter assembly

To renew

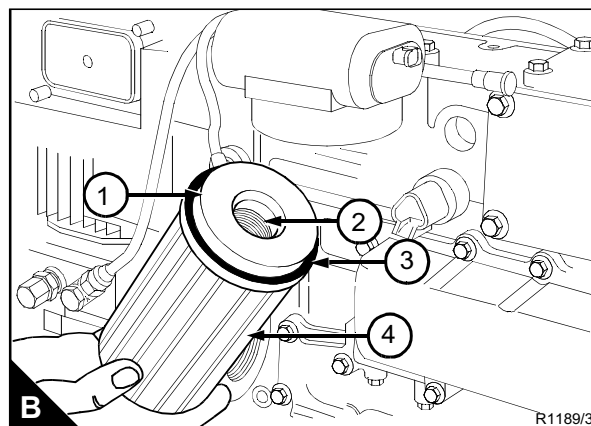
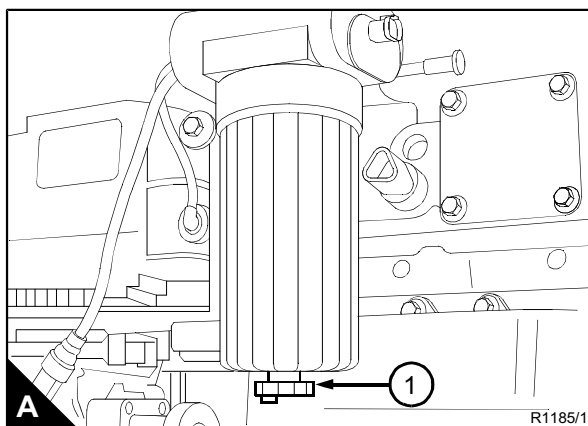
Operation 11-1

Warnings!

- 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, see "Viton seals" on page 8 for safety precautions.
- Discard the used element and fuel oil in a safe place in accordance with local regulations.
- If the fuel level in the tank is higher than the fuel lift pump, the supply and return fuel line valves must be turned off before servicing or repairs are made. If the fuel line valves are not turned off, fuel will flow through the system.
- Ensure that the starter switch is in the OFF position before any service or repairs are made to the fuel system. If the lift pump has power, fuel will be released.

Cautions:

- It is important that only genuine Perkins parts are used. The use of an element that is not a genuine Perkins part may damage the fuel injection pump.
 - The pre-filter canister and main filter elements must be renewed at the same time.
 - 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 Place a suitable container below the fuel filter assembly to retain spilled fuel oil.
 - 2 Thoroughly clean the outside surfaces of the fuel filter assembly. Open the drain tap (A1) at the bottom of the filter casing to drain the fuel from the filter.
 - 3 Use a strap wrench to loosen the filter casing. Remove the casing and element from the fuel filter head.
 - 4 To remove the filter element from the casing; Press down on the filter element (B1), against the spring pressure, and rotate the element to the left to release it from the filter casing (B4).
 - 5 Put the new filter element inside the casing and press the element down against the spring pressure. Rotate the element to the right to lock the element into the casing.
 - 6 Fit a new seal (B3) to the casing and lightly lubricate the seal face with clean fuel oil.
 - 7 Check that the thread (B2) on the inside of the element is not damaged.
 - 8 Fit the filter assembly to the fuel filter head and tighten by hand until the filter assembly contacts the filter head. Tighten the assembly a further $\frac{1}{8}$ of a turn by hand. Do not use a strap wrench.
 - 9 Close the drain tap (A1) and remove the container.



Atomisers

To identify a faulty atomiser

Operation 11-2

Regular maintenance of the atomisers is not necessary. The atomiser should be renewed and not cleaned, and renewed only if an atomiser fault occurs. The major problems that may indicate that new atomisers are needed are listed below:

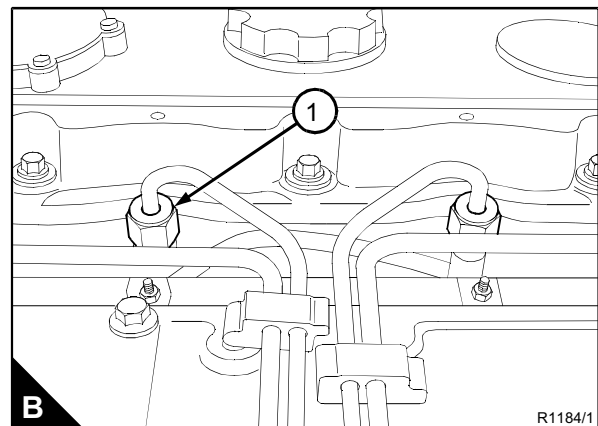
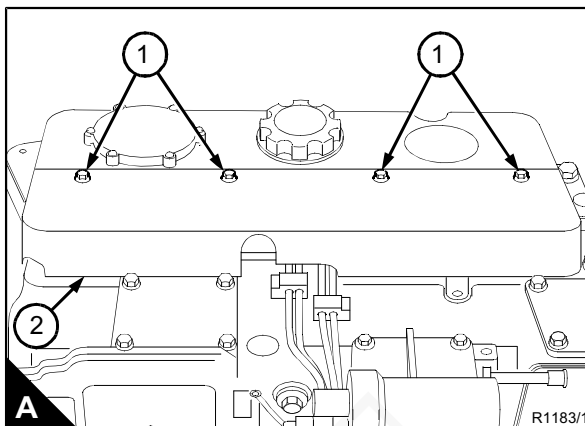
- Engine will not start or is difficult to start
- Not enough power
- Engine misfires or runs erratically
- High fuel consumption
- Black exhaust smoke
- Engine knocks or vibration
- Excessive engine temperature.

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.*

To find the defective atomiser, release the atomiser cover setscrews (A1) and remove the atomiser cover (A2), run the engine at fast idle.

Release and tighten the union nuts (B1) of the high-pressure fuel pipe at each atomiser, one at a time. Do not loosen the union nut more than half a turn. When the union nut of the defective atomiser is released, it has little or no effect on the engine speed.



To remove

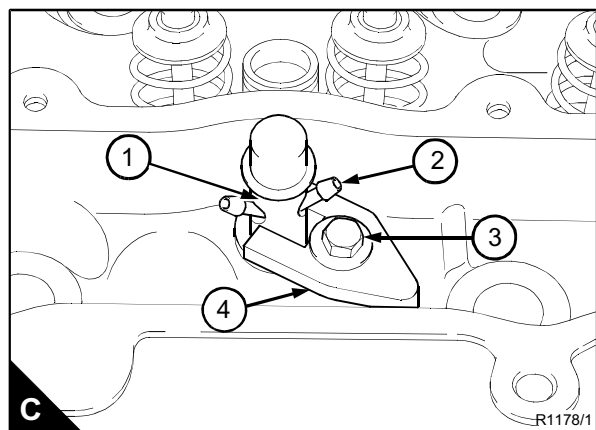
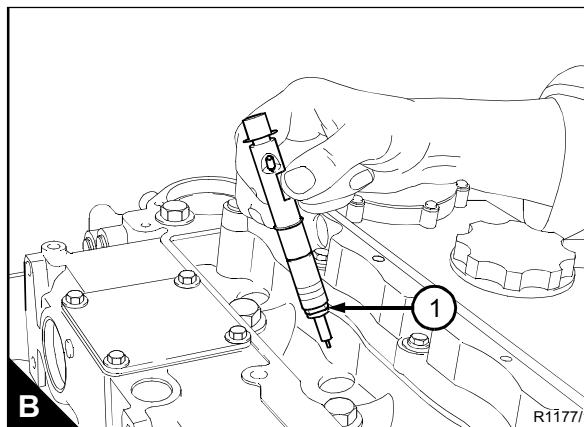
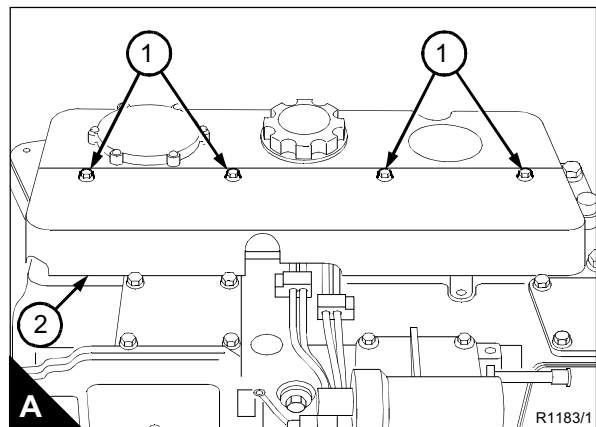
Operation 11-3

Cautions:

- Atomisers must be removed and fitted by a person with the correct training.
- 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 Release the atomiser cover setscrews (A1) and remove the atomiser cover (A2).
- 2 Remove the fuel leak-off pipe from the connection (C2).
- 3 Remove the union nuts of the high-pressure pipe from the atomiser (C1) and from the fuel injection pump. Do not bend the pipe. If necessary, remove the pipe clamps. Fit a plastic cap to cover the fuel inlet connection.
- 4 Remove the setscrew (C3) from the clamp (C4) and remove the atomiser and its seat washer from the recess in the cylinder head.

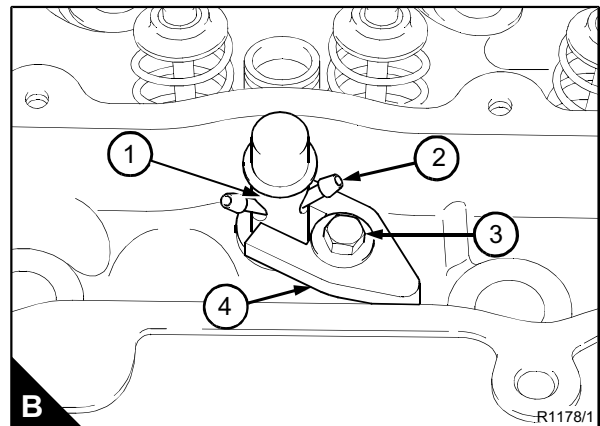
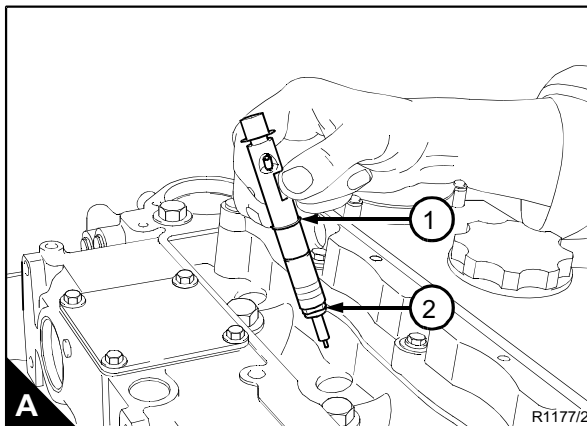
Caution: Remove and discard the seat washer (B1). If the original seat washer remains in the recess for the atomiser, the nozzle protrusion will be incorrect when a new seat washer is added.



To fit

Operation 11-4

- 1 Put the new seat washer (A2) into the seat recess in the cylinder head.
 - 2 Ensure that the atomiser seal (A1) is not damaged. Apply a small amount of clean engine oil to the seal.
- Caution:** The atomiser must be fitted so that the two leak-off connections (B2) point away from the cylinder head towards the intake manifold.
- 3 Place the atomiser (B1) into the recess in the cylinder head.
 - 4 Fit the clamp (B4), tighten the setscrew (B3) for the clamp to 27 Nm (20 lbf ft) 2,8 kgf m.
- Caution:** Do not tighten the union nuts of the high-pressure pipes to more than the recommended torque value. 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.
- 5 Remove the plastic cap and fit the high-pressure fuel pipe. Tighten the union nuts to 27 Nm (20 lbf ft) 2,8 kgf m.
 - 6 If removed earlier, fit the high pressure fuel pipe clamps.
 - 7 Fit the fuel leak-off pipes to the connectors (B2).
 - 8 Operate the engine and check for leakage of fuel and that there is no air in the system.
 - 9 Stop the engine. Refit the atomiser cover and tighten the setscrews, see Operation 3-1.



Fuel lift pump and filter assembly

To remove and to fit

Operation 11-5

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.

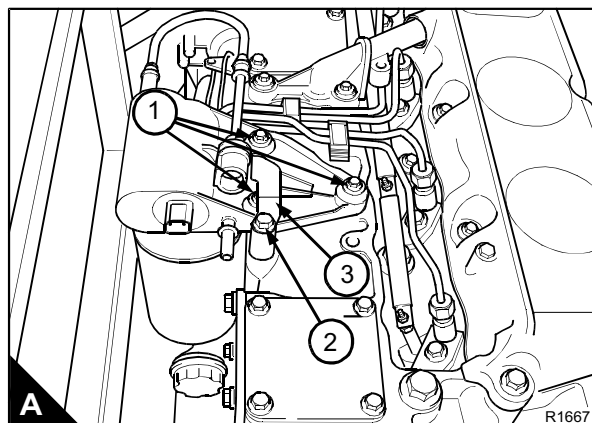
To remove

- 1 Disconnect the fuel pipes from the electric fuel lift pump and filter assembly.
- 2 Drain the electric fuel lift pump and filter assembly, see Operation 11-1.
- 3 Remove the setscrew (A2) and the spacer from the support bracket (A3) for the fuel pipes.
- 4 Remove the setscrews (A1) and rubber washers. Remove the electric fuel lift pump and filter assembly.

To fit

Note: Ensure that new rubber washers are fitted to the setscrews and the cylinder block before the electric fuel lift pump and filter assembly is fitted.

- 1 Fit the setscrews (A1) and new rubber washers to the fuel lift pump and filter assembly.
- 2 Fit the spacer and the setscrew (A2) to the support bracket (A3) for the fuel pipe.
- 3 Fit the fuel pipes to the fuel lift pump and filter assembly.
- 4 Eliminate any trapped air from the fuel system, see Operation 11-8.
- 5 Operate the engine and check for leakage of fuel and that there is no air in the system.



To test

Operation 11-6

- 1 Remove the two outlet fuel pipes from the electric fuel lift pump and filter assembly, make note of the location of the pipes to ensure that the pipes are fitted correctly.
- 2 Connect two suitable rubber hoses to the outlet pipes (feed to fuel injection pump and return to the fuel tank), and place into a three litre measuring cylinder.
- 3 Operate the engine until a consistent flow of fuel is running from the outlet pipe of the fuel injection pump.
Note: The return pipe to the fuel tank will have a slower flow than the feed pipe from the fuel injection pump.
- 4 The combined flow of both pipes should be at a rate of two litres/per minute as a minimum.
- 5 If the flow is less than two litres/per minute, replace the electric fuel lift pump and filter assembly.
- 6 Connect the electric fuel lift pump outlet pipes in the correct position.
- 7 Operate the engine and check for leakage of fuel and that there is no air in the system.

To test pressure regulator

Operation 11-7

- 1 Remove the fuel lift pipe from the fuel injection pump, fit a suitable pipe with a pressure test point and connect a 0-80 kPa (0-12 lbf/in²) 0-0,8 kgf/cm² pressure gauge.
- 2 Operate the engine at idle for two minutes to allow any trapped air to be removed.
- 3 The reading on the pressure gauge should be as below:
 - Bosch EPVE = 31 kPa (4.49 lbf/in²) 0,31 kgf/cm² at idle, and rated speed 31 kPa (4.49 lbf/in²) 0,31 kgf/cm²
 - Bosch VP40 = 27,5 kPa (3.98 lbf/in²) 0,28 kgf/cm² at idle, and rated speed 24kPa (3.48 lbf/in²) 0,24 kgf/cm²
 - Delphi DP210 = 27,5 kPa (3.98 lbf/in²) 0,28 kgf/cm² at idle, and rated speed 28kPa (4.06 lbf/in²) 0,28 kgf/cm²
- 4 The combined flow of both pipes should be at a rate of two litres/per minute as a minimum.
- 5 Connect the fuel lift pipe to the fuel injection pump. Operate the engine at idle for two minutes.
Note: If the fuel lift pump and filter assembly does not meet the above specifications check for the following; that all the electrical connections are fitted, there are no leaks in the pipes and connections, that the seal on the drain tap does not leak and that the "O" ring for the canister to the lift pump does not leak.

Air in the fuel system

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
- A fuel system component such as a filter element, or a fuel pump, has been installed during a service
- The high pressure fuel pipes have been disconnected.

To eliminate air from the fuel system

Operation 11-8

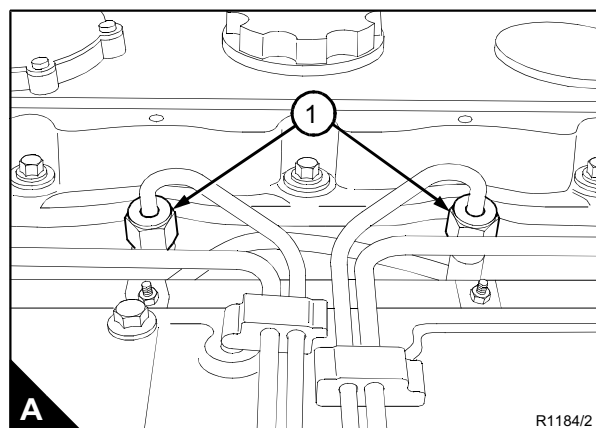
Cautions:

- *Do not operate the engine until the air is eliminated from the fuel injection pump.*
- *After the air is eliminated, operate the engine at low idle for two minutes.*

The Delphi DP210 fuel injection pump will eliminate air automatically when the start key is turned to the RUN position for three minutes.

The Bosch VE and the VP30 fuel injection pumps will not eliminate air automatically.

- 1 Release the atomiser cover setscrews and remove the atomiser cover, see Operation 3-1.
- 2 Turn the start key to the RUN position for three minutes, then return the key to the OFF position.
- 3 Loosen the high pressure pipes (A1) at the atomisers.
- 4 Operate the starter motor until fuel free from air comes from the connections.
- 5 Tighten the connections to 30 Nm (22 lbf ft) 3,0 kgf m.
- 6 Start the engine and check for leaks.
- 7 Fit the atomiser cover and tighten its setscrews, see Operation 3-1.



Bosch VP30 fuel injection pump**General description****Cautions:**

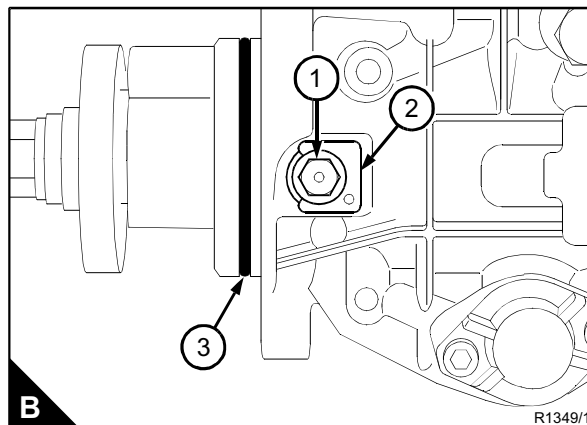
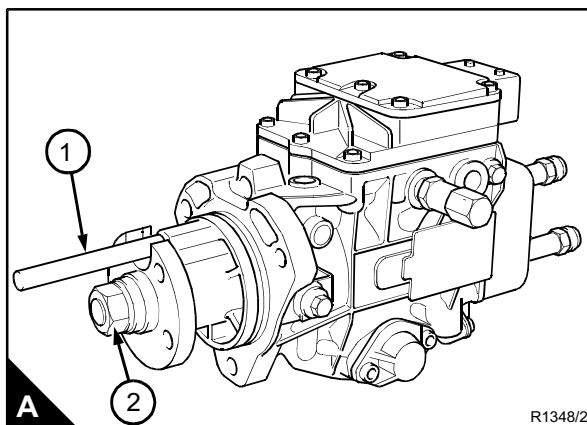
- *Do not loosen the nut (A2) from the fuel injection pump. The fuel pump hub is fitted to the shaft in the factory to ensure that the fuel pump is in the correct position for timing. If the nut is loosened and the hub moves, the hub will need to be accurately fitted to the pump by use of specialist equipment before the pump can be fitted to the engine.*
- *A new fuel injection pump will be supplied with the pump shaft in the locked position. The drive shaft of the pump must not be turned without the spacer (B2) in position under the locking screw (B1). Before the crankshaft is turned, or the pump is fitted, put the spacer into position under the locking screw to ensure that the pump drive shaft is released.*

The manufacturer fits the hub (A2) to the pump to ensure very accurate timing. These engines have the drive gear fastened to the hub instead of to the shaft of the pump.

The mounting flange has holes instead of slots to prevent incorrect adjustments to the engine timing by rotation of the fuel pump.

Accurate timing of the pump to the engine is by a pin (A1) used to align the fuel pump gear and the hub with a hole in the body of the fuel pump. The gear is passed over the pin and fastened to the hub with four flanged setscrews and hardened washers.

An 'O' ring (B3) is fitted into a groove in the pump flange. This 'O' ring is fitted instead of a joint between the pump flange and the timing case.



To remove

Operation 11-9**Special requirements**

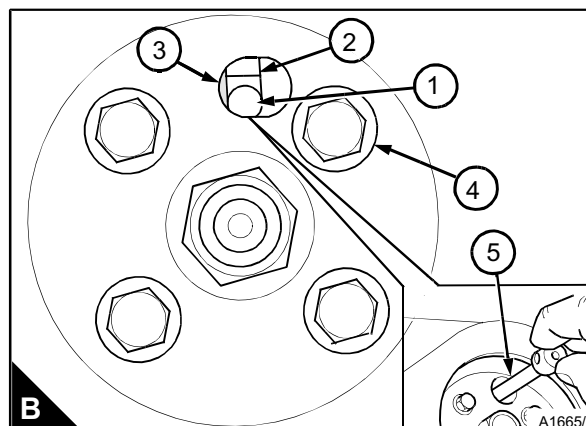
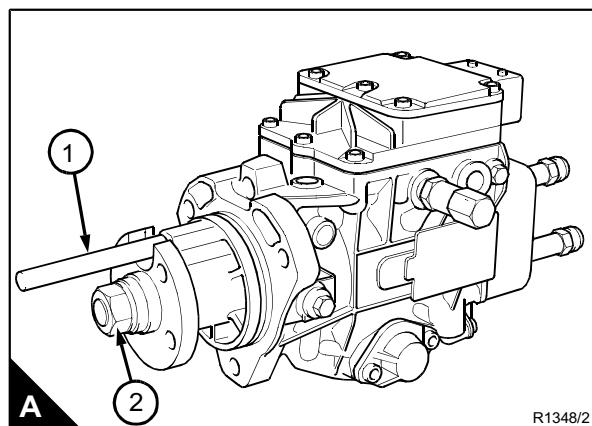
Special tools			
Description	Part number	Description	Part number
Spanner for flange nut of the Bosch fuel injection pump	21825964	Timing pin	27610032

Caution: Do not loosen the nut (A2) 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 moved, the hub will need to be accurately fitted to the pump by use of special equipment.

- 1 Disconnect the battery.
- 2 Set the engine to TDC number 1 cylinder compression stroke, see Operation 8-1.
- 3 Insert the timing pin (B5) through the hole (B3) in the fuel pump gear and the slot of the hub (B2). Push the pin fully into the hole (B1) 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.

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

- 4 Remove the low pressure and the high pressure fuel pipes from the pump.



Continued

5 Disconnect the electrical connection by pulling the locking mechanism as shown (E) from the connector. Carefully remove the connector from the fuel pump. Do not damage the pins of the connector.

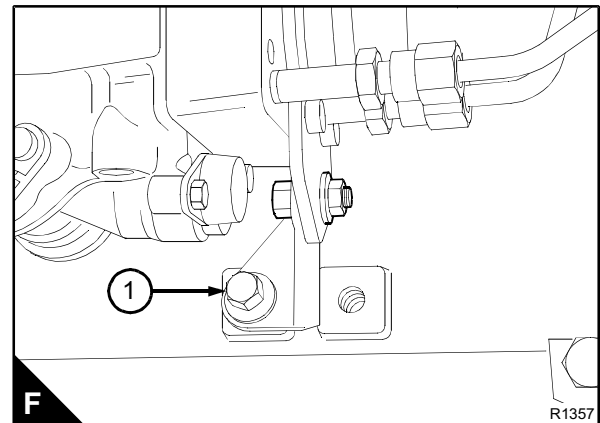
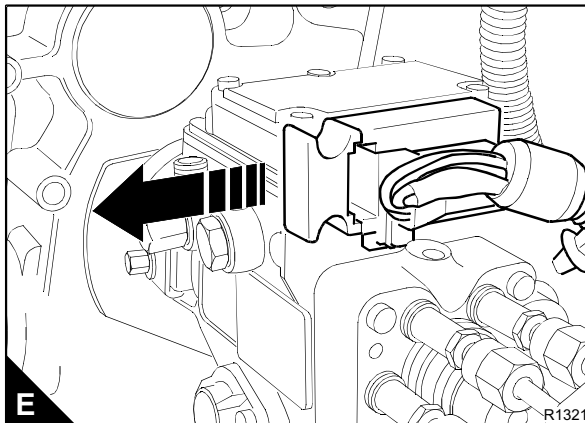
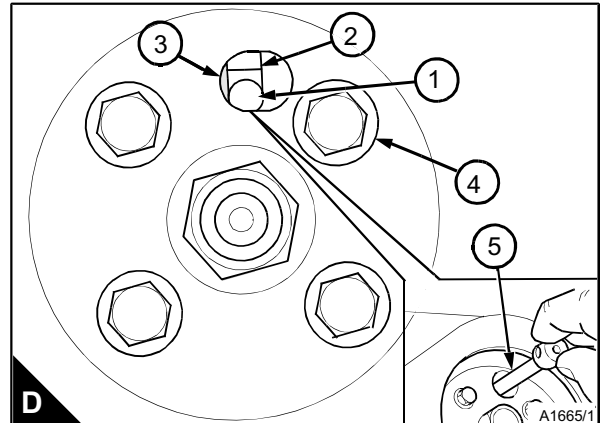
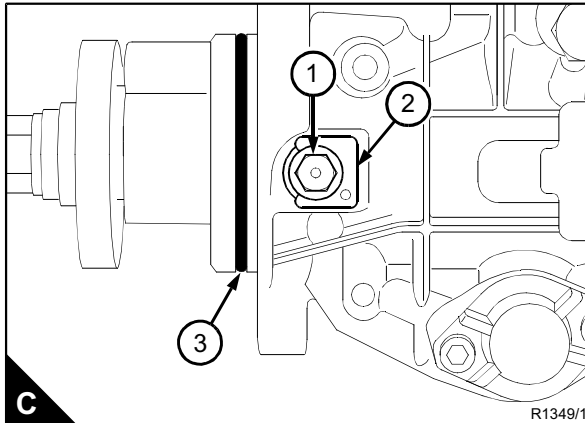
Caution: Do not rotate the crankshaft when the pump is not on the engine.

6 Remove the four setscrews and the hardened washers (D4), remove the fuel pump gear from the hub of the fuel injection pump.

7 Remove the setscrew from the fuel pump support bracket (F1).

8 Remove the setscrews and washers from the timing case that secure the fuel pump and remove the pump.

9 Discard the fuel pump 'O' ring (C3).



To fit

Operation 11-10

Special requirements

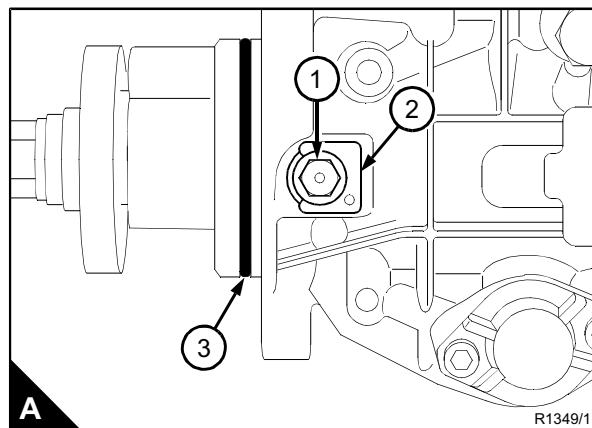
Special tools			
Description	Part number	Description	Part number
Spanner for flange nut of the Bosch fuel injection pump	21825964	Timing pin	27610032

Cautions:

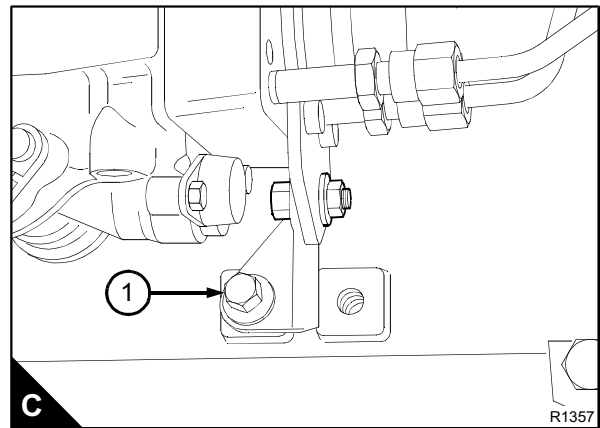
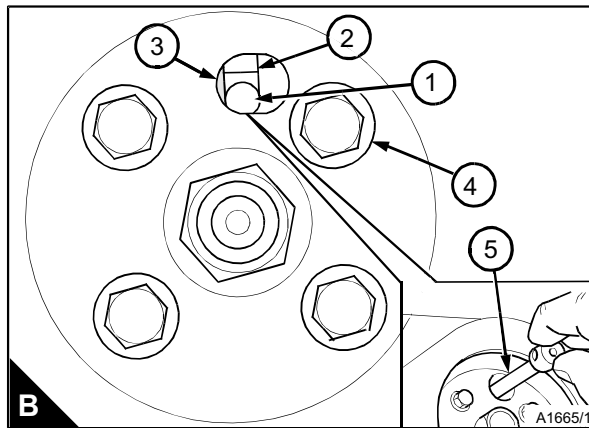
- The engine must be set to TDC number 1 cylinder compression stroke before the pump is fitted, see Operation 8-1.
- A new fuel injection pump will be supplied with the pump shaft in the locked position. The drive shaft of the pump must not be turned without the spacer (A2) in position under the locking screw (A1). Before the crankshaft is turned, or the pump is fitted, put the spacer into position under the locking screw to ensure that the pump drive shaft is released.

1 Fit a new 'O' ring (A3) to the pump flange.

2 Lightly lubricate the 'O' ring with clean engine lubricating oil. Fit the pump into position in the timing case and fit the three washers and setscrews.

*Continued*

- 3 Loosely fit the setscrew (C1) of the support bracket. Ensure that force is not applied to the fuel injection pump.
- 4 Put the fuel pump gear onto the hub of the fuel pump. The setscrews (B4) for the fuel pump gear should be in the centre of the slots to allow for the removal of backlash. Loosely fit the setscrews.
- 5 Insert the timing pin (B5) through the hole (B3) of the fuel pump gear and the slot of the hub (B2) until it can be pushed fully into the hole (B1) in the body of the fuel injection 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.
- 6 Carefully turn the gear counter-clockwise by hand to remove the backlash between the idler gear and the fuel pump gear. Do not rotate the crankshaft or the fuel injection pump shaft. Tighten the setscrews for the fuel injection pump gear to 28 Nm (20 lbf ft) 2,8 kgf m.
- 7 Remove the timing pin.
- 8 Fit the timing case cover, see Operation 6-2.
- 9 Tighten the setscrew (C1) of the support bracket to 44 Nm (32 lbf ft) 4,4 kgf m. Ensure that force is not applied to the fuel injection pump.

*Continued*

Cautions:

- 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 pump outlet. Do not tighten the pump union nut more, as this can cause a restriction at the end of the pipe. This can affect the fuel delivery.
- Use a second spanner to prevent movement of the high pressure outlet on the pump when the union nut for each high pressure pipe is tightened.

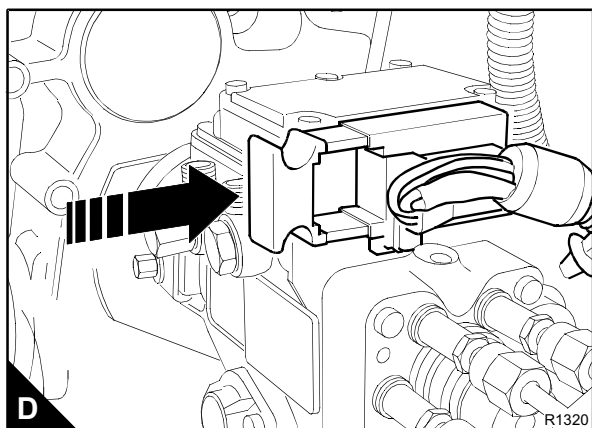
10 Fit the low pressure and the high pressure fuel pipes to the pump. Tighten the high pressure pipe union nuts to 27,5 Nm (21 lbf ft) 2,8 kgf m.

11 Fit the electrical connector to the fuel pump; to fit the electrical connector, push the connector fully into the socket on the fuel pump, to lock the connector to the fuel pump push in the locking clamp (D). Ensure that the connector pins are not damaged.

12 Connect the battery.

13 Eliminate air from the fuel system, see Operation 11-8.

14 Operate the engine and check for leakage of fuel and that there is no air in the system.

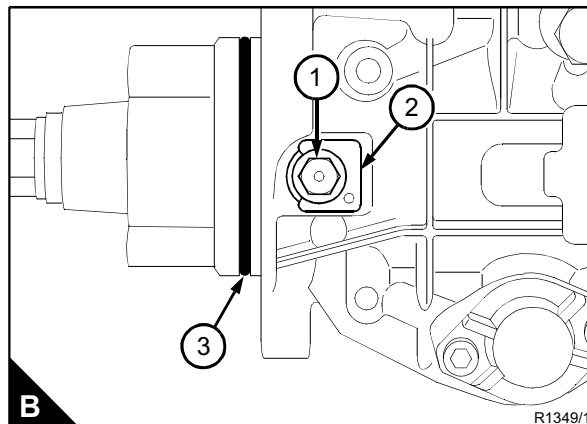
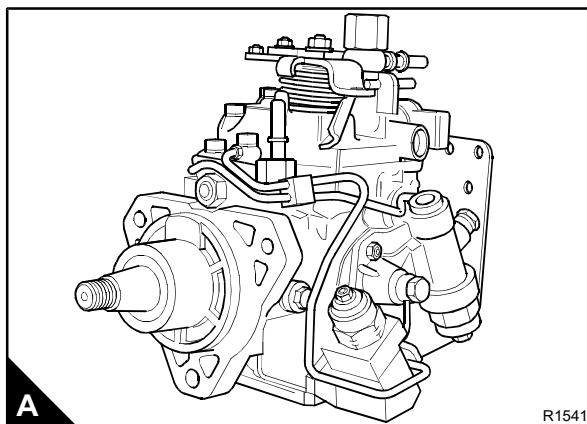


Bosch EVPE fuel injection pump**General description**

Caution: A new fuel injection pump will be supplied with the pump shaft in the locked position. The drive shaft of the pump must not be turned without the spacer (B2) in position under the locking screw (B1).

Bosch EPVE fuel injection pumps have a drive gear fastened to the shaft of the pump.

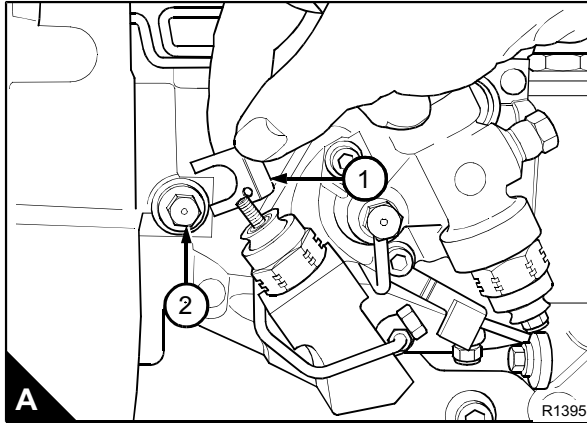
An 'O' ring (A3) is fitted into a groove in the pump flange. This 'O' ring is fitted instead of a joint between the pump flange and the timing case.



To remove

Operation 11-11

- 1 Disconnect the battery.
- 2 Set the engine to TDC number 1 cylinder compression stroke, see Operation 8-1.
- 3 Lock the pump shaft; To lock the fuel injection pump shaft loosen the locking screw (A2) and remove the spacer (A1). Tighten the locking screw (A2) to 31 Nm (23 lbf ft) 3,1 kgf m.
Caution: Use a second spanner to prevent movement of the high pressure outlet on the pump when the union nut for each high pressure pipe is released.
- 4 Remove the low pressure and the high pressure fuel pipes from the pump.

*Continued*

Caution: Do not rotate the crankshaft when the pump is not on the engine.

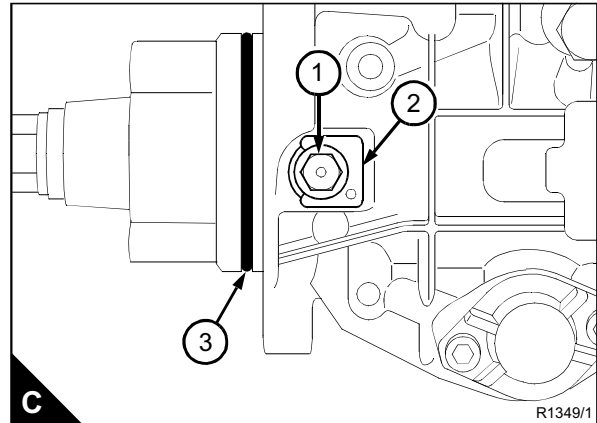
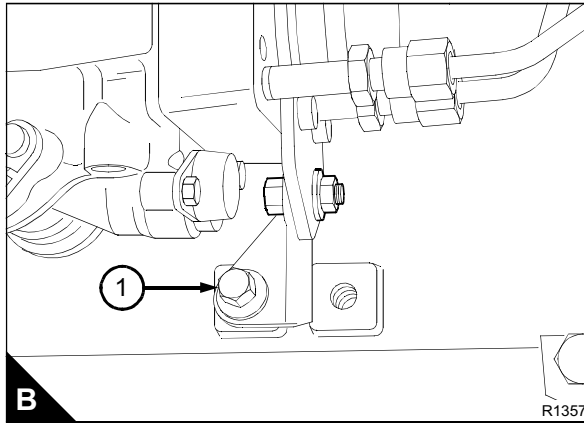
5 Remove the fuel pump gear, see Operation 6-3.

Note: Remove the KSB electrical connections.

6 Remove the setscrew from the fuel pump support bracket (B1).

7 Remove the setscrews and washers that secure the fuel pump and remove the pump.

8 Discard the fuel pump 'O' ring (C3).



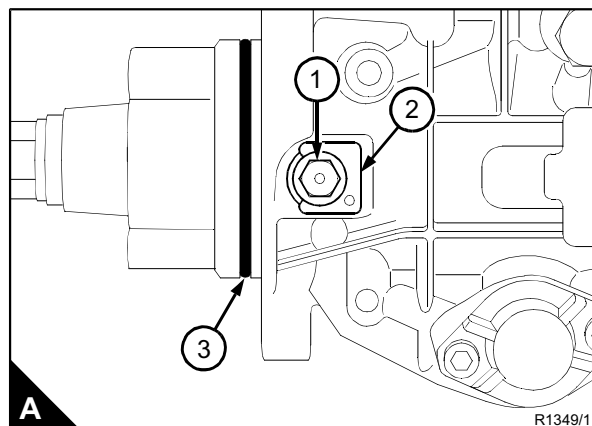
To fit

Operation 11-12

Cautions:

- The engine must be set to TDC number 1 cylinder compression stroke before the pump is fitted, see Operation 8-1.
- A new fuel injection pump is supplied with the pump shaft in the locked position. The drive shaft of the pump must not be turned without the spacer (A2) in position under the locking screw (A1).
- Do not rotate the crankshaft when the pump is not on the engine.

1 Fit a new 'O' ring (A3) to the pump flange. Lightly lubricate the 'O' ring with clean engine lubricating oil. Put the pump into position in the timing case and fit the three washers and setscrews, then tighten the setscrews to 25 Nm (18 lbf ft) 2,5 kgf m.

*Continued*

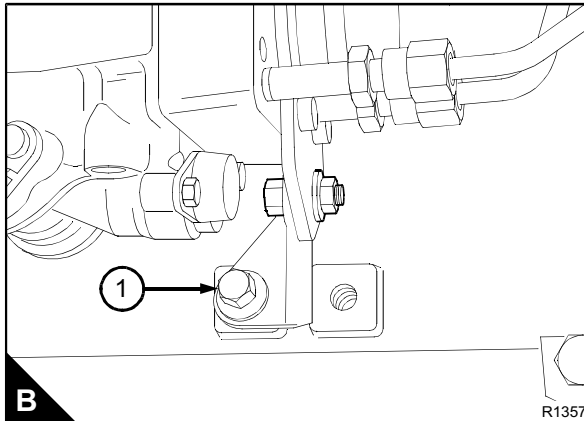
2 Loosely fit the setscrew (B1) of the support bracket. Ensure that force is not applied to the fuel injection pump.

3 Fit the fuel pump gear, see Operation 6-4.

Caution: The fuel pump gear must be fitted to the engine before the crankshaft is rotated.

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

5 Tighten the setscrew (B1) of the support bracket to 44 Nm (32 lbf ft) 4,4 kgf m. Ensure that force is not applied to the fuel injection pump.



Cautions:

- 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 pump outlet. Do not tighten the pump union nut more, as this can cause a restriction at the end of the pipe. This can affect the fuel delivery.
- Use a second spanner to prevent movement of the high pressure outlet on the pump when the union nut for each high pressure pipe is tightened.

6 Fit the low pressure and the high pressure fuel pipes to the pump. Tighten the high pressure pipe union nuts to 27,5 Nm (21 lbf ft) 2,8 kgf m.

7 Connect the battery.

8 Fit the KSB electrical connection.

9 Eliminate air from the fuel system, see Operation 11-8.

10 Operate the engine and check for leakage of fuel and that there is no air in the system.

Delphi DP210 fuel injection pump

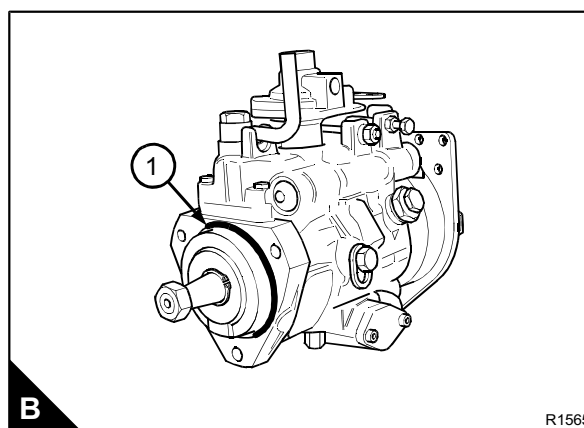
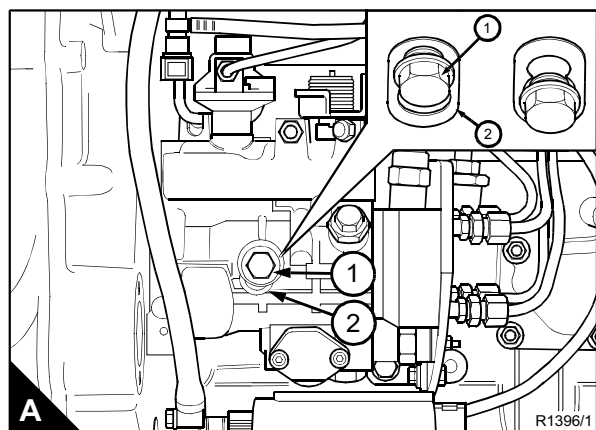
General description

Cautions:

- If the fuel injection pump is removed from the engine it will need to be returned to your nearest Perkins Dealer/Distributor for the pump timing to be checked or reset.
- Do not unlock the shaft of the fuel injection pump until the fuel pump gear is fitted.
- A new fuel injection pump will be supplied with the pump shaft in the locked position. The drive shaft of the pump must not be turned without the spacer (A2) in position under the locking screw (A1).

Delphi DP210 fuel injection pumps have a drive gear fastened to the shaft of the pump.

An 'O' ring (B1) is fitted into a groove in the pump flange. This 'O' ring is fitted instead of a joint between the pump flange and the timing case.



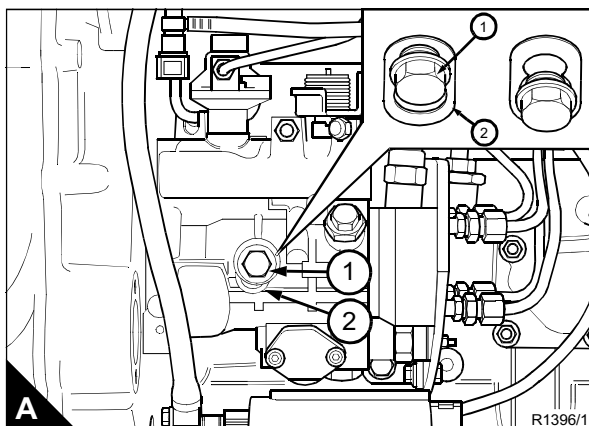
To remove

Operation 11-13

- 1 Disconnect the battery.
- 2 Set the engine to TDC number 1 cylinder compression stroke, see Operation 8-1.
- 3 Lock the pump shaft; To lock the fuel injection pump shaft loosen the locking screw (A2) and rotate the washer (A1). Tighten the locking screw (A2) to 17 Nm (12 lbf ft) 1,7 kgf m.

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

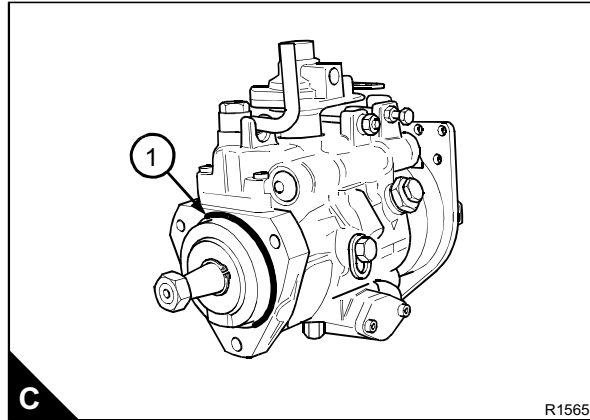
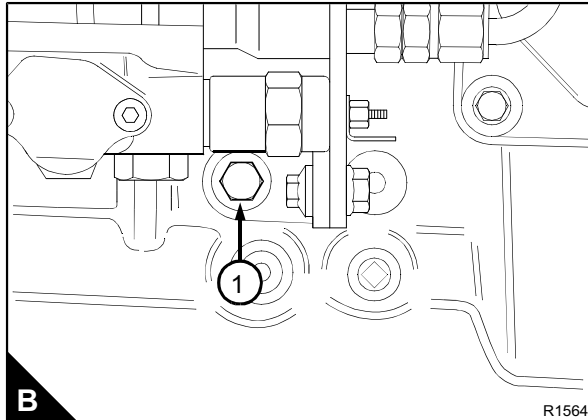
- 4 Remove the low pressure and the high pressure fuel pipes from the pump.



Continued

Caution: Do not rotate the crankshaft when the pump is not on the engine.

- 5 Remove the fuel pump gear, see Operation 6-3.
- 6 Remove the setscrew from the fuel pump support bracket (B1).
- 7 Remove the setscrews and washers that secure the fuel pump and remove the pump.
- 8 Discard the fuel pump 'O' ring (C1).

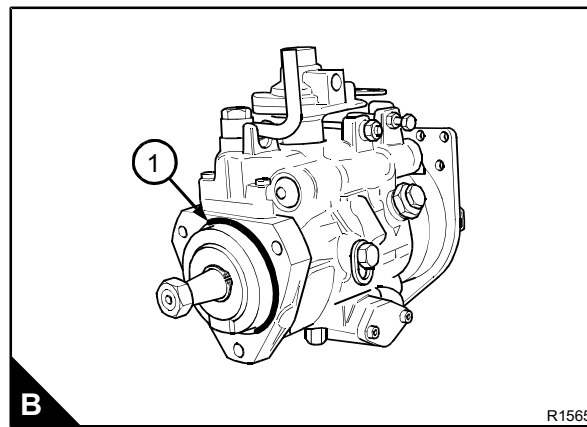
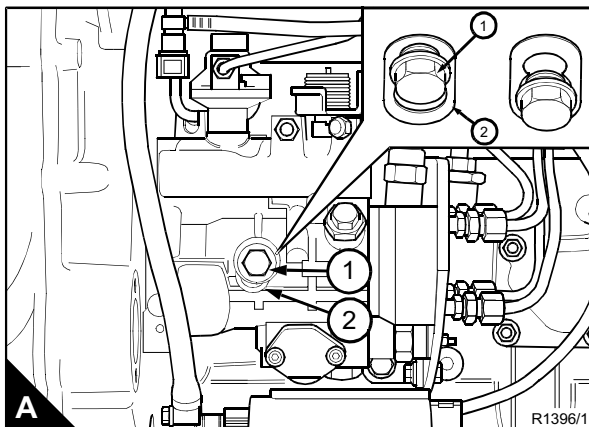


To fit

Operation 11-14

Cautions:

- The engine must be set to TDC number 1 cylinder, compression stroke before the pump is fitted, see Operation 8-1.
 - Do not unlock the shaft of the fuel injection pump until the fuel pump gear is fitted.
 - A new fuel injection pump will be supplied with the pump shaft in the locked position. The drive shaft of the pump must not be turned without the spacer (A2) in position under the locking screw (A1).
- 1 Fit a new 'O' ring (B1) to the pump flange. Lightly lubricate the 'O' ring with clean engine lubricating oil.
- 2 Fit the pump into position in the timing case, fit the three washers and setscrews, then tighten the setscrews to 25 Nm (18 lbf ft) 2,5 kgf m.

*Continued*

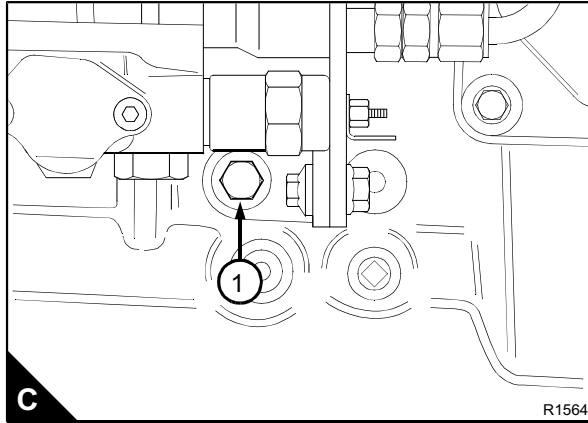
3 Loosely fit the setscrew (C1) of the support bracket. Ensure that force is not applied to the fuel pump.

4 Fit the fuel pump gear, see Operation 6-4.

Caution: The fuel pump gear must be fitted to the engine before the crankshaft is rotated.

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

6 Tighten the setscrew (C1) of the support bracket to 44 Nm (32 lbf ft) 4,4 kgf m. Ensure that force is not applied to the fuel pump.



Cautions:

- 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 pump outlet. Do not tighten the pump union nut more, as this can cause a restriction at the end of the pipe. This can affect the fuel delivery.
- Use a second spanner to prevent movement of the high pressure outlet on the pump when the union nut for each high pressure pipe is tightened.

7 Fit the low pressure and the high pressure fuel pipes to the pump. Tighten the high pressure pipe union nuts to 27,5 Nm (21 lbf ft) 2,8 kgf m.

8 Connect the battery.

9 Eliminate air from the fuel system, see Operation 11-8.

10 Operate the engine and check for leakage of fuel and that there is no air in the system.

12

Cooling system

General description

Coolant from the bottom of the radiator passes through the centrifugal coolant pump that is fitted onto the front of the timing case, to assist the flow of the coolant through the system.

The coolant pump is gear driven by the fuel injection pump gear.

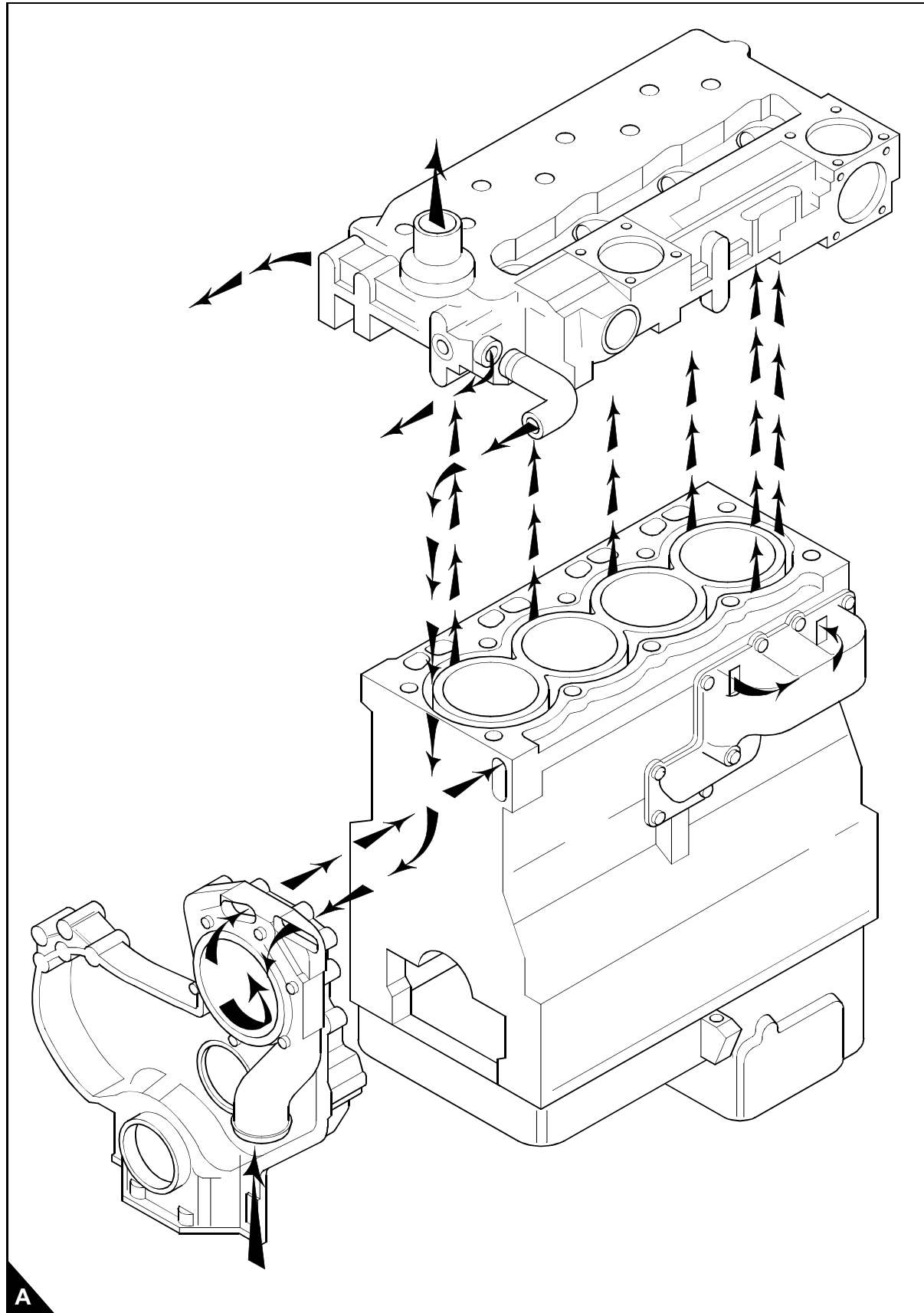
An integral oil cooler, if fitted, has an aluminium cover with a five or seven plate element. The oil cooler has no external pipes and is fitted to the left side of the cylinder block.

From the pump, the coolant passes through a passage in the timing case to the coolant jacket in the top left side of the cylinder block. The coolant continues to the rear of the cylinder block where some of the coolant passes into the lubricating oil cooler, if one is fitted. Some of the coolant passes around the element of the integral cooler and then to the rear of the cylinder block.

The coolant then passes from the rear of the cylinder block and into the cylinder head. The coolant leaves the cylinder head at the front and passes into the thermostat housing.

If the thermostat is closed, the coolant goes directly through a by-pass to the inlet side of the coolant pump. If the thermostat is open, the thermostat closes the by-pass and the coolant passes to the top of the radiator.

Coolant flow diagram



Thermostat

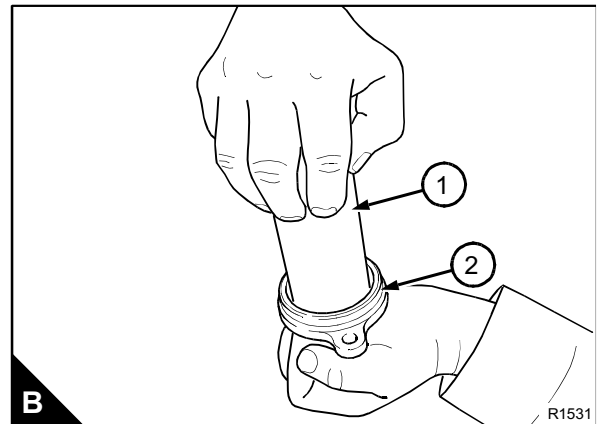
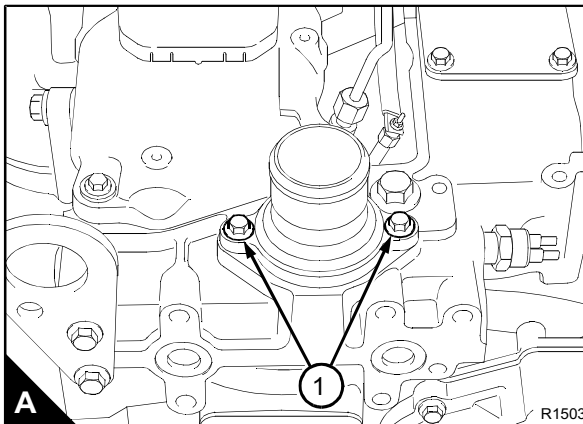
To remove

Operation 12-1**Special requirements**

Special tools	
Description	Part number
Thermostat tool	27610226

Note: Engines are fitted with a single thermostat (A). Identification of the thermostat is by the nominal temperature which is stamped on the by-pass valve.

- 1 Drain the coolant in the cooling system to a level below the thermostat position and disconnect the top hose from the coolant outlet connection.
- 2 Release the two setscrews (A1) and remove the thermostat housing from the cylinder head.
- 3 Remove the "O" ring and discard.
- 4 Press down on the thermostat using the thermostat tool (B1) and rotate the thermostat to release it from the housing (B2).
- 5 Remove the thermostat from the housing.



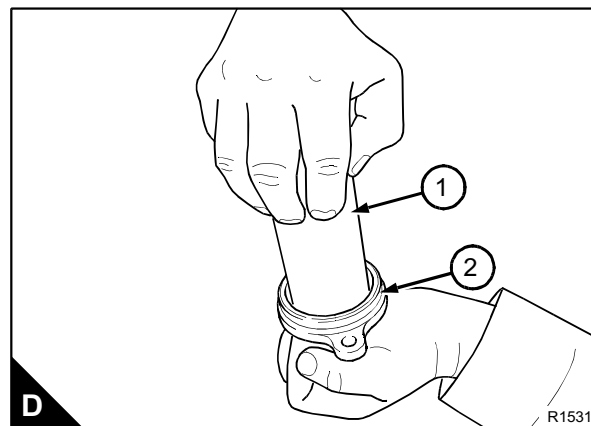
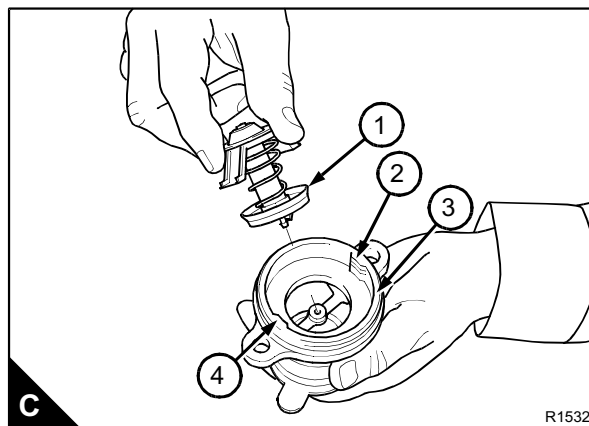
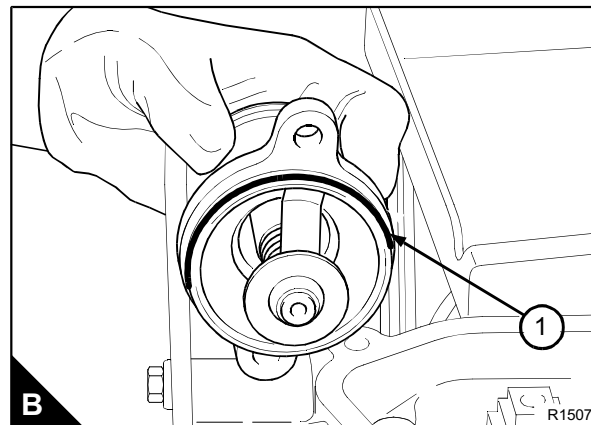
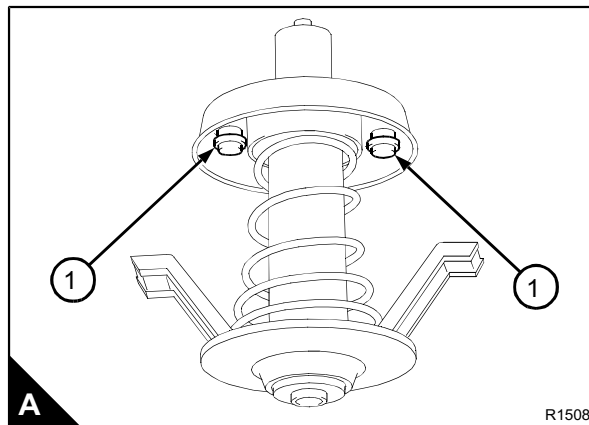
To fit

Operation 12-2

Special requirements

Special tools		Consumable products	
Description	Part number	Description	Part number
Thermostat tool	27610226	POWERPART Red rubber grease	21820221

- 1 Clean the thermostat housing. Ensure that the grooves for the spring retainers and the seat for the "O" ring are free of debris.
- 2 Ensure that the jiggle pins (A1) in the thermostat are both free to move.
- 3 Lubricate a new "O" ring (B1) with POWERPART Red rubber grease before it is fitted. Fit "O" ring. Place the thermostat (C1) in position in the housing (C3).
- 4 Use the thermostat tool (D1) to push and rotate the thermostat to engage the spring retainers into the grooves in the housing (C2) and (C4).
- 5 Fit the thermostat assembly to the cylinder head and tighten the setscrews.
- 6 Connect the top hose and fill the cooling system.



To test

Operation 12-3

Note: Do not remove the thermostat from the housing to test.

1 Place the thermostat and the housing 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 at which it is fully open. For the correct operating temperatures, refer to the Data and dimensions for "Thermostat" on page 26.

Caution: *If the thermostat does not operate correctly, it must be renewed. Do not try to adjust the settings.*

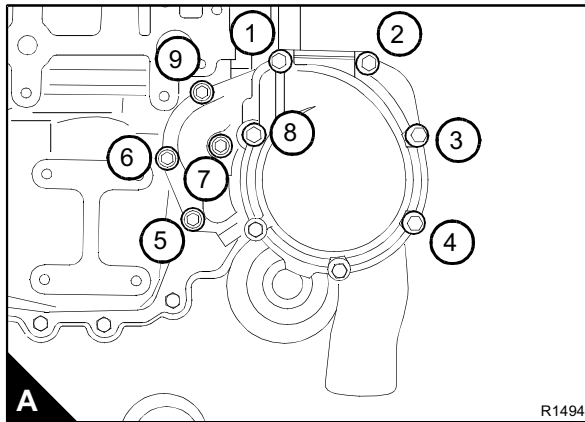
Coolant pump

Note: Identification of the coolant pump is by the part number that is cast onto the coolant pump body.

To remove

Operation 12-4

- 1 Drain the cooling system and disconnect the hose at the inlet connection of the coolant pump.
- 2 Remove the nine setscrews in (A) which retain the coolant pump and remove the coolant pump.
- 3 Remove and discard the joint.



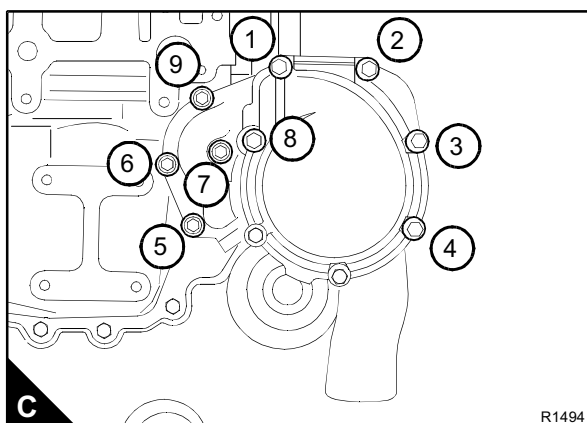
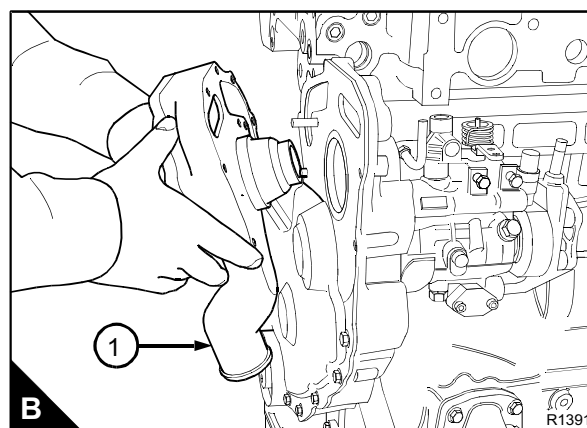
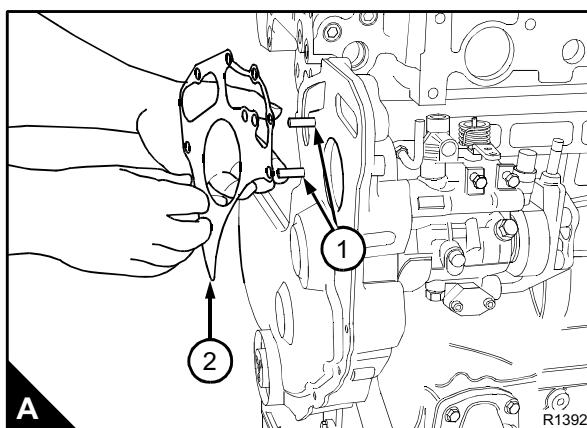
To fit

Operation 12-5

Special requirements

Consumable products	
Description	Part number
POWERPART Threadlock and nutlock	21820117

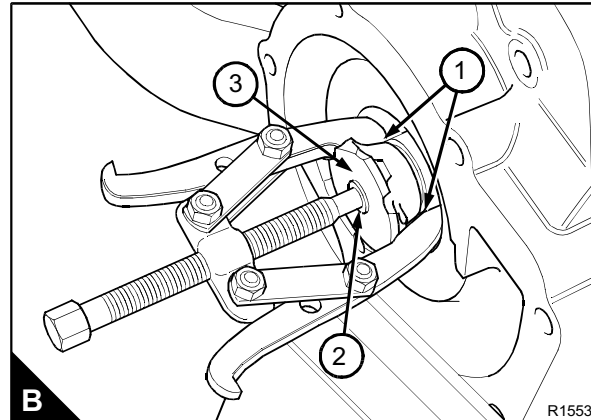
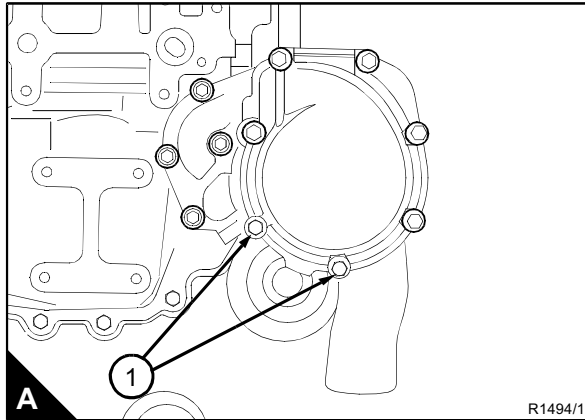
- 1 Ensure that all joint faces are clean.
 - 2 Check the drive gear of the coolant pump for wear or other damage. If the gear is damaged, the pump must be renewed.
 - 3 Fit two suitable guides (A1), fit a new joint (A2).
 - 4 Fit the pump (B1) onto the guides and into the timing case cover with its gear in mesh with the gear of the fuel injection pump.
- Note:** The setscrews that retain the coolant pump have a sealant (MEAS) applied by the manufacturer to the first 13,0 mm (0.50 in) of the threads. If the setscrews are used again, the sealant must be removed from the male and female threads and POWERPART Threadlock and nutlock applied to the first 13,0 mm (0.50 in) of the setscrew threads.
- 5 Fit and lightly tighten the seven setscrews which retain the pump to the cover of the timing case. The pump is a tight fit in the cover, but can be pulled into position if the setscrews for the pump are gradually and evenly tightened.
 - 6 Remove the guides and fit the remaining setscrews.
 - 7 Tighten all the setscrews (C) on the coolant pump to 22 Nm (16 lbf ft) 2,2 kgf m.
 - 8 Connect the hose to the inlet connection of the coolant pump and fill the cooling system.
 - 9 Operate the engine and check for leakage.



To dismantle

Operation 12-6

- 1 Remove the setscrews, (A1) the cover and the joint. Discard the joint.
- 2 To remove the impeller (B3) from the pump shaft; drill twelve 6,35 mm (0.25 in) holes between the existing holes at equal distance around the impeller. Drilling these holes will break pieces off the impeller (B3) to allow the 2 legged puller to be correctly fitted.
- 3 The impeller can be removed by using a suitable two legged puller attached to the back of the impeller (B1). Tighten the centre setscrew (B2) of the puller until the impeller is removed. Discard the impeller.

*Continued*

Caution: Do not damage the sealing face of the coolant seal housing during removal of the seal.

4 To remove the coolant seal (C4), it will be necessary to break the seal and use an extractor to remove the centre sleeve of the seal from the body of the shaft. This will loosen the grip of the seal on the shaft. To remove the body of the seal, drill three 3,175 mm (0.125 in) holes through the top of the coolant seal 120° apart. Fit three 25,4 mm (1.00 in) self-tapping screws. Insert a suitable lever through the coolant inlet of the pump body and gradually and evenly apply the lever under the head of each self-tapping screw to remove the seal. Discard the seal.

Caution: Do not damage the sealing face of the oil seal housing during removal of the seal.

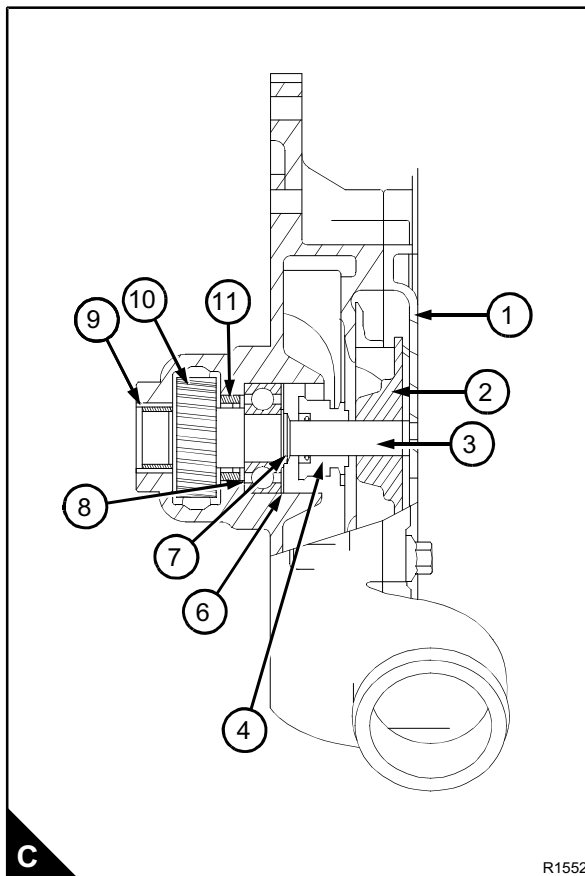
5 Remove and discard the circlips (C6) (C7).

6 Put the impeller end of the pump body face down on a suitable press. Press the drive gear end of the shaft through the gear (C10) and the pump body until the shaft (C3) and ball bearing assembly (C8) are released from the pump. Discard the bearing and the shaft. The gear will also be released through the side of the housing.

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

8 Put the impeller end of the pump body face down on a press and use a suitable mandrel to engage the outer face of the oil seal (C11). Press out the oil seal and discard it.

9 With the impeller end of the pump body face down on a press, use a suitable mandrel to engage the outer race of the needle roller bearing (C9). Press out the bearing and discard it.

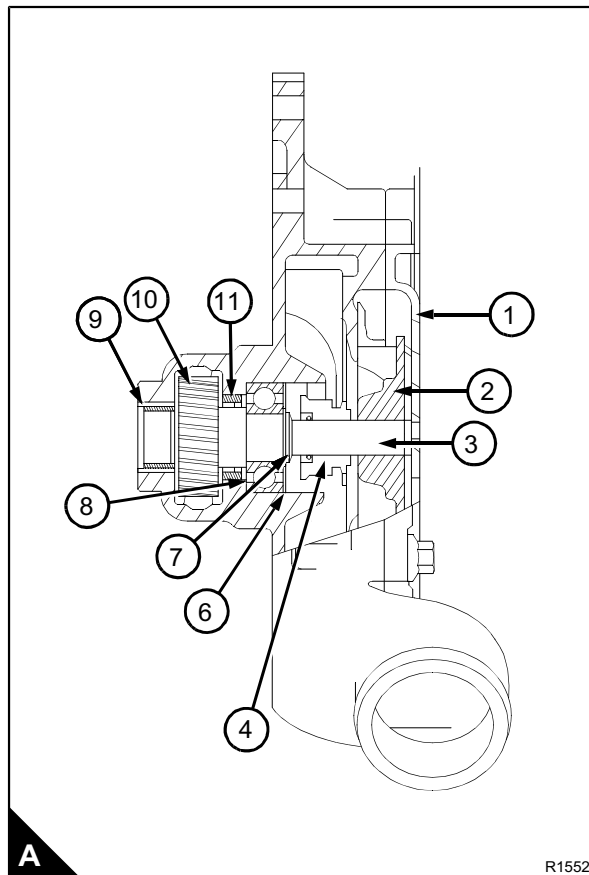


To assemble

Operation 12-7

Caution: It is important that all of the components in the kit for the coolant pump are used.

- 1 Clean thoroughly the inside of the pump body, the bearing bores and the counterbore for the coolant seal. These bores and their chamfers must be clean and free of corrosion.
- 2 Put the gear end of the pump body face down on a press. Use a suitable mandrel to engage the outer face of the oil seal and press in until the bottom face of the oil seal is level with the face of the gear housing.
- 3 With the gear end of the pump body face down on a press, position the drive gear into the correct position. Use a suitable adaptor to press the drive shaft through the oil seal and into drive gear so that there is a 1,5 mm (0.060 in) gap between the drive gear and the top face of the drive gear pocket.
- 4 Use a suitable adaptor to press the bearing (A8) onto the drive shaft, until it is against its shoulder.
- 5 Put the impeller end of the pump body face down on a press. Fit the new circlip (A6), with the bevel edge away from the oil seal to retain the bearing assembly in the body of the pump. Fit the circlip (A7) to the drive shaft to retain the bearing assembly to the drive shaft of the pump.
- 6 Turn the pump over and press the needle roller bearing (A9) into the bearing housing until the end of the bearing is level with or 0,5 mm (0.020 in) below the top of the housing.



Continued

Caution: Do not lubricate the coolant seal (B4). The coolant seal must not be contaminated with oil or grease. If the coolant seal is held by hand, it should be held by the edge of the outside flange.

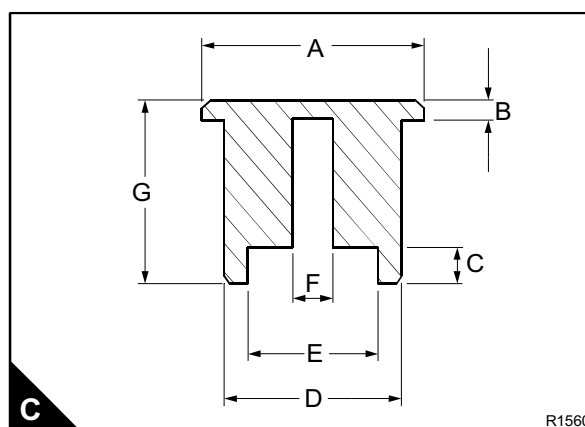
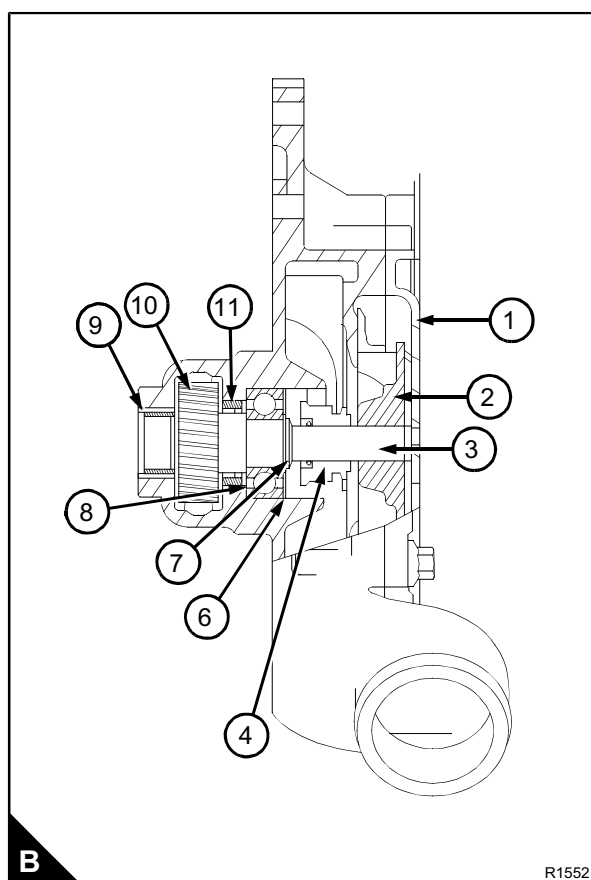
A tool (C) can be manufactured to press the new seal into position. The tool should be made of a suitable material to the dimensions shown below:

A	54,0 mm (2.125 in)	E	44,0 mm (1.732 in)
B	6,0 mm (0.236 in)	F	18,00 mm (0.708 in)
C	10,0 mm (0.393 in)	G	54,00 mm (2.125 in)
D	48,0 mm (1.889 in)		

7 Turn the pump over onto the gear end and with the widest end of the coolant seal towards the oil seal, push the seal onto the shaft until it is in contact with the coolant seal counterbore. Ensure that the seal is square with the bore and with a suitable adaptor press the seal into the counterbore, until the outer flange is in contact with the pump body. Continue to apply force for approximately ten seconds to ensure that the seal remains in position.

8 Press the impeller onto the shaft so that it is level with the top of the drive shaft.

9 Fit a new cover joint and fit the cover. Fit the setscrews and tighten to 22 Nm (16 lbf ft) 2,2 kgf m.



Fan

To remove and to fit

Operation 12-8

To remove

Remove the locknuts and remove the fan from the studs. The fan extension and the pulley can now be removed from the studs, if fitted.

To fit

Clean thoroughly the rear of the fan where the fan fits onto the fan extension. Ensure that all paint is removed from this area. Fit the pulley onto the studs, and fit the fan extension, if removed. Clean the front face of the fan extension. Fit the fan and the locknuts, refer to the Data and dimensions for "Special torques for setscrews and nuts" on page 31.

Fan drive

To remove and to fit

Operation 12-9

To remove

- 1 Loosen the pivot fasteners of the alternator and the fasteners of the alternator adjustment link. Remove the drive belt(s), see Operation 14-3.
- 2 Release the locknuts and remove the fan, see Operation 12-8. Remove the fan extension, if fitted, and the pulley.
- 3 Check the end-float of the drive shaft. If it is more than 0,25 mm (0.010 in), the fan drive assembly must be renewed.
- 4 Release the setscrews and remove the fan drive.

To fit

- 1 Fit the fan drive and tighten the setscrews to 44 Nm (33 lbf ft) 4,5 kgf m.
- 2 Fit the fan, see Operation 12-8.
- 3 Fit the belt(s) and adjust the tension, see Operation 14-3 and Operation 14-2.

Lubricating oil cooler**To remove****Operation 12-10**

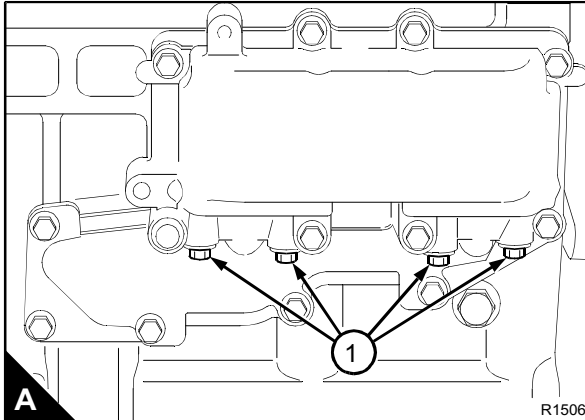
1 Drain the cooling system.

2 Place a suitable container under the oil cooler.

Note: Do not remove setscrews (A1), as these setscrews hold the oil cooler element to the cover.

3 Release the setscrews that retain the oil cooler to the cylinder block.

4 Remove the oil cooler and the joint.

**To fit****Operation 12-11**

1 Renew the joint, ensure that all the joint faces are clean.

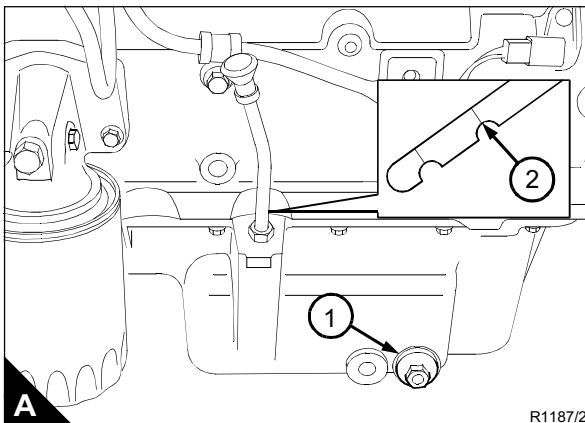
2 Fit the oil cooler.

3 Fit all the setscrews and tighten to the correct torque.

4 Fill the cooling system.

5 Check the oil level on the dipstick (A1). Refill to the correct level with new lubricating oil of an approved grade, refer to the User's Handbook TPD 1477.

6 Operate the engine and check for leakage of coolant or oil.



To dismantle and to assemble

Operation 12-12

To dismantle

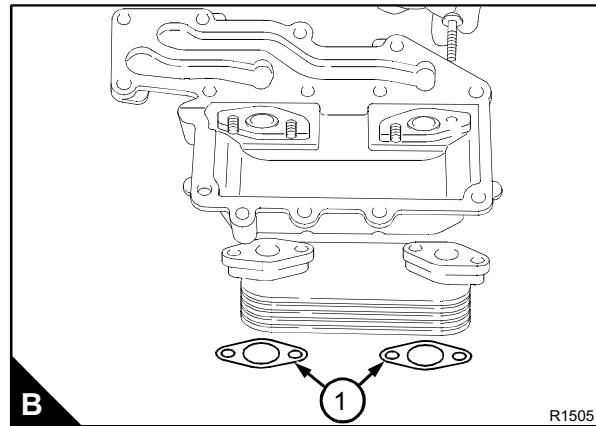
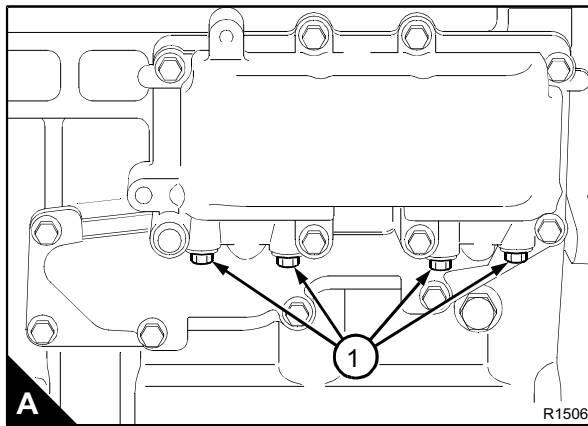
- 1 Remove the oil cooler from the cylinder block, see Operation 12-10.
- 2 Remove the four setscrews (A1) from the oil cooler and remove the cooler element.

Warning! Do not allow compressed air to contact your skin. If compressed air enters your skin, obtain medical help immediately.

- 3 Clean the element and check for cracks. If a solution is used to clean the outside of the element, ensure that this does not enter the element. Check that there are no restrictions to the flow of lubricating oil through the element of the oil cooler. If the inside of the element needs to be cleaned, use a solvent which is suitable for copper. Dry the element with low pressure air and then flush it with clean engine lubricating oil.

To assemble

- 1 Renew the joints (B1) on the flanges of the element.
- 2 Fit the element to the cover and tighten the setscrews (A1) to the correct torque.
- 3 Fit the oil cooler, see Operation 12-11.



To remove and to fit a coolant by-pass pipe

Operation 12-13

Special requirements

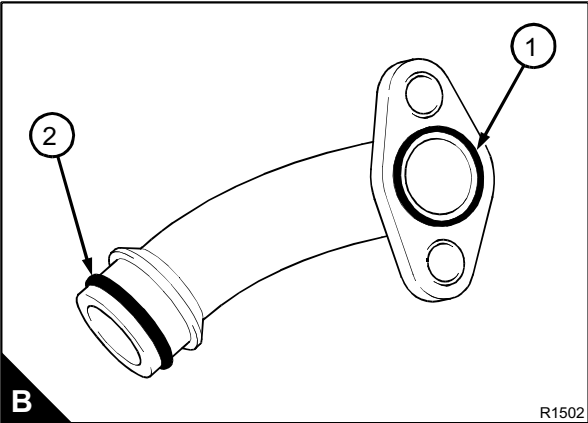
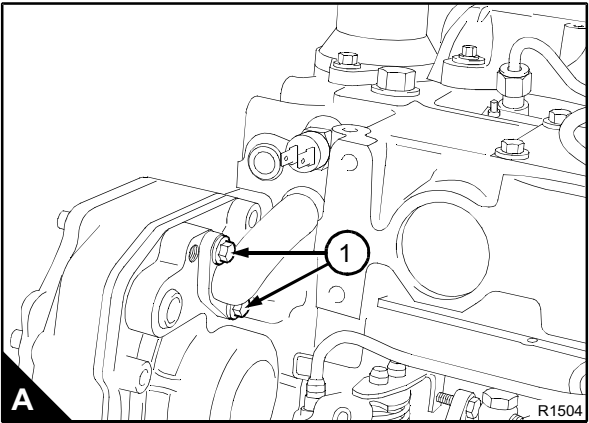
Consumable products	
Description	Part number
POWERPART Red rubber grease	21820221

To remove

- 1 Remove the two setscrews (A1).
- 2 Carefully pull the coolant by-pass pipe from the cylinder head.
- 3 Remove and discard the “O” rings.

To fit

- 1 Fit new “O” rings (B1) and lubricate with POWERPART Red rubber grease.
- 2 Carefully fit by-pass pipe into the cylinder head, ensure that the “O” ring is correctly fitted.
- 3 Fit the two setscrews (A1) and tighten to the correct torque.



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13

Flywheel and housing

General description

The steel flywheel is fitted with a hardened starter ring. The starter rings have either 115 or 126 teeth.

The flywheel housing is normally made of cast iron, but certain flywheel housings are made of aluminium alloy.

Flywheel

To remove and to fit

Operation 13-1

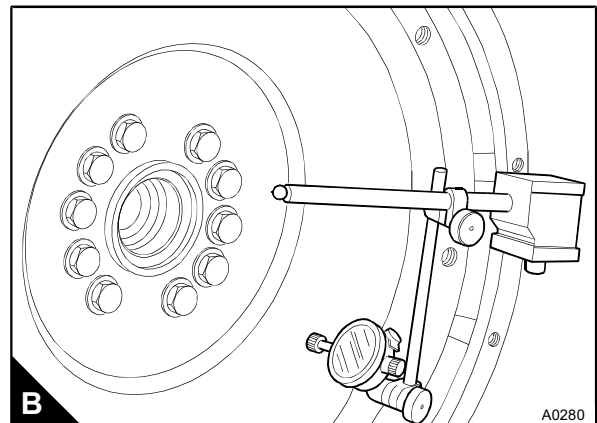
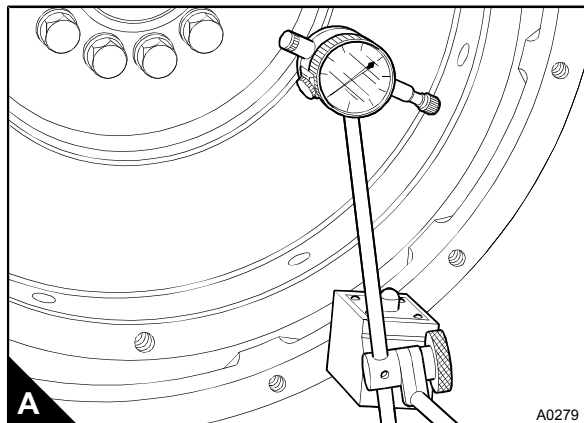
Warning! The flywheel is heavy. Use lift equipment or get help to assist with the lift operation before removal of the flywheel fasteners.

To remove

- 1 Remove two opposite setscrews from the flywheel. Fit temporarily two guide to ensure that the flywheel can be removed and fitted safely.
- 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 a hardened steel washer to each of the ten setscrews. Fit the flywheel over the guide studs and secure in place with eight of the setscrews. Do not fully tighten the setscrews. Tighten the setscrews, see "Specific torque values" on page 31.
- 3 Remove the temporary studs and fit the remaining two setscrews. Tighten the setscrews, see "Specific torque values" on page 31.
- 4 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.
- 5 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 check, keep the crankshaft pressed toward the front of the engine to remove the effect of crankshaft end-float.



Ring gear

To remove and to fit

Operation 13-2

To remove

Warning! *Wear eye protection and suitable protective clothing 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

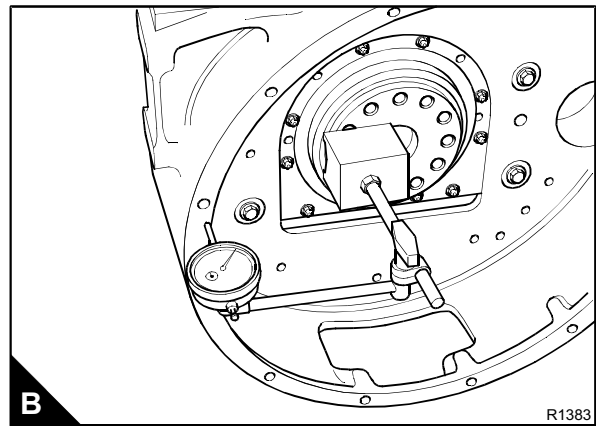
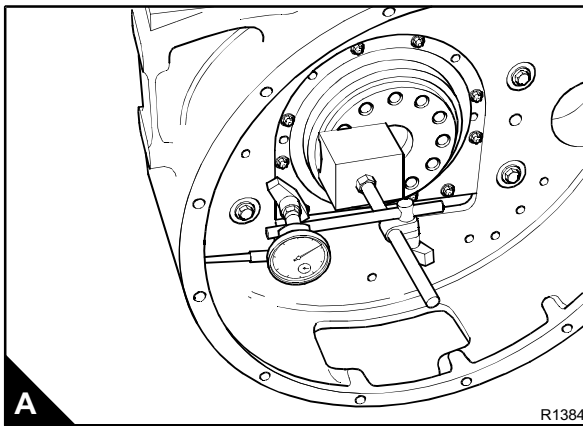
Warning! The flywheel housing is heavy, use lift equipment or get help to assist with the lift operation before removal of the flywheel housing fasteners.

To remove

- 1 Remove the starter, see Operation 14-7, and the flywheel, see Operation 13-1.
- 2 Release the housing setscrews and with a soft face hammer, hit carefully the housing 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. If a felt seal is fitted to the rear flange of the sump, renew the seal.
- 2 Fit the housing onto the dowels and lightly tighten the setscrews.
- 3 Check the housing concentricity with a dial test indicator (A). The run-out limit is given in the relevant Data and dimensions for the "Flywheel and housing" on page 27. If any adjustment is necessary, it must be made on the housing and the concentricity checked again.
- 4 Tighten the setscrews to the torque recommended in "Specific torque values" on page 31.
- 5 Check the housing alignment (B). The maximum tolerance is given in the relevant Data and dimensions for the "Flywheel and housing" on page 27. Any necessary adjustment must be made on the housing and not on the cylinder block.
- 6 Fit the flywheel, see Operation 13-1 and the starter motor, see Operation 14-7.



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14

Electrical equipment

General

Caution: Many of the operations in this chapter should be done only by a person who has had training to 'Level 2', in '1100 Series Electronic Engine Diagnostics', or greater.

Note: It may be necessary to refer to the TIPSS EST User Manual for more details.

Alternators

General description

The Denso A115i 12 volt and the A127i 12 volt and 24 volt alternators are driven from the crankshaft pulley by double belts. The diodes, resistors and the brushes are fitted inside a cover to protect them against dirt and moisture. Fans are included within the alternator casing to cool and protect the alternator.

These alternators have solid state regulators fitted within the rear cover. The regulators are sealed and repair is not possible.

For any repairs to the alternator consult your nearest Perkins Dealer/Distributor.

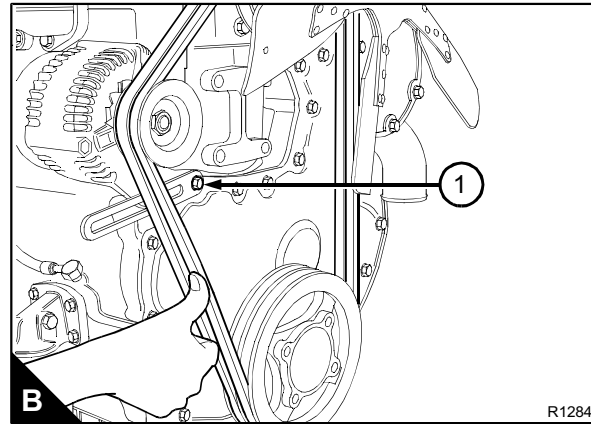
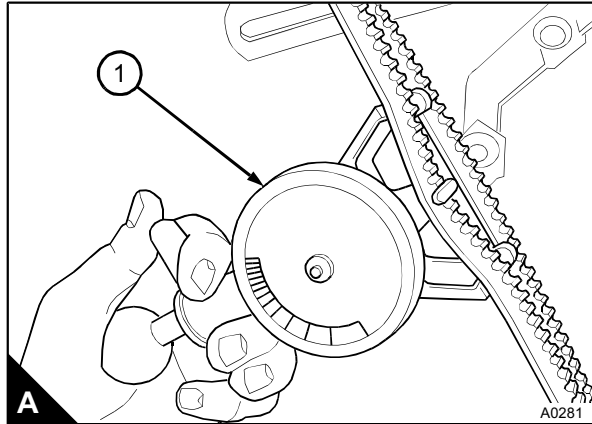
Cautions:

- Do not disconnect the battery while the engine is in operation. This will cause a voltage surge in the alternator charge system which will immediately cause damage to the diodes or to the transistors.
- Do not disconnect an electrical wire before the engine is stopped and all electrical switches are in the "off" position.
- Do not cause a short circuit by the connection of electrical wires to the wrong terminals. The correct electrical wire must be connected to the correct terminal. A short circuit or wrong connection, which gives reverse polarity, will immediately cause permanent damage to the diodes and to the transistors.
- Do not connect a battery into the system until it has been checked for the 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

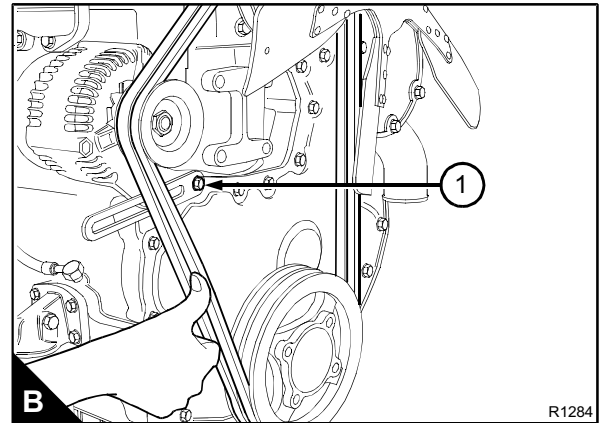
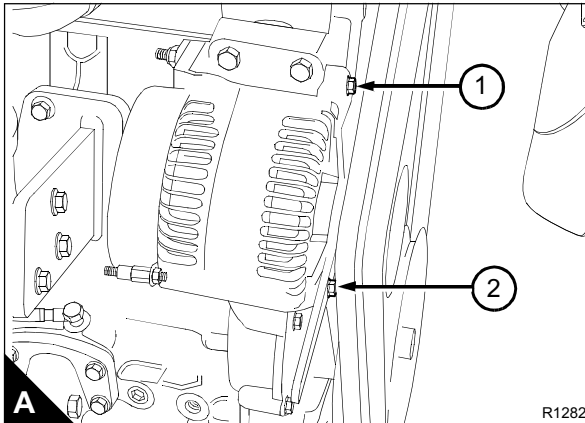
- 1 Check the belts for wear and damage and renew, if necessary, in pairs.
- 2 Check the belt tension. Check/adjust the tension on both belts. To ensure maximum belt life, it is recommended that a belt tension gauge is used. Fit the gauge (A1) at the centre of the longest free length and check the tension. If a Burroughs gauge is used, the correct tension is 535 N (120 lbf) 54 kgf. If the tension is equal to, or less than 250 N (56 lbf) 25 kgf on either belt, adjust both belts to 535 N (120 lbf) 54 kgf, see Operation 14-2.



To adjust drive belt tension

Operation 14-2

- 1 Loosen the pivot fastener (A1) of the alternator and the fasteners of the adjustment link (A2) and (B1).
- 2 Change the position of the alternator to give the correct tension. Tighten the adjustment link fasteners, and then tighten the pivot link fasteners. If there are two pivot fasteners, tighten the front fastener and then the rear fastener.
- 3 Check the belt tension again to ensure that it is still correct, see Operation 14-1.

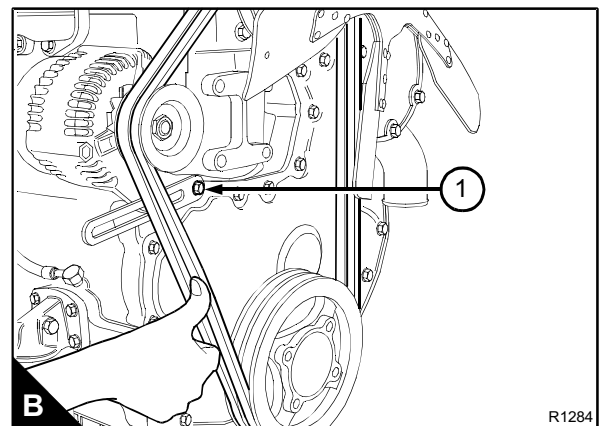
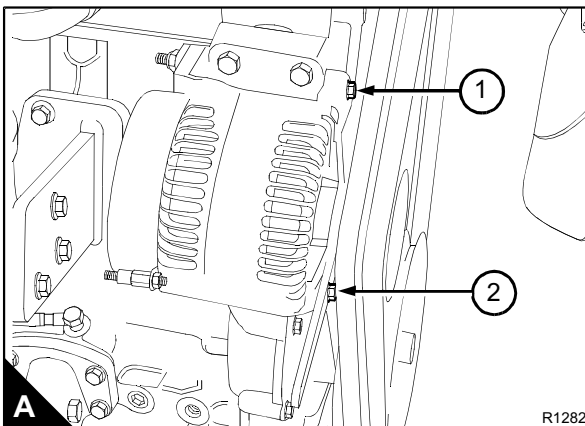


To remove and to fit the drive belts

Operation 14-3

The drive belts are supplied as a set and must be renewed as a set.

- 1 Loosen the pivot fastener (A1) of the alternator and the adjustment link fasteners (A2) and (B1).
- 2 Release all of the tension from the belts and remove the belts.
- 3 Fit the new belts and adjust the tension, see Operation 14-2. The belt tension must be checked again after the first 1000 km (600 miles) or 20 hours of operation.



To remove and to fit the alternator

Operation 14-4

To remove

Warning! Ensure that the battery earth connection has been removed before any alternator connection is removed.

- 1 Disconnect the electrical connection.
- 2 Release all the belt tension and remove the belts, see Operation 14-3.
- 3 Remove the adjustment link from the alternator and remove the pivot bolts. Make a note of the position of the 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 the washers and the distance pieces are fitted in their correct positions and that the alternator pulley is aligned to the crankshaft pulley within $\pm 2,4$ mm (0.094 in).
- 2 Fit the drive belts and adjust the drive belt tension, see Operation 14-2.
- 3 Connect the electrical connection.
- 4 If all of the work is complete, connect the battery earth connection.

To maintain

Operation 14-5

- 1 Ensure that the drive belts are not worn and that the belt tension is correct, see Operation 14-1.
- 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.

Fault diagnosis for the alternator

Operation 14-6

The alternator is designed in such a way that a flow of current (indicated by no light at the warning lamp 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 lamp does not show when the alternator is stationary and the switch is in the “ON” position, or it shows a light when the alternator is in operation
- No charge current is shown on the ammeter
- The battery is discharged
- The battery is hotter than normal which is an indication of loss of voltage control.

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

Normal operation:

- 1 Ensure that the engine has stopped and that the ignition switch is in the “OFF” position.
- 2 Check that the battery voltage is correct, either 12V to 12.8 V (12V system), or 24V to 25.6V (24V system). Check the condition of the battery if the voltage is not correct.
- 3 Turn the ignition switch to the “ON” position and check that the ignition warning lamp is illuminated.
- 4 Start the engine and operate it at a fast idle. Check that the ignition warning lamp is now extinguished.
- 5 Switch on an electrical load, such as the vehicle lights, and increase the engine to its maximum speed.
- 6 The battery voltage should now rise to either 13.5V (12V system), or 27V (24V system).
- 7 Switch off the applied electrical load and the battery voltage should rise to either 14V (12V system) or 28V (24V system).

Continued

If the warning lamp is not illuminated when the ignition switch is in the "ON" position:

1 Check that the battery voltage is correct, (see the description for Normal operation), with the ignition switch in the "OFF" position.

Note: Refer to the basic charging circuit illustration (A).

2 Check that the voltage at alternator terminal "B+" (A8) to earth is the same as the battery voltage. If it is not, the cables and wires may be damaged or disconnected. Check the connections at the alternator (A7) and at the battery (A2). Check for cable continuity. Check for earth continuity between the alternator casing and the alternator brackets.

3 Check the ignition warning lamp bulb (A4) and renew if necessary.

4 With the ignition switch (A3) in the "On" position, check the voltage between the alternator "D+" terminal (A5) and earth. If this voltage is greater than 2V then the alternator is faulty. Renew the alternator, see Operation 14-4.

If the warning light continues to be illuminated when the alternator is in operation:

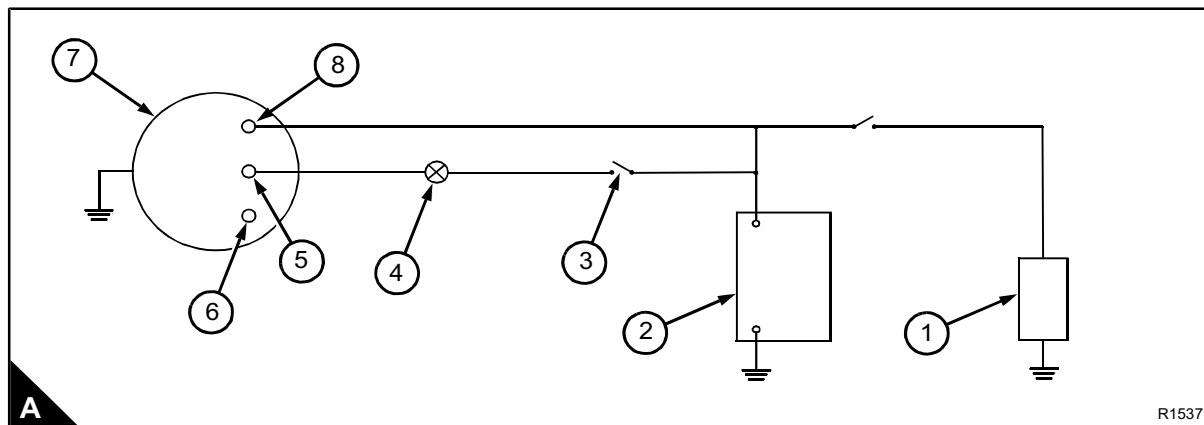
1 Set the ignition switch to the "On" position.

2 Start and run the engine at a fast idle speed. Measure the voltages between the alternator terminal "B+" (A8) and earth, and between alternator terminal "D+" (A5) and earth. The voltages should be between 13V and 15V (12V system) and between 26V and 30V (24V system). If the voltages are not within this range then the alternator is faulty. Renew the alternator, see Operation 14-4.

3 Increase the engine to its maximum, switch on an electrical load (A1) such as the vehicle lights, and measure the voltages between the alternator terminal "B+" (A8) and earth, and the alternator terminal "D+" (A5) and earth. The voltages should be between 13V and 15V (12V system) and 26V to 30V (24V system). If these values are correct then the fault is within the charging system circuit. Check that the cables and connections are all correct. If the voltages are still incorrect then the alternator is faulty. Renew the alternator, see Operation 14-4.

Key to the basic charging circuit illustration (A).

- 1 Applied electrical load.
- 2 Battery.
- 3 Ignition switch.
- 4 Ignition warning light.
- 5 Alternator terminal "D+".
- 6 Alternator terminal "W".
- 7 Alternator.
- 8 Alternator terminal "B+".



Starter motors**General description**

The Dense P95RL (12 volt) and the R4.5 (24 volt) starter motors are operated by a solenoid and have roller clutch drives. 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 14-7

Warning! Always disconnect the battery terminals before the removal of any component of the electrical system.

Caution: Care must be taken to avoid damage to the engine speed and timing sensor fitted to the cylinder block (A) when a starter motor is removed from, or fitted to, the left side of the engine.

Note: The starter motor may be fastened to the flywheel housing by either setscrews or studs and nuts.

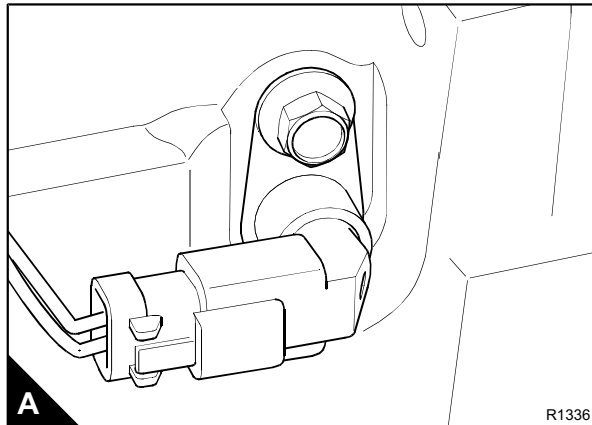
To remove

- 1 Disconnect the starter motor cables.
- 2 Remove the fasteners and remove the starter motor.

To fit

Note: The starter motors may have an 'O' ring fitted to the starter motor flange. Check the condition of the 'O' ring and renew, if necessary.

- 1 Check that the starter motor is free from faults, oil and grease.
- 2 Clean the flange face of the starter motor and the face of the flywheel housing.
- 3 Fit the starter motor and tighten the M10 setscrews or nuts to a torque of 44 Nm (33 lbf ft) 4,5 kgf m.
- 4 Connect the starter motor cables.
- 5 Connect the battery.



To maintain the brush gear and the commutator**Operation 14-8**

Repairs to the starter motor are not recommended. Your Perkins Dealer/Distributor has specialist equipment and personnel with the correct training to repair your starter motor.

To test on the engine**Operation 14-9**

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.

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

Starting aid

General description

The starting aid for the 1100 Series four cylinder engines consists of a set of glow plugs, one on each cylinder. The glow plugs are fitted in the cylinder head near the atomisers. The tip of the glow plugs reaches into the combustion chamber in the piston crown.

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

To remove and to fit a glow plug

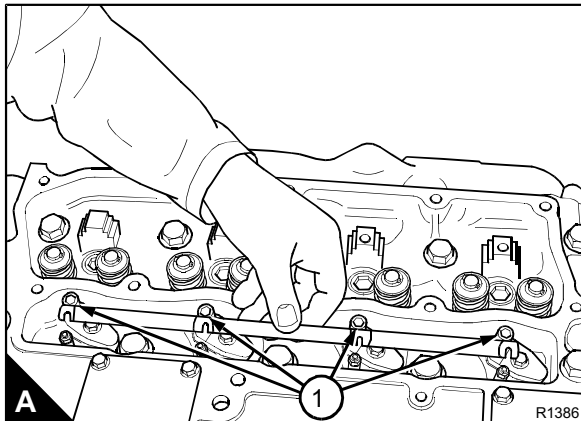
Operation 14-10

To remove

- 1 Disconnect the glow plugs power supply cable.
- 2 Remove the four nuts (A1) that fasten the bus-bar, remove the bus-bar.
- 3 With a suitable socket, loosen, then remove the glow plugs.

To fit

- 1 Ensure that the threads of the glow plugs and the cylinder head holes are clean.
- 2 Fit the glow plugs into the correct holes in the cylinder head, then gradually tighten to 18 Nm (13 lbf ft) 1,8 kgf m.
- 3 Fit the bus-bar and the four nuts, tighten the nuts to 2 Nm (1.5 lbf ft) 0,2 kgf m.
- 4 Connect the glow plugs power supply cable.



To check the glow plugs' power supply continuity

Operation 14-11

- 1 Disconnect the glow plugs' power supply cable and the bus-bar.
- 2 Apply one probe of a multi-meter, that can check continuity, to the terminal of the glow plug and apply the other probe to a suitable earth. If the continuity is correct the multi-meter will give an audible signal. If there is no audible signal, renew the glow plug. Repeat this check for all of the glow plugs.

Note: If a multi-meter is not available the following procedure can be used.

- 1 Connect a 12V test lamp between the positive terminal of the battery and earth to check that the lamp will light.
- 2 Connect the test lamp between the terminal of the glow plug, that is furthest away from the power supply, and earth.
- 3 Operate the control switch, the test lamp should be illuminated if the power supply is correct.
- 4 Disconnect the cables at each glow plug.
- 5 Connect the test lamp to the positive terminal of the battery and to the terminal of a glow plug. The lamp will be illuminated if the continuity is correct. If the test lamp is not illuminated, renew the glow plug.
- 6 When all of the glow plugs have been checked, connect the bus-bar to the glow plugs and reconnect the power supply cable.

To check the operation of the glow plug

Operation 14-12

- 1 Disconnect the glow plugs' power supply cable and the bus-bar.
- 2 Connect a 50-0-50 ammeter between the power supply cable and the terminal of a glow plug.
- 3 Connect a voltmeter between the glow plug terminal and the earth.
- 4 Engage the control switch and check the readings of the ammeter and the voltmeter:

- 12 volt Beru glow plugs.

With a 12 volt supply, there is an immediate initial current of 30 amperes, that becomes approximately 21 amperes for each glow plug. This will reduce to approximately 14 amperes after 8 seconds, 10 amperes after 20 seconds and reach 9 amperes after 60 seconds.

- 24 volt Beru glow plugs.

With a 24 volt supply, the initial current is approximately 12 amperes for each glow plug, that becomes approximately 8.5 amperes after 8 seconds, 7 amperes after 20 seconds and reach 6 amperes after 60 seconds.

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

When all of the glow plugs have been checked, remove the ammeter and the voltmeter and connect the power supply cable. Check that the glow plugs are correctly fitted.

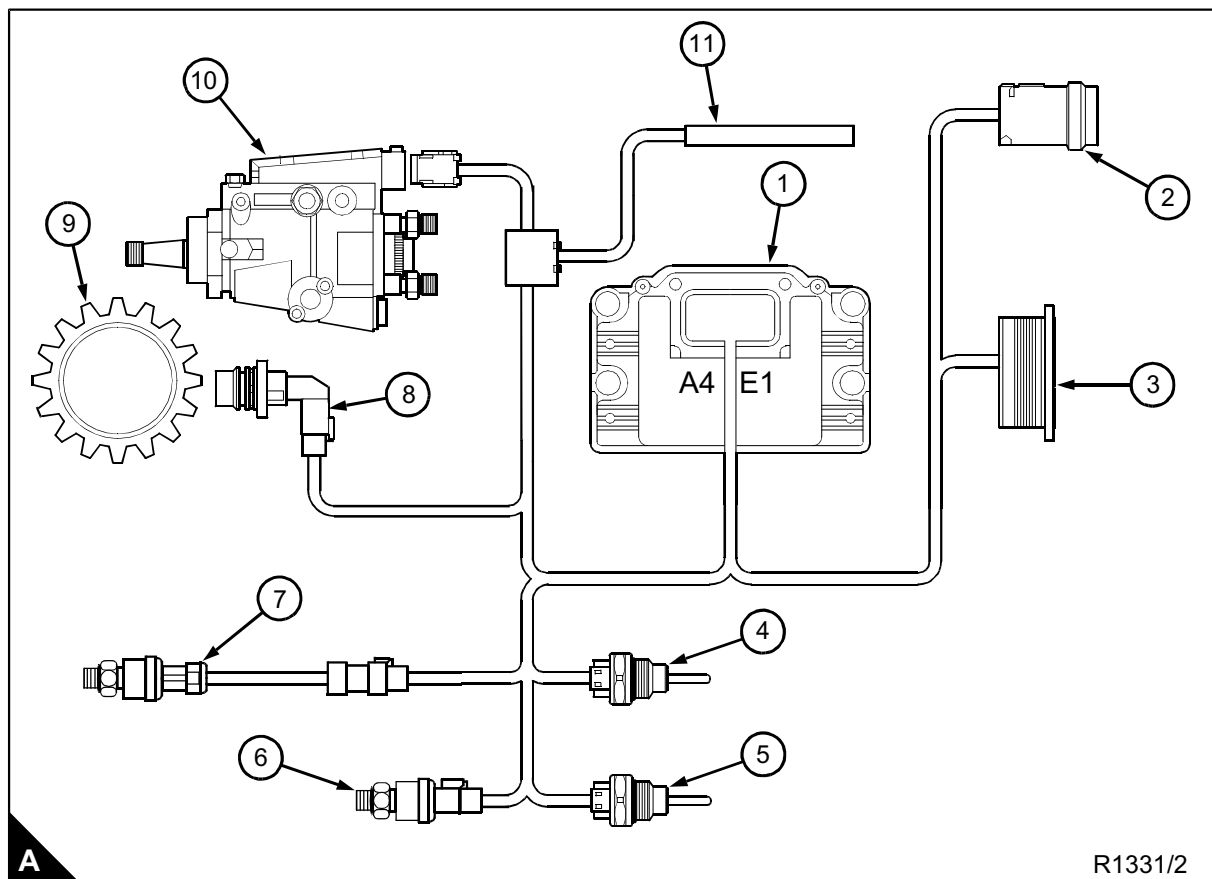
Electronic components**General**

Some 1100 Series 4 cylinder engines have an electronic management system. The system is controlled by an Engine Control Module (ECM). The ECM receives signals from the sensors, and the electronic fuel injection pump, and has an output to the electronic fuel pump. The ECM controls the engine operation to meet the operator requirements.

The electronic management system consists of the following components (A):

- 1 Engine Control Module (ECM)
- 2 Diagnostic Connector
- 3 Machine Interface Connector (MIC)
- 4 Intake Manifold Air Temperature Sensor
- 5 Engine Coolant Temperature Sensor
- 6 Engine Oil Pressure Sensor
- 7 Intake Manifold Pressure Sensor
- 8 Speed and Timing Sensor
- 9 Crankshaft Timing Ring
- 10 VP30 Electronic Fuel Injection Pump.
- 11 Voltage Load Protection Module (VLPM).

For engine diagnostics and fault finding; refer to the 1100 Series Diagnostic Manual or the on-line Diagnostic Guide.



Programming configuration parameters

Many programmable configuration parameters affect engine operation. These parameters may be changed by using the TIPSS-EST service tool. The parameters are kept in the memory of the ECM.

All parameters can be read and passwords can be used to protect them from unauthorised changes.

The parameters are divided into two groups:

System configuration parameters affect 'critical settings' for the engine and can only be changed with factory passwords, by TIPSS-EST. They do not normally need to be changed during the life of the engine. A complete list of these parameters is available from the Helpdesk.

Some examples of system configuration parameters are:

- Full Load Setting (FLS) - This is a number which represents fuel system adjustments made at the factory.
- Software part number - This is the part number of the software that was programmed into the ECM.
- Engine serial number - This should match the engine serial number that is stamped on the engine information plate. A new ECM will be supplied without the engine serial number programmed into it.

Customer configurable parameters allow the OEM to change engine parameters to match the application. They may be changed many times, if a customer changes his requirement. These can be changed with TIPSS-EST. This may require a customer password, if one has been programmed into the ECM.

An example of these parameters is:

- Idle speed - This is the number that sets the engine idle speed.

Passwords

Passwords are divided into two groups.

Factory passwords are required to perform each of the functions listed below:

- To program a new ECM - When an ECM is renewed, the system configuration parameters must be programmed into the new ECM. A new ECM will allow system configuration parameters to be programmed only once, without factory password. After this time, they are protected by factory passwords.
- To change the engine rating - This requires a change to the ECM software code, which is protected by factory passwords.
- To read a customer password - If the owner has lost the customer password, it will not be possible to program customer parameters. In this case, the factory passwords can be used to find the customer password.
- To remove certain diagnostic codes from the memory of the ECM - The factory passwords are needed to remove 'Critical event' codes from the memory of the ECM, once they are logged.

Caution: *Operating the engine with the ECM software not designed for that engine will result in engine damage. Be sure that the ECM software is correct for your engine.*

Notes:

- Some other codes require customer passwords, but most of the logged codes do not need passwords to remove them from the memory of the ECM.
- To obtain factory passwords, either refer to the Helpdesk or proceed as if you already have the password. At some point if the factory passwords are needed, TIPSS-EST will also need them but it will give the information needed to obtain them.

If a customer password has been entered, it will be needed to make changes to ANY customer parameter.

TIPSS-EST can be used to change customer parameters.

To obtain a customer password, contact the supplier of the equipment. If the owner has lost the password, it may be found by using TIPSS-EST:

- In TIPSS-EST, go to the 'Information' menu, access 'Passwords' and record the information shown.
- Go to the 'Factory Password' screen and use the factory passwords.
- Record the customer password from the 'View Customer Passwords' screen. The customer password may then be used to change customer parameters.

To remove and to fit the Engine Control Module (ECM)

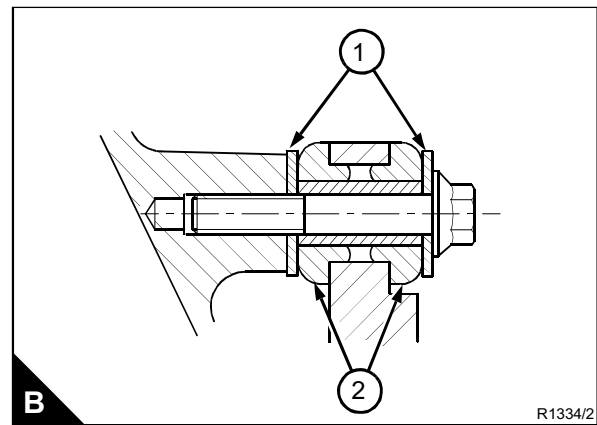
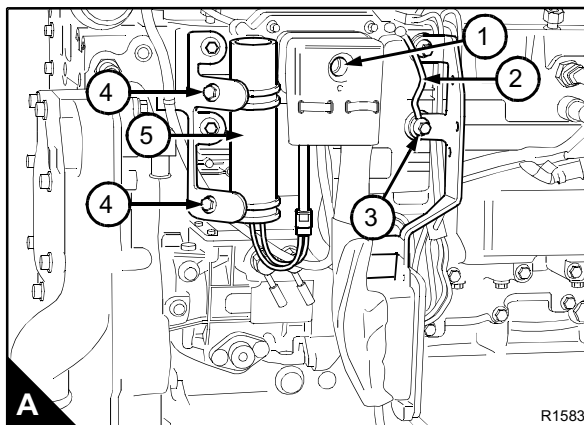
Operation 14-13

Cautions:

- If an ECM is returned for repair, or under warranty, then the ECM connector must be covered with a plastic blanking cap to prevent the entry of water and dirt into the unit. If this blanking cap is not fitted then the warranty may be affected.
- The ECM is protected from vibration by rubber mountings that are fitted in the holes for the fasteners. The fitting of the earth cable must be correct to prevent damage to the electronic components.

To remove

- 1 Ensure that the engine start switch is in the OFF position. Remove the battery terminals.
- 2 Loosen the Allen screw (A1) for the connector and remove the connector with the plastic cover from the ECM, care must be taken to ensure that the connectors in the ECM socket are not damaged.
- 3 Loosen the four setscrews that secure the ECM to the cylinder block. Remove the ECM from the engine. Note the position of the spacers, washers and the earth cable (A2).

**To fit**

Caution: The ECM is programmed for the application. The Electronic Service Tool (EST) will confirm the ECM program. If a new ECM is fitted ensure that it has been programmed correctly. Contact your nearest Perkins Dealer/Distributor for further information.

- 1 Check the connectors and sockets in the ECM and the harness connector for wear or damage. If wear or damage is found, the connectors, sockets or harness must be renewed. Refer to the 1100 Series Diagnostic Manual for the test procedures.
- 2 Check the seal for the ECM connector, if necessary, renew the seal.
- 3 Check the rubber mountings (B2) for wear or cracks, if wear or cracks are found, renew the mountings.

Continued

Caution: The earth cable (C2) must be fitted correctly to prevent damage to the electronic components.

4 Fit the ECM to the engine; ensure that the rubber mountings (D3) and the earth cable (E1) are fitted in the correct positions.

Note: The earth cable has a special washer fitted to the cable, ensure that when the setscrew for the earth cable is tightened that the cable is not rotated and tension is not put on the cable.

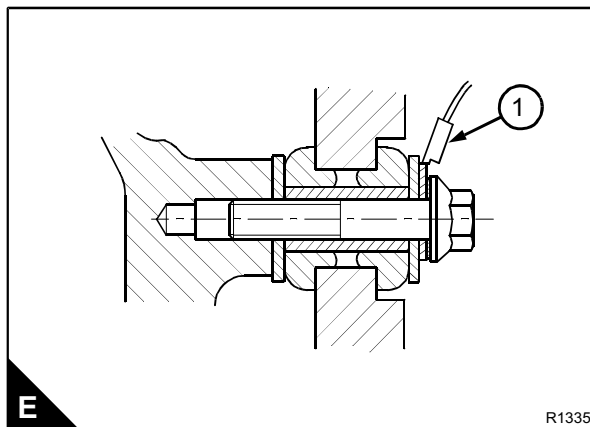
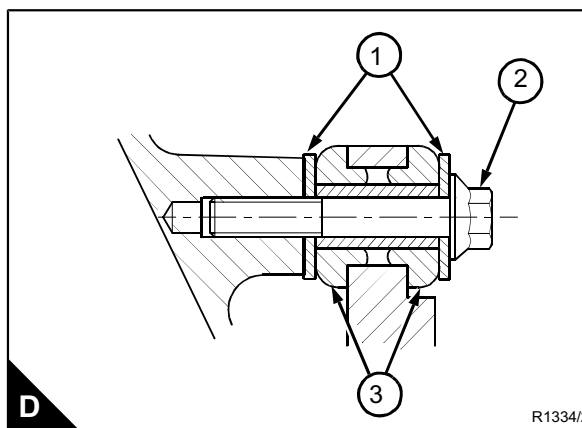
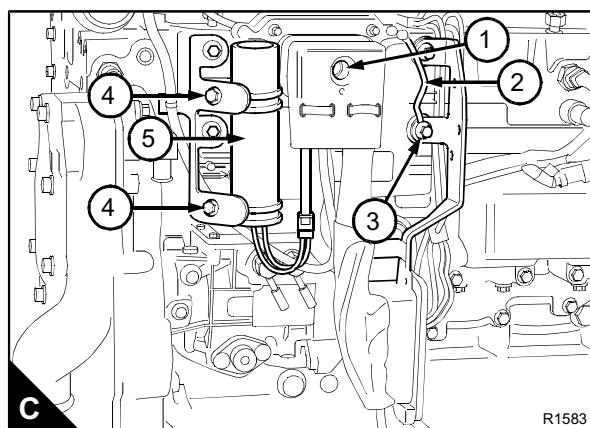
5 Tighten the four setscrews (D2) to 22 Nm (16 lbf ft) 2,2 kgf m.

Cautions:

- Do not use the connector Allen screw (C1) to pull the connector into position. This will damage the connector.
- Ensure that the recommended Allen screw torque for the ECM connector to the ECM is not exceeded as this will damage the connector body.

6 Fit the harness connector to the ECM; to fit the harness connector, engage the connector in the ECM, push the connector fully into the ECM and tighten the securing screw (C1) to 6,0 Nm (4 lbf ft) 0,6 kgf m.

7 Fit the battery terminals.



To remove and to fit the Voltage Load Protection Module (VLPM)

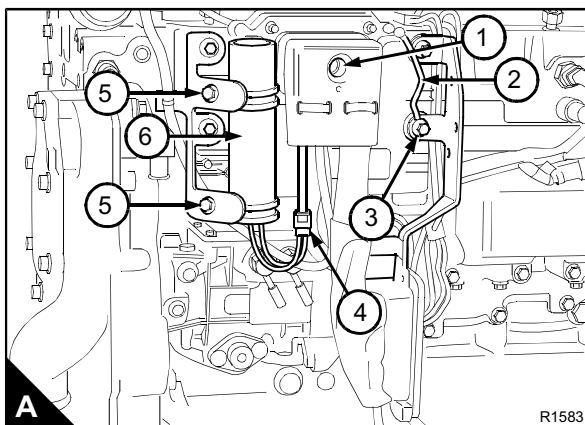
Operation 14-14

To remove

- 1 Disconnect the electrical connector from the VLPM.
- 2 Remove the setscrews (A5) that secure the connector to the ECM.
- 3 Carefully remove the VLPM (A6).

To fit

- 1 Carefully insert the VLPM (A6) into the clips and tighten the setscrew (A5), to 22 Nm (16 lbf ft) 2,2 kgf m.
- 2 Connect the VLPM cable to the connector within the wiring harness, between the ECM and the fuel injection pump cable.
- 3 Lightly pull the harness connector to ensure that it is locked to the VLPM connector (A4).



To program a new ECM

Operation 14-15

The new ECM must be programmed and configured.

- If communication with the old ECM is still possible, use the 'ECM replacement' feature in EST to get the configuration parameters from it, see 'Using the TIPSS-EST ECM replacement feature'.
- If communication with the old ECM is not possible, see 'If the ECM replacement feature cannot be used'.

The ECM is the main component of the system. If a problem occurs, it is easy to assume that the ECM is faulty, this is usually the wrong diagnosis.

Most failures occur at the wiring and connectors, or at a sensor input or output. Follow the diagnostic test procedures and do not renew an ECM, unless it is faulty.

Note: If a new ECM is needed, and if the suspect ECM can communicate with TIPSS-EST, the ECM parameters can be transferred from the suspect ECM to the new ECM unless it is faulty.

To use the TIPSS-EST 'ECM replacement feature'.

Notes:

- The new ECM may or may not be supplied with software installed at the factory.
- TIPSS-EST User Manual will provide an explanation for any errors that may occur during the programming.
 - 1 Go to the 'Service / Copy Configuration' menu, select the 'ECM Replacement' feature and load the parameters from the faulty ECM onto EST.
 - 2 Connect the new ECM to the ECM connectors.
 - 3 Get the part number of the 'flash file' from SPI.
 - 4 Get the 'flash file' from the TIPSS CD, if it is not on the CD go to the Perkins Secured Internet for it.
 - 5 Load the 'flash file' software into the new ECM.
 - 6 Use the TIPSS-EST 'ECM replacement' feature to program the new ECM.
 - 7 Check for active codes.
 - 8 Program any required parameters that have not been programmed.

If the 'ECM replacement' feature cannot be used.

Notes:

- The new ECM may or may not be supplied with the software installed at the factory.
- TIPSS-EST User Manual will provide an explanation for any errors that may occur during the programming.
 - 1 Record the engine serial number.
 - 2 Contact the Helpdesk or go to the Perkins Secured Internet (PTMI) to obtain the configuration parameters.
 - 3 Connect the new ECM to the ECM connectors.
 - 4 Get the part number for the 'flash file' from SPI.
 - 5 Get the 'flash file' from the TIPSS CD, if it is not on the CD go to the Perkins Secured Internet for it.
 - 6 Load the 'flash file' software into the new ECM.
 - 7 Check the memory of the ECM for active codes.
 - 8 Program any parameters that may be needed and have not been programmed already.

To remove and to fit the speed and timing sensor

Operation 14-16

Warning! The 'O' ring (B1) fitted to the speed and timing sensor is made of "Viton", see the safety precautions for "Viton seals" on page 8.

Note: The engine speed and timing sensor is not adjustable. The sensor and securing bracket is a single unit and should not be dismantled. The sensor must be fitted so that the securing bracket (A2) is fully against the machined surface of the cylinder block.

To remove

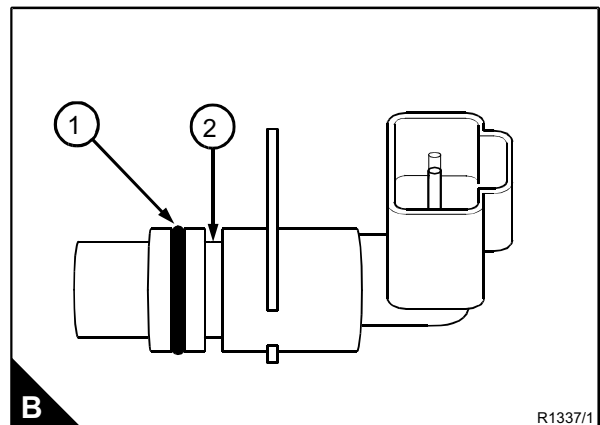
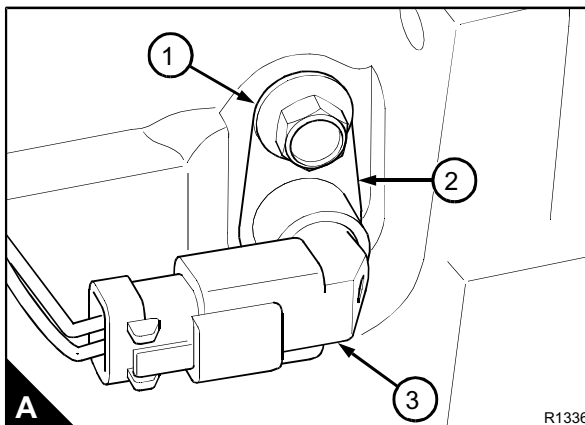
- 1 Disconnect the electrical connector from the sensor.
- 2 Remove the setscrew (A1) that secures the sensor to the cylinder block.
- 3 Carefully remove the sensor (A3) from the cylinder block. Do not use a lever, this can cause damage to the sensor.
- 4 Discard the 'O' ring (B1).

To fit

- 1 Ensure that the sensor body and the bore in the cylinder block are clean and free from oil and dirt.
- 2 Fit a new 'O' ring to the sensor in the first groove (B1). Apply a small amount of clean engine oil to the 'O' ring.

Note: The second groove (B2) in the sensor is not used.

- 3 Push the sensor fully into the bore of the cylinder block (A). Do not use the setscrew to pull the sensor into position. Align the hole in the sensor bracket to the hole in the cylinder block and loosely fit the setscrew (A1).
- 4 Tighten the setscrew to 22 Nm (16 lbf ft) 2,2 kgf m.
- 5 Check that the sensor bracket is fitted fully against the machined surface of the cylinder block.
- 6 Check that the connector seal is in place, that it is clean and is not damaged. Renew the seal if it is damaged.
- 7 Carefully fit the electrical connector to the sensor to ensure that the connector pins are not bent during this operation.
- 8 Lightly pull the harness connector to ensure that it is locked to the sensor connector.



To remove and to fit a pressure sensor

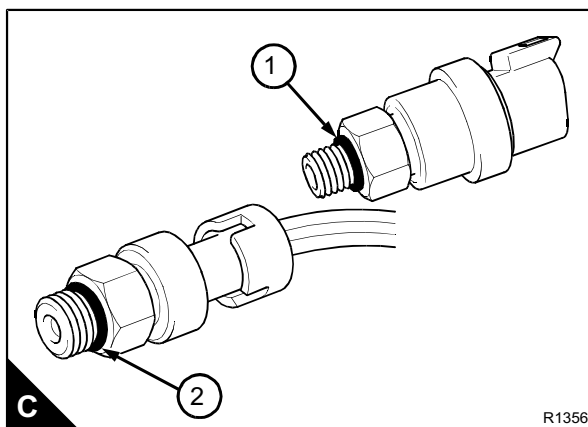
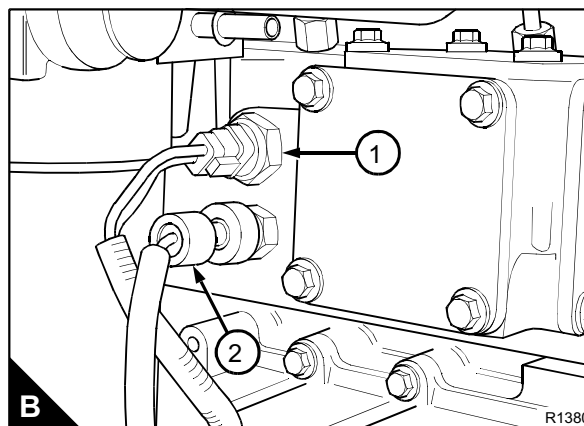
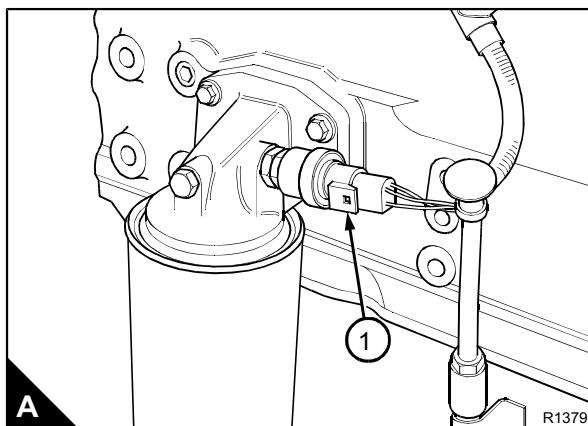
Operation 14-17

Warning! The 'O' ring (C2) fitted to the oil pressure sensor is made of "Viton", see the safety precautions for "Viton seals" on page 8.

There are two pressure sensors fitted to the engine. One sensor is fitted to the oil filter head (A1) for the oil pressure and one sensor is fitted to the intake manifold. The pressure sensor fitted to the intake manifold (B2) has a cable with a connector permanently connected to the sensor.

To remove

- 1 For the oil pressure sensor; disconnect the electrical connector from the sensor.
For the intake manifold pressure sensor; disconnect the electrical cable from the wiring harness.
- 2 With a suitable spanner, loosen, then remove the sensor from the oil filter head (A1) or the intake manifold.
- 3 Discard the 'O' ring (C1 or C2).

*Continued*

To fit

1 Ensure that the threads of the sensor, and the threads in the oil filter head (D1) or the intake manifold, are clean and free from damage.

2 Fit a new 'O' ring (F1 or F2) to the sensor.

Note: The 'O' ring for the intake manifold pressure sensor is yellow. The 'O' ring for the oil pressure sensor is brown. (Temperature sensor 'O' rings are black).

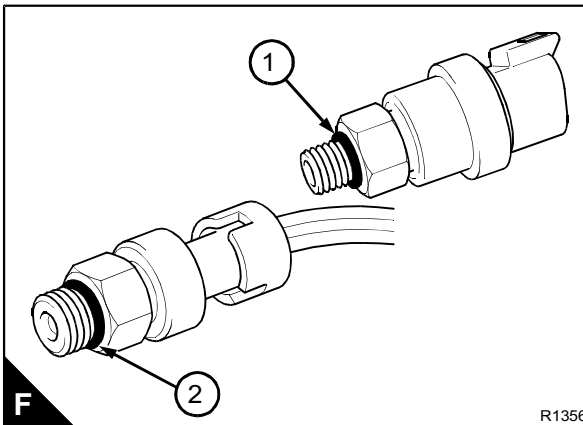
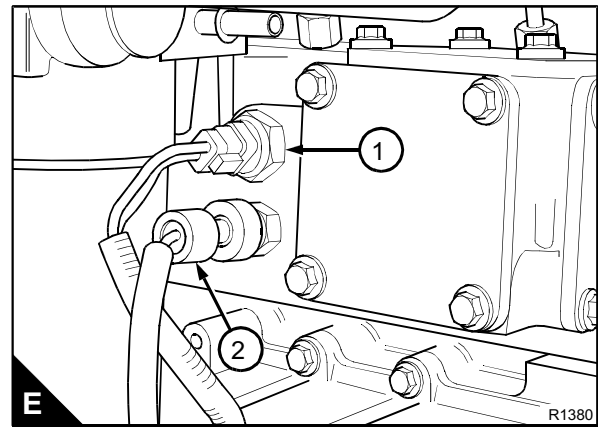
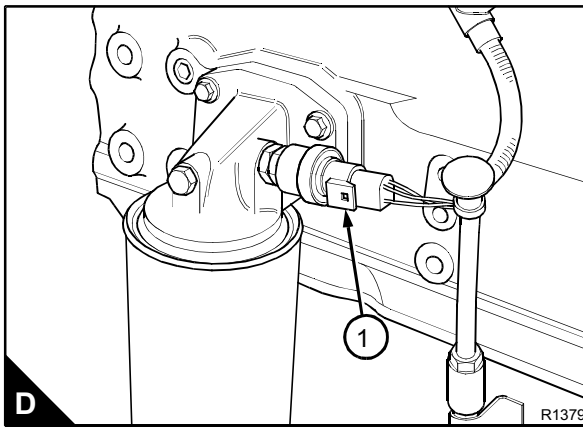
Caution: Do not use air operated tools to fit pressure sensors as these may damage the sensor.

3 Fit the sensor to the oil filter head (D1) or the intake manifold (E2), tighten the oil pressure sensor to 10 Nm (7 lbf ft) 1,0 kgf m and the intake manifold pressure sensor to 20 Nm (15 lbf ft) 2,1 kgf m.

4 Check that the connector seal is in place, that it is clean and is not damaged. Renew the seal if it is damaged, see Operation 14-19.

5 Carefully fit the electrical connector to the sensor to ensure that the connector pins are not bent during this operation.

6 Lightly pull the harness connector to ensure that it is locked to the sensor connector.



To remove and to fit a temperature sensor.

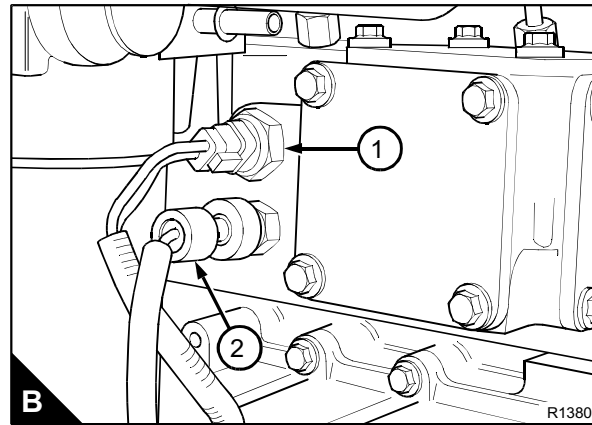
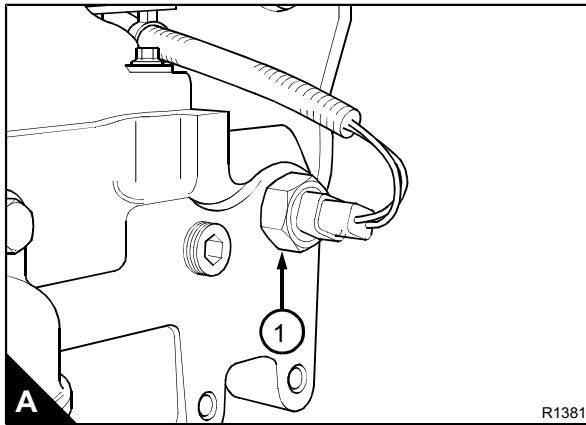
Operation 14-18

There are two temperature sensors fitted to the engine. One sensor is fitted to the cylinder head (A1) for the coolant temperature and one sensor is fitted to the intake manifold (B1) for the air intake temperature.

To remove

Caution: Before the coolant temperature sensor is removed from the cylinder head, ensure that the coolant is drained to a level that is below the sensor or the cylinder head.

- 1 Disconnect the connector from the sensor.
- 2 With a suitable spanner, loosen then remove the sensor from the cylinder head or the intake manifold.
- 3 Discard the 'O' ring.



Continued

To fit

1 Ensure that the threads of the sensor and the threads in the cylinder head or the intake manifold are clean and free from damage.

2 Fit a new 'O' ring (E1) to the sensor.

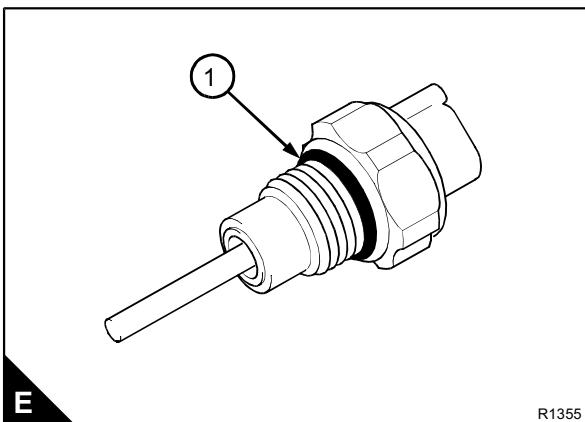
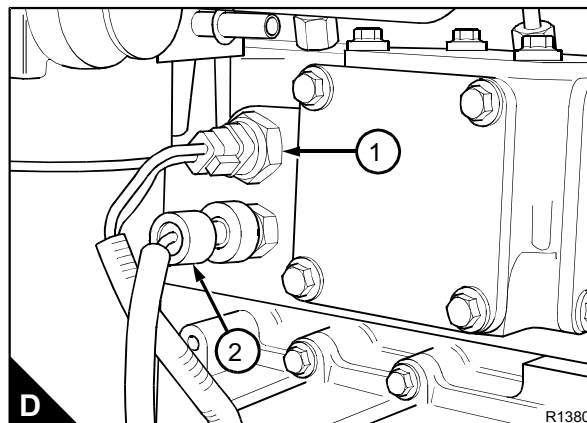
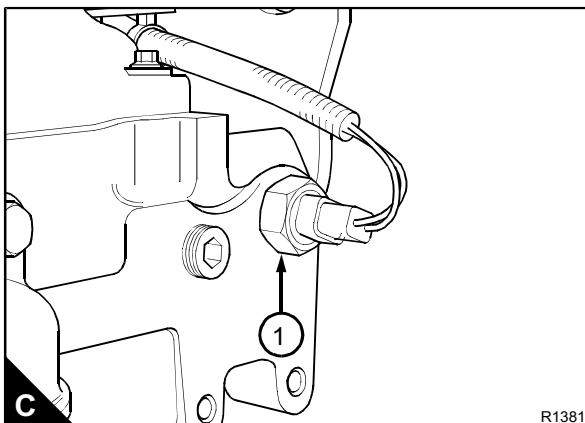
Note: The 'O' rings for the temperature sensors are black.

3 Fit the sensor to the cylinder head (C1) and the induction manifold (D1), tighten the sensor to 20 Nm (15 lbf ft) 2,1 kgf m.

4 Check that the connector seal is in place, that it is clean and is not damaged. Renew the seal if it is damaged, see Operation 14-19.

5 Carefully fit the electrical connector to the sensor to ensure that the connector pins are not bent during this operation.

6 Lightly pull the harness connector to ensure that it is locked to the sensor connector.



Wiring harness

Cautions:

- Repairs to the wiring harness should not be carried out unless directed by the Diagnostic Manual.
- If a wiring harness is returned under warranty, the MIC connector must be covered with a plastic blanking cap to prevent the entry of water and dirt into the unit. If this blanking cap is not fitted then the warranty may be affected.

Note: A repair kit is available for all wiring harness repairs.

There are three main options for wiring harness repair, these are:

- 1 Renew the complete wiring harness.
- 2 Renew the pins or sockets, complete with wires attached.
- 3 Renew the connector, complete with wires attached.

Repairs that are difficult, or may take a long time to repair, should not be carried out. It may be more cost effective to renew the wiring harness.

New connector pins and sockets are supplied with a short wire attached. The end of the wire must be crimped to the wiring harness, see Operation 14-21.

New connectors are supplied complete with pins or sockets and short wires attached. The ends of these wires must be crimped to the wiring harness, see Operation 14-21.

The tables below show a list of repair options that are recommended for each of the connectors and the main wiring harness:

Sensor connector

Description	Repair
Damage to the connector body	Remove the connector pins from the body and fit to a new connector body
Damage to the connector pins or sockets	Remove the damaged connector pin or socket and fit a new connector pin or socket
Damage to the connector body and the connector pins or sockets	Renew the complete connector

Diagnostic connector

Note: If several connector pins are damaged, it is recommended that the complete connector is renewed.

Description	Repair
Damage to the connector body	Remove the connector pins from the body and fit to a new connector body
Damage to a connector pin	Remove the damaged connector pin and fit a new connector pin
Damage to the connector body and the connector pins	Renew the complete connector

Fuel injection pump connector

Repairs to the fuel injection pump connector are not recommended because specialist equipment and personnel with the correct training are necessary. It is more cost effective to renew the wiring harness.

Continued

ECM and MIC connectors

Note: If several connector pins or sockets are damaged, it is more cost effective to renew the connector.

Description	Repair
Damage to the connector body	Renew the connector body
Damage to a connector pin or socket	Remove the damaged connector pin or socket and fit a new connector pin or socket

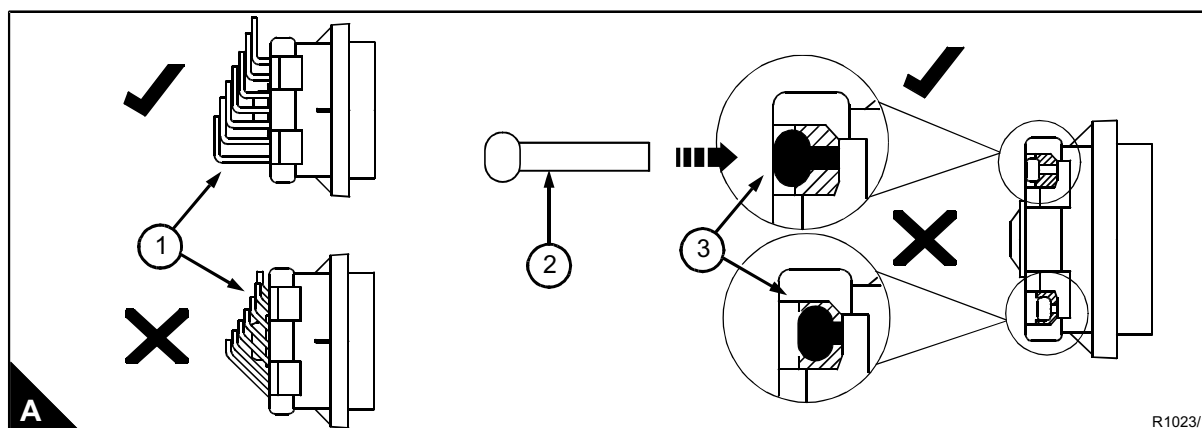
Wiring harness

Note: If several wires are damaged, it is more cost effective to renew the wiring harness.

Description	Repair
Cut wire	Use a crimp to join the wires together
Damage to wire insulation only	Remove the damaged section of wire, replace with a new section of wire and crimp to the original wires
Damage to wire by corrosion	Remove the damaged section of wire, replace with a new section of wire and crimp to the original wires
Damage to the harness outer cover	Repair with tape

Cautions:

- Do not bend the wires directly from the rear of the connector (A1) as distortion of the rear seal will result, and this will allow water to enter the connector.
- Ensure that all ECM and MIC connector holes, that are not used by a wire to a socket or a pin, are closed by a blanking plug (A2) to ensure a waterproof seal. The blanking plugs must be inserted into the connector so that the head of the blanking plug is pushed against, but not into, the connector end seal (A3).



To repair a sensor connector

Operation 14-19

To repair a sensor connector, the body can be renewed, individual pins and sockets can be renewed or the connector complete with wires attached can be renewed.

The connectors (A) have locking wedges that are pushed into the connectors to lock the pins or sockets in position.

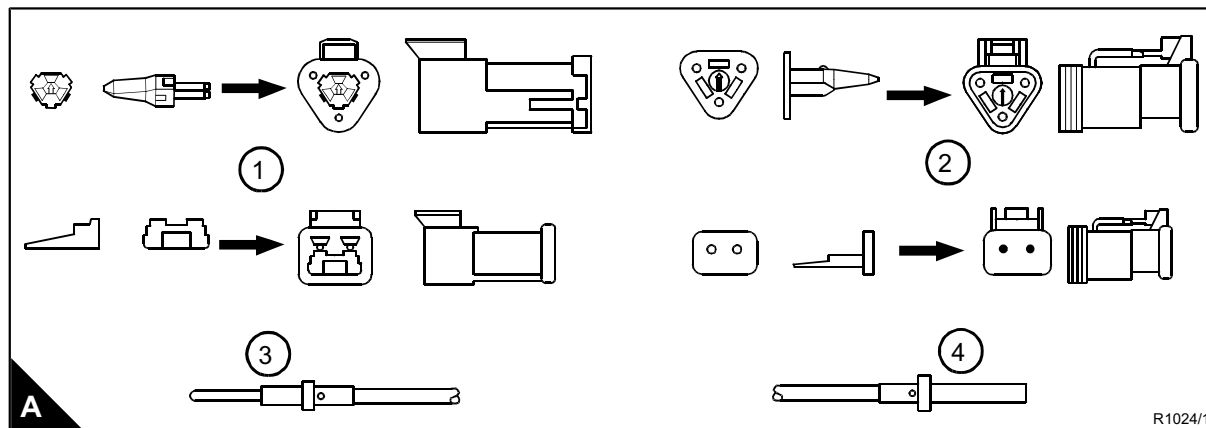
Sensor Connector types

Male connectors (A1).

Female connectors (A2).

Connector pin (A3) with wire connected.

Connector socket (A4) with wire connected.



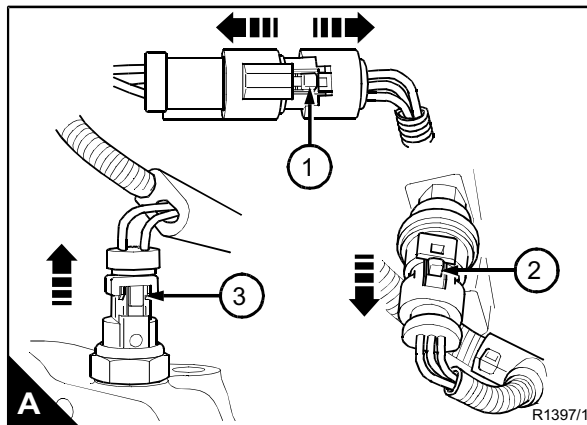
To remove a connector from a sensor or another connector**Cautions:**

- Do not use tools to separate the two parts of a sensor connector (A), because damage to the locking mechanism may result.
- Do not pull on the wires to separate a sensor connector.

1 Before a connector is removed from a sensor, or from another connector, ensure that the connector and the local area are clean, free from dirt, oil and grease.

2 For a male and female sensor / harness connectors; hold the connector in two hands and press the locking mechanism (A1) until it releases. Hold the locking mechanism down and lightly pull the two parts of the connector until they separate.

For a pressure or temperature sensor; hold the locking mechanism (A2) or (A3) down and lightly pull on the connector until it separates from the sensor.

**To remove a pin from a male connector**

1 To remove the locking wedge from a male connector, insert a small thin screwdriver blade between the locking wedge and the connector body. Lightly lift the locking wedge off the connector body. Put the locking wedge in a safe place so that it can be fitted later.

2 Release the connector pin locking mechanism and lightly pull the wire out of the connector.

To remove a socket from a female connector

1 To remove the locking wedge from a female connector, use thin long-nose pliers, hold the pliers firmly in one hand and lightly pull the female connector until the locking wedge is removed. Put the locking wedge in a safe place so that it can be fitted later.

2 Release the connector socket locking mechanism and lightly pull the wire out of the connector.

To insert a pin or socket into a sensor connector

1 Hold the wire of the pin or socket that is to be inserted into the connector approximately 25,4 mm (1.0 inch) behind the contact crimped area.

2 Hold the connector with the rear seal towards you.

3 Push the pin or socket fully into the connector seal.

4 When all contacts are in position, insert the locking wedge and push it into place.

Note: For locking wedges that have an arrow, the arrow must be fitted towards to the connector locking mechanism.

5 To connect a new wire or connector to the wiring harness, see Operation 14-21.

To repair a Diagnostic, a ECM, or a MIC connector

Operation 14-20

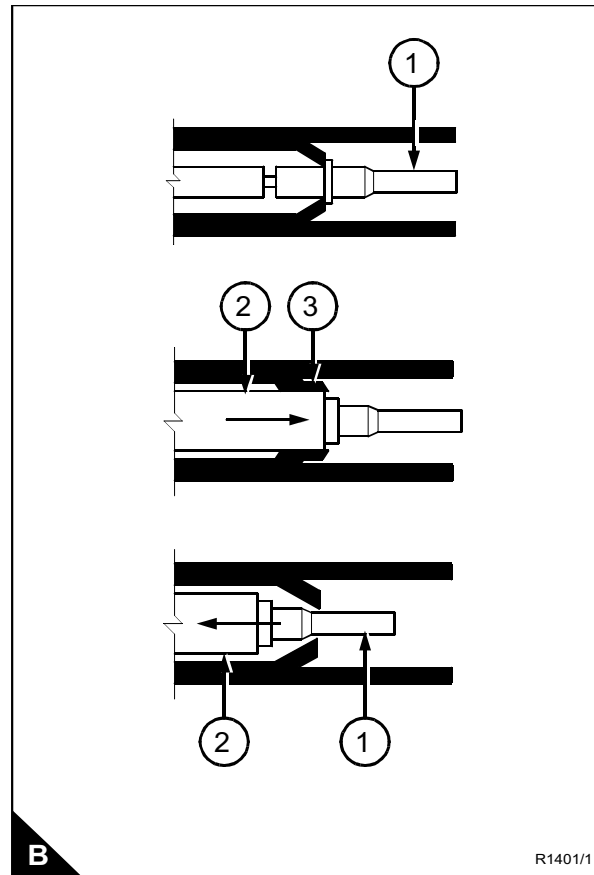
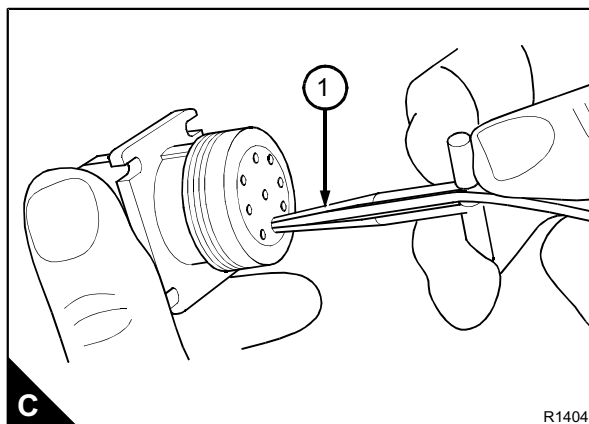
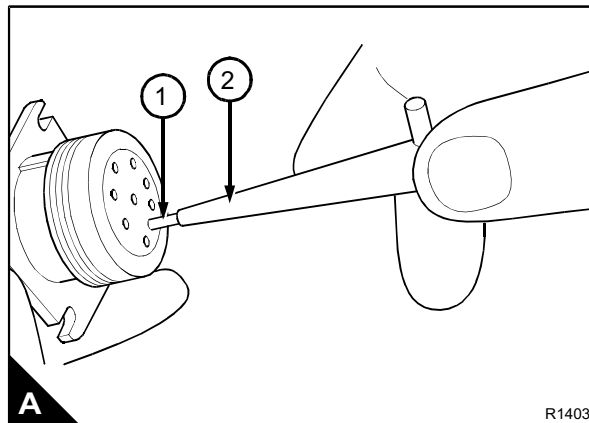
It is recommended that if several pins need to be replaced, or if the connector body is damaged, it may be cost effective to renew the harness.

To remove a pin or a socket from a connector

Notes:

- The procedure is the same for the Diagnostic, ECM and MIC connectors.
 - The tool required to remove the contact pins or sockets from these connectors is supplied in the wiring harness repair kit.
- 1 Before a connector pin or socket is removed from a connector, ensure that the connector and the local area are clean, free from dirt, oil and grease.
 - 2 Carefully fit the removal tool (A2) onto the wire (A1) that is attached to the pin (B1) or the socket to be removed.
 - 3 Carefully push the removal tool (C1) along the wire and into the seal of the connector.
 - 4 Carefully push the removal tool (B2) fully into the connector to release the connector locking mechanism (B3).
 - 5 With the removal tool (B2) fully engaged onto the pin or the socket, carefully withdraw the pin or the socket (B1) with the removal tool.

Caution: After the repair of Diagnostic, ECM and MIC connectors, ensure that the seals are fitted and are correctly in position as damage to the connector body can result if they are not.



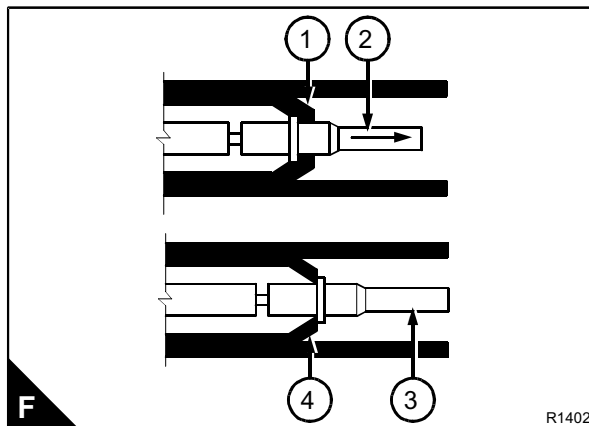
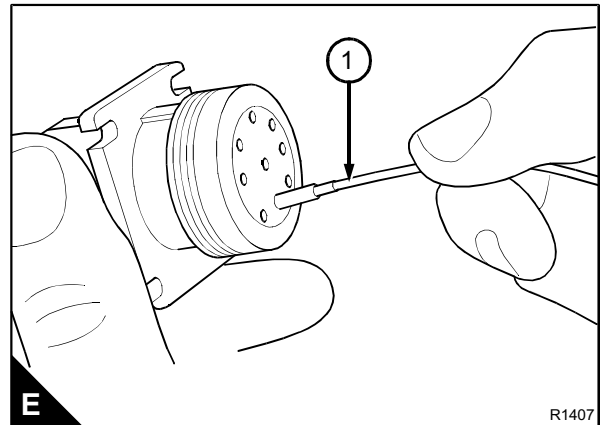
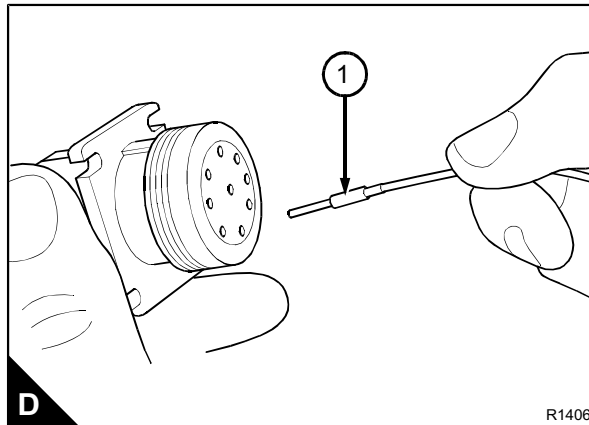
To insert a pin or socket into a connector.**Cautions:**

- Do not bend the wires directly from the rear of the connector as distortion of the rear seal will result, and this will allow water to enter the connector. (See illustration on page 245).
- Ensure that all ECM and MIC connector holes that are not used by a wire to a socket or a pin, are closed by a blanking plug to ensure a waterproof seal. The blanking plugs must be inserted into the connector so that the head of the blanking plug is pushed against, but not into, the connector end seal. (See illustration on page 245).

Notes:

- The procedure is the same for Diagnostic, ECM and MIC connectors.
 - New pins and sockets are supplied with a short length of wire fitted.
 - Any pin or socket holes that are not used in the connector must have blanking plugs fitted.
- 1 Hold the wire (D1) approximately 25,4 mm (1.0 inch) behind the pin or socket.
 - 2 Hold the connector with the rear of the connector towards you.
 - 3 Push the pin or socket (E1) or socket through the connector rear seal.
 - 4 Push the pin or socket (F2) into the connector until the pin or socket is against the locking mechanism (F1).
 - 5 Push the pin or socket (F3) until the locking mechanism (F4) is in position behind the pin or socket.
 - 6 Carefully pull on the wire to test that the pin or socket is locked in position. If the pin or socket pulls out of the connector, repeat the procedure from stage 1.

Caution: After the repair of Diagnostic, ECM and MIC connectors, ensure that the seals are fitted and are correctly in position as damage to the connector body can result if they are not.



To connect a new wire or connector to the wiring harness

Operation 14-21

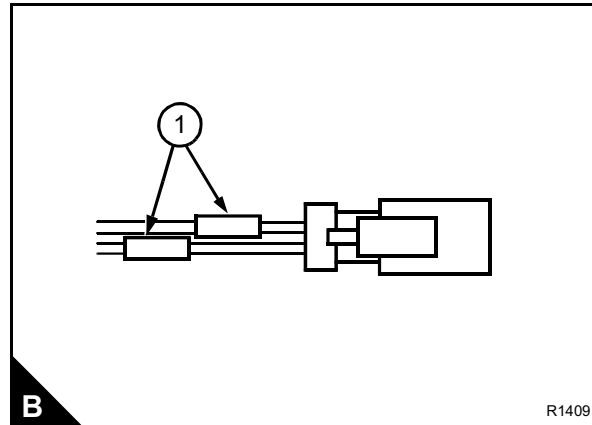
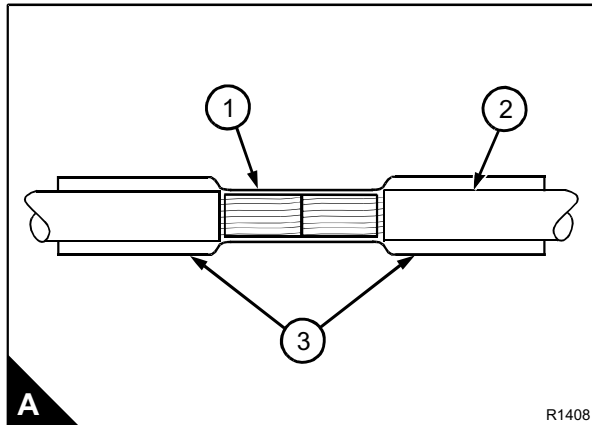
Caution: Do not solder the wires to the wiring harness. The wires must be correctly crimped.

Notes:

- Connector sleeves that are supplied in the wiring harness repair kit have a heat-shrink cover that has sealant applied to the inner surface.
- The new pins, sockets, and complete connectors that are supplied in the wiring harness kit, all have short wires connected to them.

- 1 Cut the original wire to give the correct length when the new wire is connected.
- 2 Remove the insulation from the end of the wires that are to be joined.
- 3 Put the wires (A2) into the connector sleeve (A) and using a crimping tool, crimp the middle area (A1).
- 4 Apply enough heat to the heat-shrink part of the connector (A3) to seal the wires inside the connector sleeve.

Note: If more than one wire is to be crimped to the wiring harness the connector sleeves (B1) must be fitted at different lengths from the connector.



15

Auxiliary equipment

General description

The power take-off (PTO) adaptor provides a means to use the engine power to operate auxiliary equipment.

The idler gear drives the splined shaft of the adaptor.

Power steering pump

To remove and to fit

Operation 15-1

To remove

- 1 Disconnect the pipes at the power steering pump and fit covers to the open ends of the pipes.
- 2 Release the setscrews and remove the pump.

To fit

- 1 Renew the 'O' ring and lubricate it with clean engine lubricating oil.
- 2 Check the drive coupling, or the gear, for wear and damage. Renew if necessary.
- 3 Fit the pump and tighten the setscrews.
- 4 Remove the covers from the open ends of the pipes and fit the pipes.

Adaptor for a hydraulic pump or a steering pump

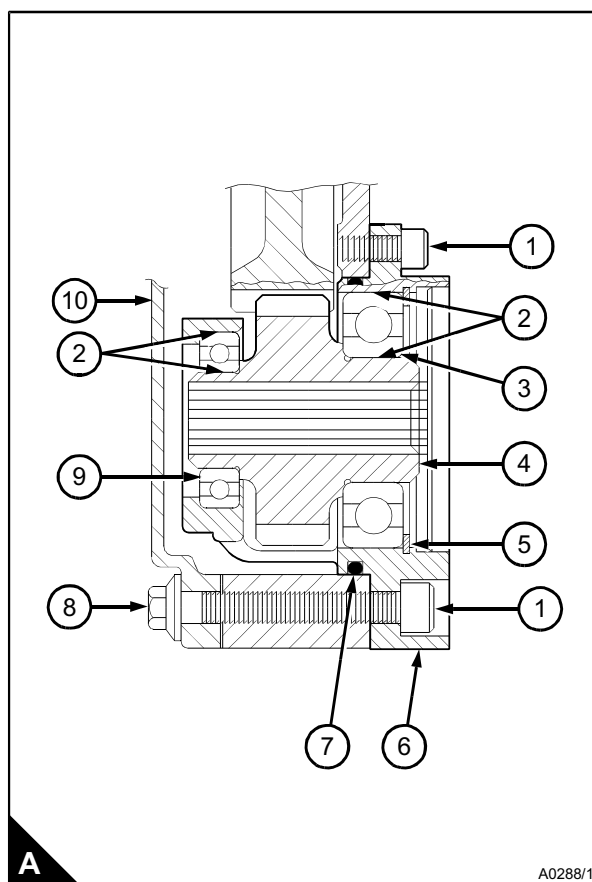
To remove and to fit

Operation 15-2**To remove**

- 1 Remove the Allen screws (A1) and remove the adaptor assembly from the rear of the timing case.
- 2 Remove the setscrews (A8) and the rear cover (A10).
- 3 Check the gear (A4), the spline drive and the bearings (A3 and A9) for wear and damage, renew the components if necessary.

To fit

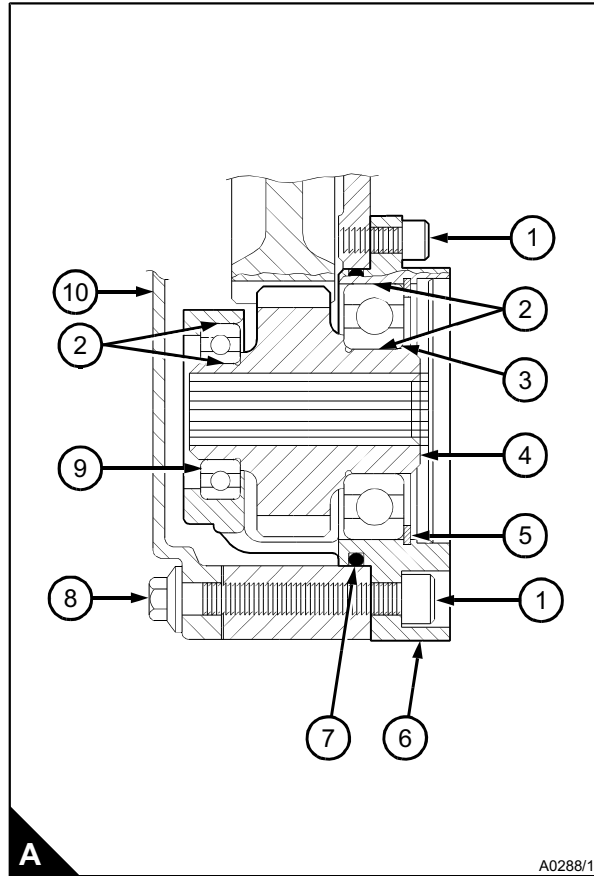
- 1 Fit a new 'O' ring (A7) in its recess in the housing (A6) and lightly lubricate it with clean engine lubricating oil. Lubricate the bearings (A3) and (A9) with clean engine lubricating oil. Fit the rear cover (A10) and fit the adaptor assembly to the timing case and tighten the cap screws.



To dismantle

Operation 15-3

- 1 Remove the circlip (A5). Provide a support for the flange face of the housing (A6). Use a suitable adaptor on the front bearing (A9) to press the gear and bearings out of the housing.
- 2 Remove the bearings (A3 and A9) from the gear (A4) with a suitable puller.



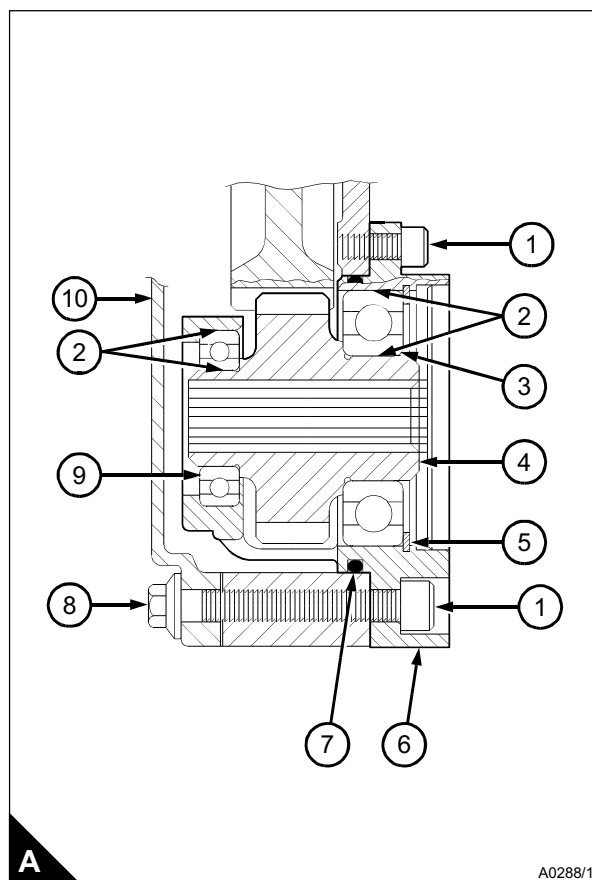
To assemble

Operation 15-4

Special requirements

Consumable products	
Description	Part number
POWERPART Retainer (oil tolerant)	21820603

- 1 Apply a narrow ring of POWERPART Retainer (oil tolerant) to the outer surface of the front bearing (A9) in the position shown (A2). Provide a support for the front face of the housing. Use a suitable adaptor on the outer race of the bearing to press the front bearing onto the shoulder in the housing. Remove any excess retainer.
- 2 Apply a narrow ring of POWERPART Retainer (oil tolerant) to the inner surface of the front bearing (A9) in the position shown (A2). Provide a support for the bearing. With the small diameter of the gear (A4) toward the bearing, press the gear into the bearing until the gear is against its shoulder.
- 3 Apply a narrow ring of POWERPART Retainer (oil tolerant) to the outer surface and to the inner surface of the rear bearing (A3) in the positions shown (A2). Ensure that the support is under the front bearing. Use a suitable adaptor on the outer ball race of the bearing to press the bearing into the housing and onto the shoulder on the gear (A4). Remove any excess retainer. Fit the circlip (A5) into its groove in the housing.
- 4 Check the backlash between the power take-off gear and the idler gear. The backlash is 0,11/0,17 mm (0.004/0.007 in).



Exhauster

To remove and to fit

Operation 15-5

To remove

- 1 Disconnect the lubricating oil and vacuum pipes from the exhauster and fit covers to the open ends of the pipes.
- 2 Release the setscrews and remove the exhauster.

To fit

- 1 Ensure that the joint faces of the exhauster and the timing case are clean and renew the joint. Fit the exhauster to the timing case and tighten the setscrews.
- 2 Remove the covers from the open ends of the pipes and connect the oil pipe and the vacuum pipe to the exhauster.

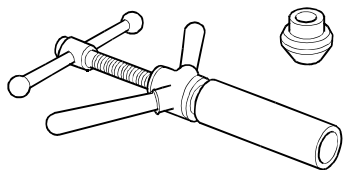
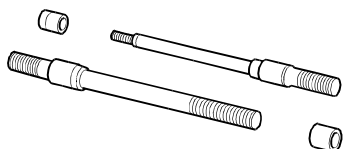
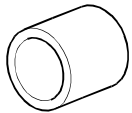
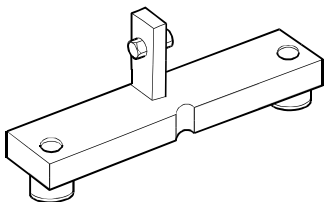
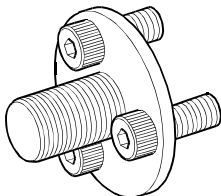
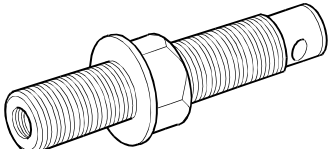
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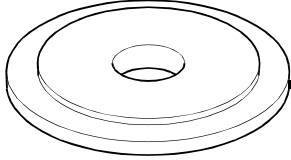
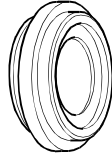
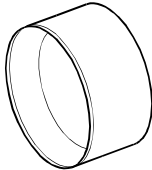
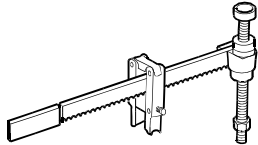
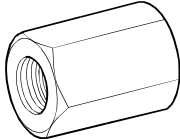
Special tools

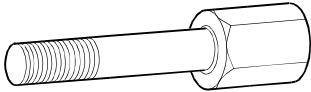
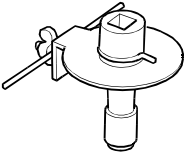
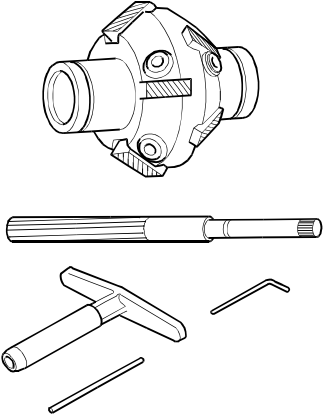
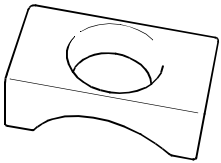
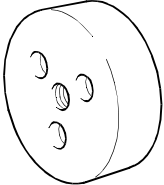
These tools are available through your nearest Perkins Dealer/Distributor. If you cannot obtain the correct tool locally contact:

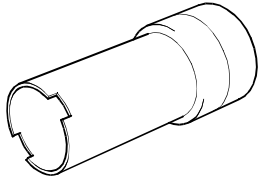
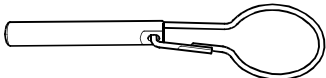
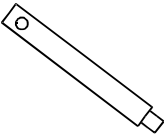
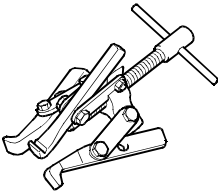
The Perkins Service Department, Peterborough, PE1 5NA, England, UK. Tel 01733 583000, Fax 01733 582240, Telex 32501 PERKEN G.

List of special tools

Part number	Description	Illustration
21825478	Remover / replacer for valve guides (main tool). Reference number PD.1D.	
21828479	Adaptor for use with 21825478. Reference number PD.1D-13.	
27610234	Inlet and outlet valve guide adaptor for use with 21825478.	
27610248	Bosch EPVE fuel pump timing adaptor. Reference number.	
21825496	Gauge for piston height, valve depth and cylinder liner flange; for use with 21825617. Reference number PD.41D.	
21825580	Fastener plate for use with 21825577. Reference number PD.170-3.	
21825577	Replacer tool for seal of timing case cover (main tool). Reference number PD.170.	

Part number	Description	Illustration
21825578	Pressure plate for use with 21825577. Reference number PD.170-1.	
27610217	Adaptor for front seal for use with 21825577. Reference number.	
21825491	Replacer tool for pistons. Reference number PD.206.	
21825617	Dial gauge for use with 21825496. Reference number PD.208.	
21825666	Valve spring compressor. Reference number PD.6118B.	
21825931	Stud adaptor for use with 21825666. Reference number PD.6118-7.	

Part number	Description	Illustration
27610235	Setscrew adaptor for use with 21825666.	
21825607	Angle gauge to tighten cylinder head setscrews. Reference number PD.198. (MS.1531).	
27610030	Combined reamer/cutters and handle for valve guides and 30° valve seat inserts. Reference number.	
27610227	Rocker assembly tools.	
27610225	Timing pin for balancer drive shaft. Reference number.	
27610216	Timing case alignment tool. Reference number.	

Part number	Description	Illustration
27610226	Thermostat fitting and removal tool. Reference number.	
27610212	Camshaft gear timing pin. Reference number.	
27610211	Crankshaft timing pin. Reference number.	
27610032	Bosch VP30 fuel injection pump timing pin. Reference number.	
27610230	Three legged puller. Reference number.	
UKMK0662	Wiring harness repair kit	

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