Perkins New 1000 Series

Models AJ to AS and YG to YK

WORKSHOP MANUAL

4 and 6 cylinder diesel engines for industrial and agricultural applications

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PACE

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General information

Introduction

This Workshop Manual has been written to provide assistance in the service and overhaul of Perkins New 1000 Series engines. For overhaul procedures the assumption is made that the engine is removed from the application. The engine conforms with USA (EPA/CARB) stage 1 and EEC stage 1 emissions legislation for agricultural and industrial applications.

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. Generally, the type of pump fitted is as shown below.

- Lucas/Delphi - DP200 Series
- Bosch - EPVE
- Stanadyne - DB4.

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

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

POWERPART recommended consumable products are listed on page 8. Reference to the relevant consumable products is also made at the beginning of each operation, where relevant.

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.

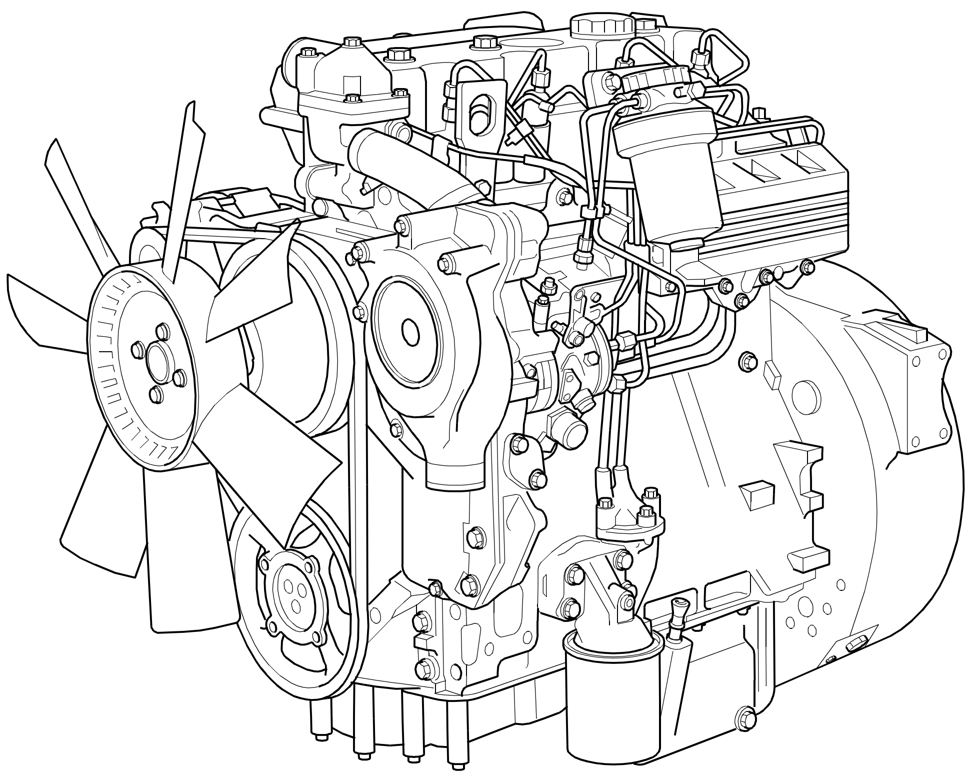
Danger is indicated in the text by two methods:

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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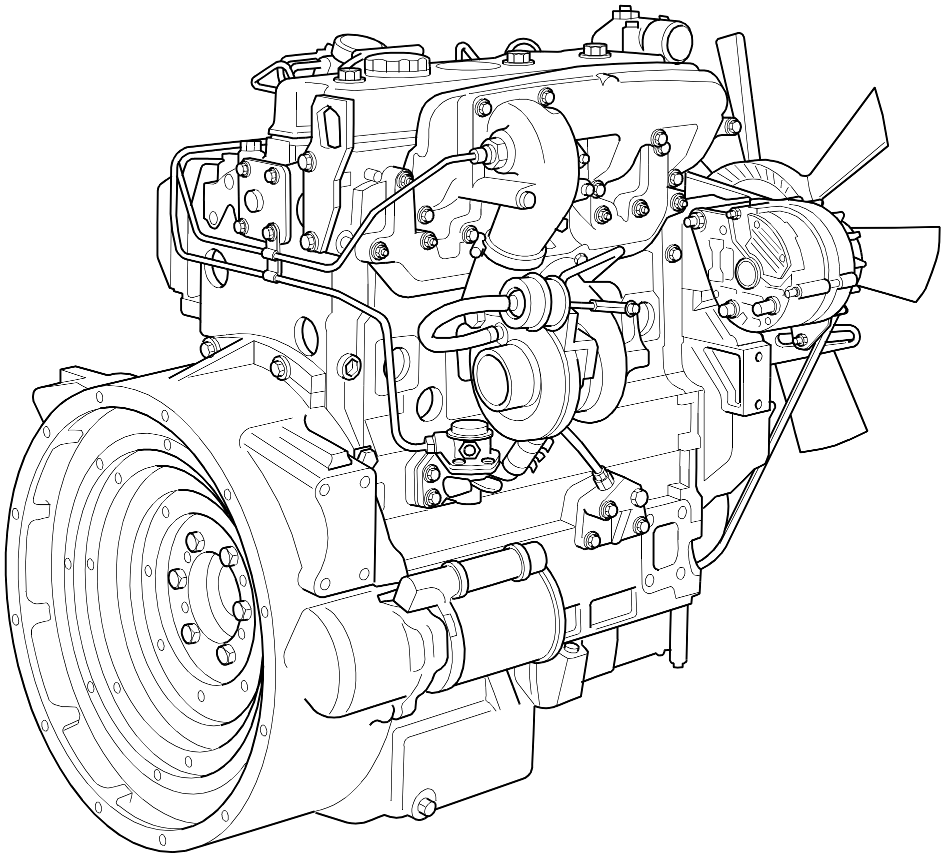
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Engine identification

The Perkins New 1000 Series engines have been designed for industrial and agricultural applications. There are both four and six cylinder engines, each of which will have three basic engine types, naturally aspirated, turbocharged and turbocharged with an intercooler.

In this workshop manual, the different engine types are indicated by their code letters. These are the first two letters of the engine number as indicated below:

AJ	Four cylinder, naturally aspirated
AK	Four cylinder, turbocharged
AM	Four cylinder, turbocharged and intercooled
AP	Four cylinder, naturally aspirated, belt driven coolant pump
AQ	Four cylinder, turbocharged, belt driven coolant pump
AR	Four cylinder, naturally aspirated, 103 mm cylinder bore
AS	Four cylinder, naturally aspirated, belt driven coolant pump, 103 mm cylinder bore
YG	Six cylinder, naturally aspirated
YH	Six cylinder, turbocharged
YJ	Six cylinder, charge cooled, air to air
YK	Six cylinder, turbocharged and intercooled

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:

AK80920*U510256B*

The components of the engine number are as follows:

AK80920*U510256B*

AK	Model code number
80920	Build list number
U	Built in the UK
510256	Engine serial number
B	Year of manufacture

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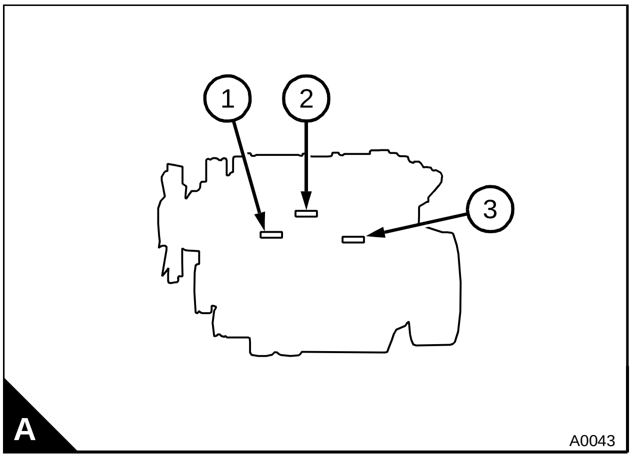


Date letters for engines start from the 1st of January each year. To comply with the new emissions legislation that engines built before 1st April 1999 can be clearly identified from those built after this date, a new letter has been used from the 1st of April 1999. The date letters used are as follows:

From the 1st of January 1999 to the 31st of March 1999 the date letter is E.

From the 1st of April 1999 to the 31st of January 1999 the date letter is F.

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

Other identification labels fitted to the engine include:

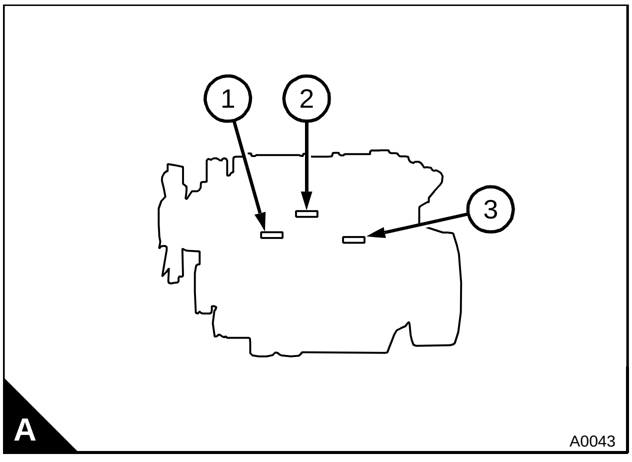
An emissions legislation label (A3) fitted to the side of the cylinder block.

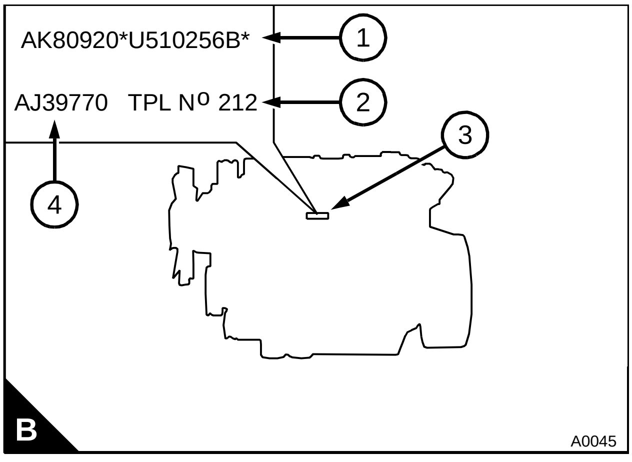
A label (A1) with the fuel injection pump part numbers.

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

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

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





Safety precautions

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

- 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 operators position.
- If your skin comes into contact with high-pressure fuel, obtain medical assistance immediately.
- Diesel fuel and lubricating oil (especially used lubricating oil) can damage the skin of certain persons. Protect your hands with gloves or a special solution to protect the skin.
- Do not wear clothing which is contaminated by lubricating oil. Do not put material which is contaminated with oil into the pockets of clothing.
- Discard used lubricating oil in a safe place to prevent contamination.
- Ensure that the control lever of the transmission drive is in the "out-of-drive" position before the engine is started.
- Use extreme care if emergency repairs must be made in adverse conditions.
- The combustible material of some components of the engine (for example certain seals) can become extremely dangerous if it is burned. Never allow this burnt material to come into contact with the skin or with the eyes, see "Viton seals" on page 6 for safety precautions.
- Read and use the instructions relevant to lift equipment, see "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.

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.

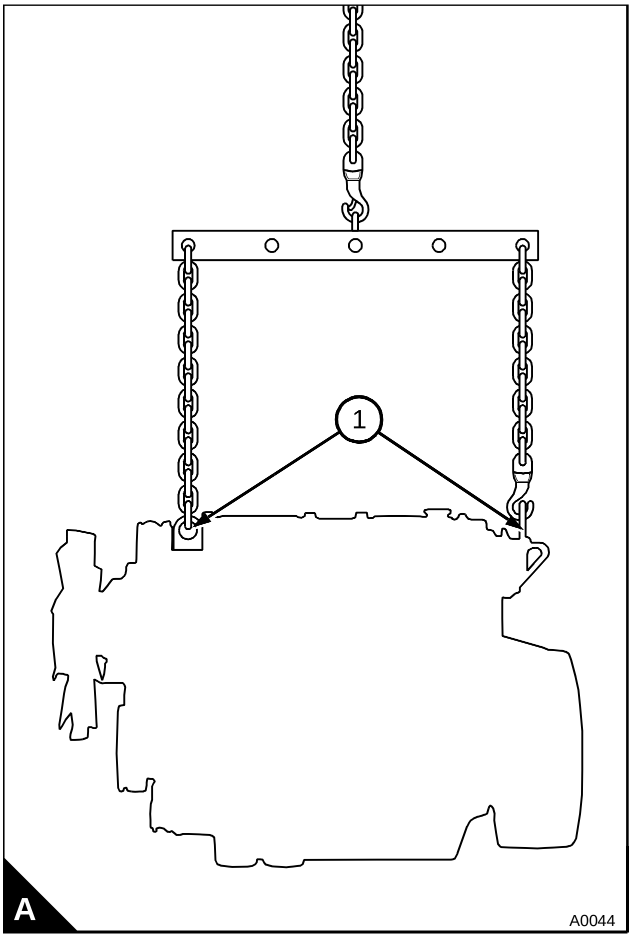
Engine lift equipment

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	500 kg (1100 lbs)
Six cylinder engines	600 kg (1320 lbs)

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
- 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.



POWERPART recommended consumable products

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

POWERPART Antifreeze

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

POWERPART Easy Flush

Cleans the cooling system. Part number 21825001.

POWERPART Gasket and flange sealant

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

POWERPART Gasket remover

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

POWERPART Griptite

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

POWERPART Hydraulic threadseal

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

POWERPART Industrial grade super glue

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

POWERPART Lay-Up 1

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

POWERPART Lay-Up 2

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

POWERPART Lay-Up 3

Protects outside metal parts. Part number 1734115.

POWERPART Metal repair putty

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

POWERPART Pipe sealant and sealant primer

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

Continued

POWERPART Radiator stop leak

For the repair of radiator leaks. Part number 21820127.

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.

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Specifications

Basic engine data

Number of cylinders:

AJ, AK, AM, AP, AQ, AR, AS 4
YG, YH, YJ, YK 6
Cylinder arrangement .. .. .In line
Cycle ... ... Four stroke
Direction of rotation . ... Clockwise from the front

Induction system:

AJ, AP, AR, AS, YG. ... ... Naturally aspirated
AK, AQ, YH.. ... ... Turbocharged
AM, YJ, YK .. .. Turbocharged, intercooled
Combustion system . ...Direct injection

Nominal bore:

AJ, AK, AM, AP, AQ, YG, YH, YJ, YK . ... 100 mm (3.937 in)
AR, AS. ... ... 103 mm (4.055 in)
Stroke .. .. 127 mm (5.00 in)

Compression ratio:

AJ, AK, AM, AP, AQ, YG, YH, YJ, YK 17.25:1
AR, AS. 18.5:1

Cubic capacity:

AJ, AK, AM, AP, AQ ... ... .4 litres (243 in^3)
AR, AS. ... ... 4,23 litres (258 in^3)
YG, YH, YJ, YK ... ... .6 litres (365 in^3)

Firing order:

AJ, AK, AM, AP, AQ, AR, AS 1, 3, 4, 2
YG, YH, YJ, YK 1, 5, 3, 6, 2, 4

Valve tip clearances (hot or cold):

- Inlet ... ... 0,20 mm (0.008 in)
- Exhaust . ... 0,45 mm (0.018 in)

Lubricating oil pressure **(1)**

AJ, AK, AM, AP, AQ, YG, YH, YJ, YK . ... 280 kPa (40 lbf/in^2) 2,5 kgf/cm^2
AR, AS. ... ... 207 kPa (30 lbf/in^2) 2,1 kgf/cm^2

(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:

- Inlet .. .. 46° (88° included angle) or 31° (118° included angle)
- Exhaust ... ... 46° (88° included angle) or 31° (118° included angle)

Leak test pressure . ... 200 kPa (29 lbf/in^2) 2,04 kgf/cm^2
Head thickness .. .. 102,79/103,59 mm (4.047/4.078 in)
Finish grade of head face for cylinder head joint ... ... 1,10/3,20 micrometers

Diameter of parent bore for valve guide:

- Inlet .. ..13,00/13,027 mm (0.5118/0.5128 in)
- Exhaust ... ...14,00/14,027 mm (0.5512/0.5522 in)

Minimum permissible thickness after head face has been machined ... ...102,48 mm (4.035 in)

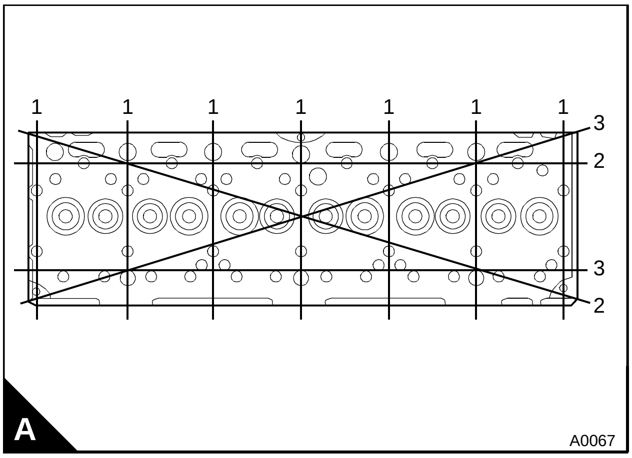
Maximum permissible distortion of cylinder head

Four cylinder engines

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

Six cylinder engines

A1... ... ...0,13 mm (0.005 in)
A2... ... ...0,25 mm (0.010 in)
A3... ... ...0,25 mm (0.010 in)



Inlet and exhaust valves

Inlet 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.. ... ... 0,089 mm (0.0035 in)
- Service limit ... ...0,100 mm (0.008 in)

Diameter of valve head:

- Engine types AJ, AK, AM, AP, AQ, YG, YH, YJ, YK. ... ...42,88/43,12 mm (1.688/1.698 in)
- Engine types AR and AS... ... ...44,88/45,12 mm (1.776/1.767 in)

Angle of valve face .. .. 45° or 30°
Full length, engine types AJ, AK, AM, AP, AQ, YG, YH, YJ, YK. ... ...122,65/123,30 mm (4.829/4.854 in)
Full length, engine types AR and AS... ... ...123,75/124,40 mm (4.872/4.897 in)
Seal arrangement ... ... Rubber seal fitted to valve guide, colour green

Depth of valve head below the face of cylinder head:

- Production limits, engine types AJ, AK, AM, AP, AQ, YG, YH, YJ, YK. ... .1,40/1,70 mm (0.055/0.067 in)
- Service limit, engine types AJ, AK, AM, AP, AQ, YG, YH, YJ, YK ... ... 1,95 mm (0.077 in)
- Production limits, engine types AR and AS... ... ...0,40/0,60 mm (0.016/0.024 in)
- Service limit, engine types AR and AS.. ... ...0,805 mm (0.032 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 (0.0016/0.0033 in)

Maximum permissible clearance in valve guide:

- Production limits ... ... 0,104 mm (0.0041 in)
- Service limit ... ...0,121 mm (0.011 in)

Diameter of valve head:

- Engine types, AJ, AK, AM, AP, AQ, YG, YH, YJ, YK ... ...40,88/41,12 mm (1.609/1.619 in)
- Engine types AR and AS... ... ...41,88/42,12 mm (1.649/1.658 in)

Angle of valve face .. .. 45° or 30°
Full length, engine types, AJ, AK, AM, AP, AQ, YG, YH, YJ, YK ... ...122,65/123,30 mm (4.829/4.854 in)
Full length, engine types AR and AS... ... ...123,75/124,40 mm (4.872/4.897 in)
Seal arrangement ... ... Rubber seal fitted to valve guide, colour brown

Depth of valve head below face of cylinder head:

- Production limits, engine types, AJ, AK, AM, AP, AQ, YG, YH, YJ, YK ... .1,50/1,80 mm (0.059/0.071 in)
- Service limit, engine types, AJ, AK, AM, AP, AQ, YG, YH, YJ, YK ... ... 2,05 mm (0.081 in)
- Production limits, engine types AR and AS... ... ...0,40/0,60 mm (0.016/0.024 in)
- Service limit, engine types AR and AS.. ... ...0,805 mm (0.032 in)

Dimensions of recesses for valve seat inserts

Engine types AJ to AQ and YG to YK

Inlet

A1... ... ... 10,585/10,715 mm (0.4167/0.4219 in)
A2... ... ... 45,535/45,560 mm (1.7927/1.7937 in)
A3... ... ... .Radius 0,38 mm (0.015 in) maximum

Exhaust

A1... ... ... 10,585/10,715 mm (0.4167/0.4219 in)
A2... ... ... 43,535/43,560 mm (1.7139/1.7149 in)
A3... ... ... .Radius 0,38 mm (0.015 in) maximum

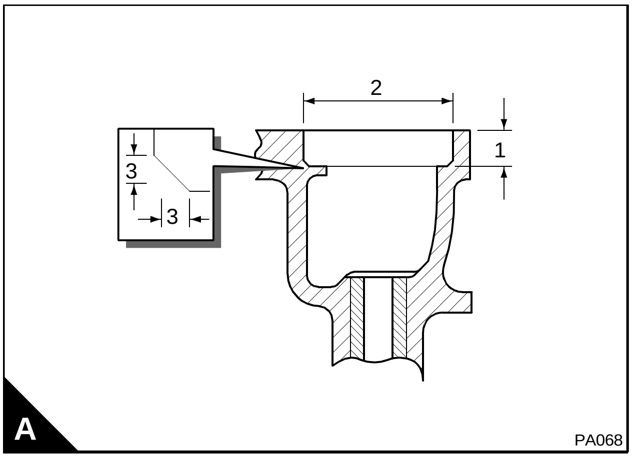
Engine types AR and AS

Inlet

A1... ... ... 10,585/10,715 mm (0.4167/0.4219 in)
A2... ... ... 48,035/48,060 mm (1.8911/1.8921 in)
A3... ... ... .Radius 0,38 mm (0.015 in) maximum

Exhaust

A1... ... ... 10,585/10,715 mm (0.4167/0.4219 in)
A2... ... ... 44,035/44,060 mm (1.7336/1.7346 in)
A3... ... ... .Radius 0,38 mm (0.015 in) maximum



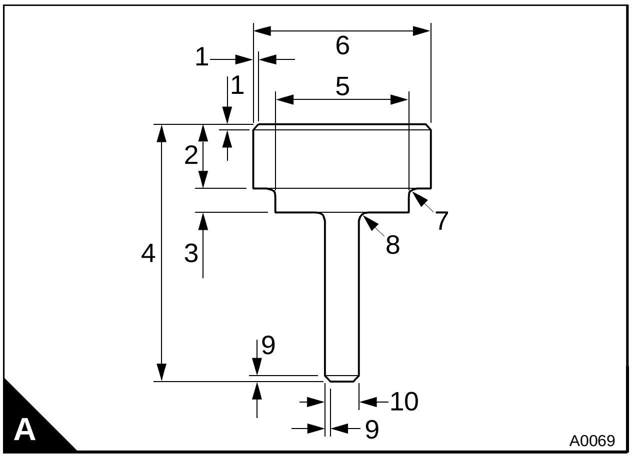
Valve seat insert tool

Inlet (for 45° valves and 30° valves), engine types AJ to AQ and YG to YK

A1 ... 1,5 mm (0.06 in)
A2 ... 20 mm (0.800 in)
A3 ... 7,0 mm (0.28 in)
A4 ... 100 mm (4.00 in)
A .. 37,25/37,45 mm (1.467/1.474 in)
A6 ... 44,75/45,00 mm (1.772/1.762 in)
A7 ... Radius 1,4 mm (0.055) maximum
A8 ... Radius 1,5 mm (0.06)
A9 ... 1,5 mm (0.06 in)
A10 .. 8,54/8,57 mm (0.336/0.337 in)

Exhaust (for 45° valves and 30° valves), engine types AJ to AQ and YG to YK

A1 ... 1,5 mm (0.06 in)
A2 ... 20 mm (0.80 in)
A3 ... 7,0 mm (0.28 in) maximum
A4 ... 100 mm (4.00 in)
A5 ... 34,38/34,58 mm (1.354/1.361 in)
A6 ... 42,75/43,00 mm (1,683/1.693 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 .. 8,54/8,57 mm (0.336/0.337 in)

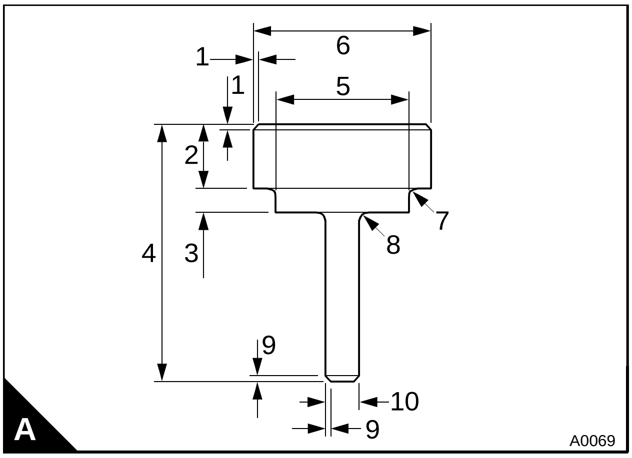


Inlet (45° valves), engine types AR and AS

A1... ... ...1,5 mm (0.06 in)
A2... ... ... .20 mm (0.800 in)
A3... ... ...7,0 mm (0.28 in)
A4... ... ... .100 mm (4.00 in)
A5... ... ... 37,82/38,02 mm (1.488/1.496 in)
A6... ... ... 47,25/47,50 mm (1.860/1.870 in)
A7... ... ...Radius 1,4 mm (0.055) maximum
A8... ... ... Radius 1,5 mm (0.06)
A9... ... ...1,5 mm (0.06 in)
A10. ... ... 8,54/8,57 mm (0.336/0.337)

Exhaust (45° valves), engine types AR and AS

A1... ... ...1,5 mm (0.06 in)
A2... ... ...20 mm (0.80 in)
A3... ... ... 7,0 mm (0.28 in) maximum
A4... ... ... .100 mm (4.00 in)
A5... ... ... 36,62/36,82 mm (1.441/1.449 in)
A6... ... ... 43,25/43,50 mm (1,702/1.712 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. ... ... 8,54/8,57 mm (0.336/0.337 in)



Valve guides and valve springs

Valve guides

Inside diameter of partially finished guide ... ...8,600/8,700 mm (0.3386/0.3425 in)
Inside diameter of finished guide. ... ...9,000/9,022 mm (0.3543/0.3552 in)

Outside diameter:

Inlet.. ... ...13,034/13,047 mm (0.5131/0.5137 in)
Exhaust ... ...14,034/14,047 mm (0.5525/0.5530 in)
Interference fit of valve guide in cylinder head ... ...0,047/0,007 mm (0.0003/0.0019 in)
Full length ... ...51,25 mm (2.018 in)
Protrusion from bottom of recess for valve spring... ... ...14,85/15,15 mm (0.585/0.596 in)

Valve springs

Fitted length. ... ...39,0 mm (1.54 in)

Load at fitted length:

- Engine types, AJ, AK, AM, AP, AQ, YG, YH, YJ, YK ... ...246/277,5 N (55.3/62.4 lbf) 25,1/28,3 kgf
- Engine types AR and AS... ... ...136,3/153,7 N (30.6/34.5 lbf) 13,9/15,7 kgf

Number of active coils 3.3
Number of damper coils 0
Direction of coils .. .. Left hand

Tappets, rocker shaft, rocker levers and bushes

Tappets

Diameter of tappet stem .. ..18,99/19,01 mm (0.7475/0.7485 in)
Diameter of tappet bore in cylinder block ... ...19,05/19,08 mm (0.7500/0.7512 in)
Clearance of tappet in cylinder block... ... ...0,04/0,09 mm (0.0015/0.0037 in)

Rocker shaft

Outside diameter . ...19,01/19,04 mm (0.7485/0.7495 in)

Rocker levers and bushes

Diameter of parent bore for bush. ... ... 22,23/22,26 mm (0.8750/0.8762 in)
Outside diameter of bush ... ...22,28/22,31 mm (0.8770/0.8785 in)
Interference fit of bush in rocker lever . ...0,020/0,089 mm (0.0008/0.0035 in)
Internal diameter of fitted bush when reamed . ...19,06/19,10 mm (0.7505/0.7520 in)
Clearance between rocker lever bush and rocker shaft .. .. 0,03/0,09 mm (0.001/0.0035 in)
Maximum permissible clearance between rocker lever bush and rocker shaft ... ... 0,13 mm (0.005 in)

Pistons and piston cooling jets

Pistons

Type ... ... "Fastram" combustion bowl inserted top ring groove, graphite skirt
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... ... ... 0,38/0,50 mm (0.015/0.020 in)

Width of groove for top ring:

- Engine types AJ, AK, AM, AP, AQ, YG, YH, YJ, YK ... ... Tapered
- Engine types AR and AS . ... 2,60/2,62 mm (0.1023/0.1031)

Width of groove for second ring . ... 2,56/2,58 mm (0.1008/0.1016 in)

Width of groove for third ring:

- Engine types, AJ, AK, AM, AP, AQ, YG, YH, YJ, YK .. .. 3,54/3,56 mm (0.1393/0.1401 in)
- Engine types, AR and AS ... ... 3,53/3,55 mm (0.1389/0.1397 in)

Piston cooling jets

Valve open pressure .. .. 178/250 kPa (26/36 lbf/in^2) 1,8/2,6 kgf/cm^2

Piston rings

Top compression ring:

- Engine types, AJ, AK, AM, AP, AQ, YG, YH, YJ, YK .. .. Barrel face, molybdenum insert, wedge
- Engine types AR and AS . ... Barrel face, molybdenum insert, rectangular

Second compression ring .. .. Taper face, cast iron, outside bottom step
Oil scraper ring... ... ... Coil spring loaded, chromium faced

Width of top ring:

- Engine types, AJ, AK, AM, AP, AQ, YG, YH, YJ, YK .. .. Tapered
- Engine types AR and AS . ... 2,475/2,49 mm (0.097/0.098 in)

Width of second ring .. .. 2,48/2,49 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, AJ, AK, AM, AP, AQ, YG, YH, YJ, YK .. .. Wedge
- Engine types AR and AS only.. ... ... 0,110/0,145 mm (0.004/0.006 in)

Clearance of second ring in groove ... ... 0,07/0,1 mm (0.003/0.004 in)
Clearance of third ring in groove ... ... 0,05/0,09 mm (0.002/0.003 in)

Gap of top ring:

- Engine types, AJ, AK, AM, AP, AQ, YG, YH, YJ, YK .. .. 0,28/0,63 mm (0.011/0.025 in)
- Engine types AR and AS . ... 0,28/0,51 mm (0.011/0.020 in)

Gap of second ring:

- Engine types, AJ, AK, AM, AP, AQ, YG, YH, YJ, YK .. .. 0,40/0,85 mm (0.016/0.034 in)
- Engine types AR and AS . ... 0,30/0,63 mm (0.012/0.025 in)

Gap of third ring:

- Engine types, AJ, AK, AM, AP, AQ, YG, YH, YJ, YK .. .. 0,25/0,75 mm (0.010/0.031 in)
- Engine types AR and AS . ... 0,30/0,63 mm (0.012/0.025 in)

Connecting rods and big end bearings

Connecting rods

Type. ... ... 'H' section, wedge shape small end
Location of cap to connecting rod ... ... Flat joint face with dowels or serrations
Diameter of parent bore for big end. ... ... 67,21/67,22 mm (2.6460/2.6465 in)
Diameter of parent bore for small end. ... ... 43,01/43,04 mm (1.693/1.694 in)
Length grades.. ... ... F, G, H, J, K, L
Length between centres .. .. 219,05/219,10 mm (8.624/8.626 in)

Big end bearings

Type:

- Naturally aspirated engines... ... ... Steel back, aluminium/tin bearing material
- Turbocharged engines .. .. Steel back, lead bronze bearing material with lead finish

Width:

- Naturally aspirated engines... ... ... 31,62/31,88 mm (1.245/1.255 in)
- Turbocharged engines .. .. 31,55/31,88 mm (1.240/1.255 in)

Thickness at centre of bearings:

- Naturally aspirated engines... ... ... 1,835/1,842 mm (0.0723/0.0725 in)
- Turbocharged engines .. .. 1,835/1,844 mm (0.0723/0.0726 in)

Bearing clearance:

- Naturally aspirated engines... ... ... 0,035/0,081 mm (0.0014/0.0032 in)
- Turbocharged engines .. .. 0,030/0,081 mm (0.0012/0.0032 in)

Available undersize bearings... ... ...0,25 mm (-0.010 in); -0,51 mm (-0.020 in); -0,76 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 tin bearing materials
Outside diameter . ... 43,11/43,15 mm (1.6972/1.6988 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:

- Four cylinder engines .. .. 76,16/76,18 mm (2.998/2.999 in)
- Six cylinder engines. ... ... 76,159/76,190 mm (2.9984/2.9996 in)

Maximum wear and ovality on journals and crank pins . ... 0,04 mm (0.0016 in)
Width of front journal.. ... ... 36,93/37,69 mm (1.454/1.484 in)
Width of centre journal... ... ... 44,15/44,22 mm (1.738/1.741 in)
Width of all other journals .. .. 39,24/39,35 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.. ... ... 133,27/133,37 mm (5.247/5.251 in)

Depth of recess for spigot bearing:

- Four cylinder engines .. .. 20,22/20,98 mm (0.796/0.826 in)
- Six cylinder engines. ... ... 14,72/15,48 mm (0.579/0.609 in)

Bore of recess for spigot bearing:

- Four cylinder engines .. .. 46,96/46,99 mm (1.849/1.850 in)
- Six cylinder engines. ... ... 51,97/51,99 mm (2.046/2.047 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 numbers 3131H024
Nitrocarburised... ... ...Part numbers 3131H022, 31315991, 31315995, 31315681
60 hour Nitride ... ... .Part numbers 3131H021
Nitreg . ... .Part numbers 3131H031

Crankshaft overhaul

***Cautions*:**

- *The “Nitreg” process is a special factory process that needs specialist equipment and personnel with the correct training. Do not use any other heat treatment process on these crankshafts.*
- *In service it is not possible to regrind the “Nitreg” crankshaft for overhaul purposes. A “new for old” crankshaft is available.*

Notes:

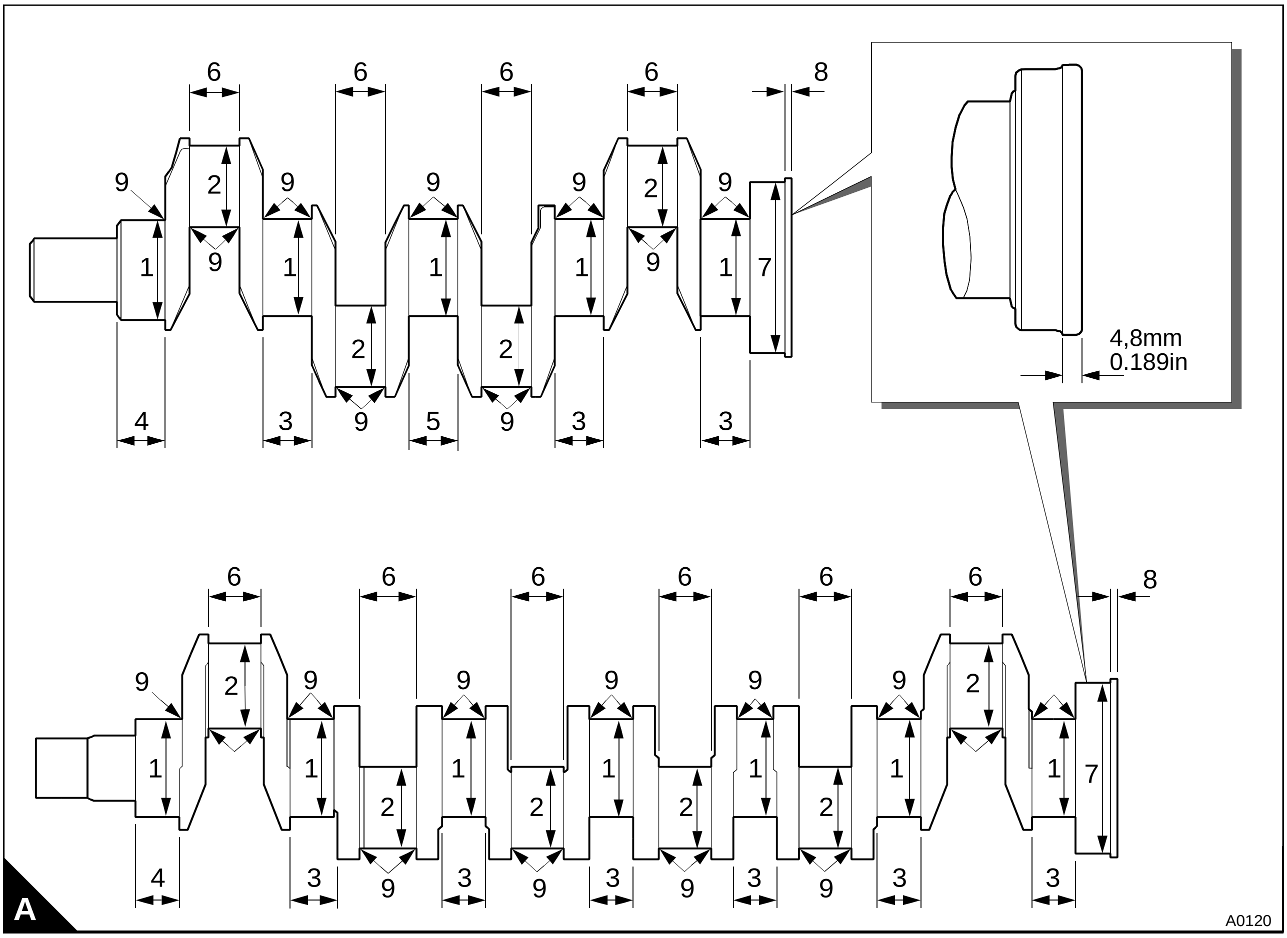
- Induction hardened crank shafts need not be hardened after they have been machined undersize.
- Nitrocarburised crankshafts must be hardened again each time they are machined. These crankshafts must be nitrocarburised or, if this process is not available, they can be nitrided for 20 hours. If neither process is available a new crankshaft, or a “new for old” crankshaft, must be fitted.
- Crankshafts which have been nitrided for 60 hours can be reground 0,25 mm (0.010 in) without the need to harden them again.
- 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.

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	75,905/75,926 mm (2.9884/2.9892 in)	75,651/75,672 mm (2.9784/2.9792 in)	75,397/75,418 mm (2.9684/2.9692 in)
2	63,216/63,236 mm (2.4888/2.4896 in)	62,962/62,982 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	37,82 mm (1.489 in) maximum	-	-
5	44,68 mm (1.759 in) maximum	-	-
6	40,55 mm (1.596 in) maximum	-	-
7	133,17 mm (5.243 in) minimum	-	-
8	Do not machine this diameter	-	-
9	3,68/3,96 mm (0.145/0.156 in)	-	-

Surface finish for journals, crank pins and fillet radii must be 0,4 microns (16 micro inches). Surface finish for seal area of 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	4 cylinder crankshafts	6 cylinder crankshafts
1	Mounting	Mounting
2	0,08 mm (0.003 in)	0,10 mm (0.004 in)
3	0,15 mm (0.006 in)	0,20 mm (0.008 in)
4	0,08 mm (0.003 in)	0,25 mm (0.010 in)
5	Mounting	0,20 mm (0.008 in)
6	-	0,10 mm (0.004 in)
7	-	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

Four cylinder engines. ... ... .Steel back, 20% tin-aluminium bearing material
Six cylinder engines ... ... .Steel back, 20% tin-aluminium bearing material

Bearing width

Four cylinder engines:

Centre bearing ... ... 36,32/36,70 mm (1.430/1.445 in)
All other bearings ... ... 31,62/31,88 mm (1.245/1.255 in)

Six cylinder engines:

Centre bearing ... ... 36,32/36,70 mm (1.430/1.445 in)
All other bearings ... ... 30,86/31,12 mm (1.215/1.225 in)

Bearing thickness at centre

Four cylinder engines. ... ... 2,083/2,089 mm (0.0820/0.0823 in)
Six cylinder engines ... ... 2,083/2,089 mm (0.0820/0.0823 in)

Bearing clearance

Four cylinder engines:

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

Six cylinder engines:

All other bearings ... ... 0,047/0,117 mm (0.0018/0.0046 in)
Available undersize bearings. ... ... 0,25 mm (-0.010 in); -0,51 mm (-0.020 in); -0,76 mm (-0.030 in)

Crankshaft thrust washers

Type. ... ...Steel back, lead bronze 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

Diameter of drive shaft for front bearing.. ... ... 28,562/28,575 mm (1.1245/1.1250 in)
Diameter of drive shaft for rear bearing... ... ... 23,787/23,800 mm (0.9365/0.9370 in)
Number of teeth on gear of drive shaft 21
Backlash from gear of drive shaft to idler gear ... ... 0,17/0,29 mm (0.007/0.011 in)
End-float of drive shaft. ... ... 0,13/0,30 mm (0.005/0.012 in)
Diameter of bore for front bearing of drive shaft.. ... ... 34,912/34,937 mm (1.3745/1.3755 in)
Diameter of bore for rear bearing of drive shaft... ... ... 29,972/29,993 mm (1.1800/1.1808 in)
Diameter of bore for idler gear. ... ... 47,64/47,65 mm (1.8755/1.8760 in)
Diameter of hub of idler gear... ... ... 38,09/38,10 mm (1.4996/1.5000 in)
End-float of idler gear .. .. 0,07/0,23 mm (0.003/0.009 in)
Thickness of thrust washer for idler gear. ... ... 4,14/4,29 mm (0.163/0.169 in)
Number of teeth on idler gear.. 37
Inside diameter of bushes in balancer frame and end cover (fitted) ... .. 38,133/38,174 mm (1.5013/1.5029 in)
Diameter of spigots for balance weights.. ... ... 38,054/38,069 mm (1.4982/1.4988 in)
Fit of spigot in bush . ... 0,064/0,120 mm (0.0025/0.0047 in)
End-float of balance weights ... ... 0,19/0,40 mm (0.007/0.016 in)
Backlash of gears on balance weights ... ... 0,10/0,27 mm (0.004/0.011 in)
Backlash of drive gear to spline on balance weight. ... ... 0,05/0,20 mm (0.002/0.008 in)
Number of teeth on drive gear. 24
Number of teeth on spline on balance weight 16

Timing case and drive assembly

Camshaft

Diameter of number 1 journal ... 50,71/50,74 mm (1.9965/1.9975 in)
Diameter of number 2 journal ... 50,46/50,48 mm (1.9865.1.9875 in)

Diameter of number 3 journal:

- Four cylinder engines ... 49,95/49,98 mm (1.9665/1.9675 in)
- Six cylinder engines ... 50,20/50,23 mm (1.9765/1.9775 in)

Diameter of number 4 journal:

- Six cylinder ... 49,95/49,98 mm (1.9665/1.9675 in)

Clearance of all journals ... 0,06/0,14 mm (0.0025/0.0055 in)

Cam lift:

- Inlet, engine types AJ, AK, AM, AP, AQ, YG, YH, YJ, YK ... 7,62/7,69 mm (0.2999/0.3029 in)
- Inlet, engine types AR and AS ... 8,58 mm (0.3378 in)
- Exhaust, engine types AJ, AK, AM, AP, AQ, YG, YH, YJ, YK ... 7,71/7,79 mm (0.3036/0.3066 in)
- Exhaust, engine types AR and AS ... 8,80 mm (0.3464 in)

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

End-float:

- Production limits ... 0,10/0,41 mm (0.004/0.016 in)
- Service limits ... 0,53 mm (0.021 in)

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

Camshaft thrust washer

Type ... 360°
Depth of recess in cylinder block for thrust washer ... 5,46/5,54 mm (0.215/0.218 in)
Thickness of thrust washer ... 5,49/5,54 mm (0.216/0.218 in)
Relationship of thrust washer to front face of cylinder block ... -0,05/+0,08 mm (-0.002/+0.003 in)

Camshaft gear

Number of teeth ... 56
Diameter of bore ... 34,93/34,95 mm (1.3750/1.3760 in)
Outside diameter of hub of camshaft ... 34,90/34,92 mm (1.3741/1.3747 in)
Clearance fit of gear on hub ... 0,008/0,048 mm (0.0003/0.0019 in)

Fuel pump gear

Number of teeth ... 56
Bore ... 36,00/36,06 mm (1.417/1.419 in)
Clearance fit on hub ... 0,003/0,075 mm (0.0001/0.0030 in)

Crankshaft gear

Number of teeth ... 28
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/+0,048 mm (-0.0008/+0.0010 in)

Idler gear and hub

Number of teeth... 63
Diameter of bore of gear.. ... ... 57,14/57,18 mm (2.2495/2.2512 in)
- with needle roller bearings ... ... 69,01/69,03 mm (2.717/2.718 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 (1.9999/2.000 in)
Outside diameter of hub .. .. 50,70/50,74 mm (1.9960/1.9975 in)
-with needle roller bearing ... ... 54,987/55,000 mm (2.1648/2.1654 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 ... ... 0,24/0,33 mm (0.009/0.013 in)
- Service limit ... ... 0,38 mm (0.015 in)

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

Idler gear and hub for the compressor

Number of teeth... 32
Diameter of bore of gear.. ... ... 55,010/55,025 mm (2.1657/2.1663 in)
Outside diameter of hub .. .. 50,000/49,990 mm (1.9960/1.9975 in)
End float of gear with needle roller bearing fitted: ... ... 0,12/0,16 mm (0.005/0.006 in)
Backlash gear.. ... ... 0,07 mm (0.003 in) minimum

Timing case front cover

Front cover oil seal depth ... ... 10,20/10,70 mm (0.402/0.421 in)

Cylinder block assembly

Cylinder block

Height between top and bottom faces. ... ... 441,12/441,33 mm (17.367/17.375 in)
Diameter of parent bore for cylinder liner ... ... 104,20/104,23 mm (4.103/4.104 in)
Depth of recess for flange of cylinder liner .. .. 3,81/3,91 mm (0.150/0.154 in)
Diameter of recess for flange of cylinder liner . ... 107,82/107,95 mm (4.245/4.250 in)
Diameter of cylinder bore, engine types AR and AS only ... ... 103,000/103,025 mm (4.0551/4.0561 in)
Maximum permissible bore wear, engine types AR and AS only ... ... 0,15 mm (0.006 in)
Diameter of first oversize cylinder bore,
engine types AR and AS only.. ... ... 103,500/103,525 mm (4.0748/4.0757 in)
Diameter of second oversize cylinder bore,
engine types AR and AS only.. ... ... 104,000/104,025 mm (4.0944/4.0954 in)
Diameter of parent bore for main bearing ... ... 80,416/80,442 mm (3.1660/3.1670 in)

Camshaft bore diameter

Four cylinder engines:

- Number 1 (for bush) .. .. 55,56/55,59 mm (2.188/2.189 in)
- Number 2... ... ... 50,55/50,60 mm (1.990/1.992 in)
- Number 3... ... ... 50,04/50,09 mm (1.970/1.972 in)

Six cylinder engines:

- Number 1 (for bush) .. .. 55,56/55,59 mm (2.188/2.189 in)
- Number 2... ... ... 50,55/50,60 mm (1.990/1.992 in)
- Number 3... ... ... 50,29/50,34 mm (1.980.1.982 in)
- Number 4... ... ... 50,04/50,09 mm (1.970/1.972 in)

Bore of bush for number 1 camshaft journal ... ... 50,79/50,85 mm (2.000/2.002 in)

Cylinder liners

Type:

- Production ... ... Dry, interference fit, flanged, with flame ring
- Service. ... ...Dry, transition fit, flanged, with flame ring
- Partially finished liner... ... ... Dry, interference fit, flanged, with flame ring

Outside diameter of production liner.. ... ... 104,25/104,28 mm (4.105/4.106 in)
Interference fit of production liner .. .. 0,03/0,08 mm (0.001/0.003 in)
Inside diameter of production liner. ... ...100,00/100,025 mm (3.937/3.938 in)
Transition fit of service liner ... ... +/- 0,03 mm (+/- 0.001 in)
Inside diameter of service liner with a flame ring (fitted) ... ...100,00/100,063 mm (3.937/3.939 in)
Maximum permissible wear of liner bore ... ...0,25 mm (0.010 in)
Thickness of flange ... ... 3,81/3,86 mm (0.150/0.152 in)
Relative position of top of liner flange to top face of cylinder block ... ...0,10 mm (0.004 in) above
Relative position of top of liner flange to top face of cylinder block ... ... 0,10 mm (0.004 in) below

Cylinder liner specifications

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

Partially finished liner

Interference fit of liner in parent bore. ... ... 0,025/0,076 mm (0.003/0.001 in)
Inside diameter of partially machined liner. ... ... 99,162/99,415 mm (3.9040/3.9139 in)

Preliminary bore

Final size of liner before it is honed ... ... 99,873/99,924 mm (3.9320/3.9340 in)
Surface finish . ... Ra 3,2 to 4,0 micrometers
Maximum ovality and taper ... ... 0,02 mm (0.0008 in)

Diamond hone

Hone angle (cross hatch)... ... ... 35°
Finish size, diamond honed ... ...99,95 mm (3.9350 in)
Surface finish . ... Ra 2,2 to 3,0 micrometers
Maximum ovality and taper ... ...0,012 mm (0.0005 in)

Silicone carbide base hone

Hone angle (cross hatch)... ... ... 35°
Finish size, silicon carbide base hone ... ...100,012 mm (3.9374 in)
Surface finish . ... Ra 1,3 to 1,6 micrometers
Maximum ovality and taper ... ...0,010 mm (0.0004 in)

Silicone carbide plateau hone

Final finish size, silicon carbide (plateau hone) . ...100,017 mm (3.9376 in)
Final surface finish grade... ... ... 0,65/1,3 micrometers

Cylinder bore specifications (engine types AR and AS)

Note: Two oversize pistons are available in service:- 0,5 mm (0.020 in) and 1,0 mm (0.040 in).

Caution: *Specialist training and equipment is needed to machine the cylinder bore. For further information contact your nearest Perkins Distributor.*

Preliminary bore

Final size of standard bore before it is honed.. ... ... 102,873/102,924 mm (4.0501/4.0521 in)
First oversize of bore before it is honed .. .. 103,373/103,424 mm (4.0698/4.0718 in)
Second oversize of bore before it is honed . ... 103,873/103,924 mm (4.0894/4.0914 in)
Surface finish... ... ... Ra 3,2 to 4,0 micrometers
Maximum ovality and taper.. ... ... 0,02 mm (0.0008 in)

Diamond hone

Hone angle (cross hatch) ... ... 35°
Finish size of standard bore, diamond honed.. ... ... 102,949/102,961 mm (4.0531/4.0536 in)
Finish size of first oversize of bore, diamond honed ... ... 103,449/103,461 mm (4.0727/4.0732 in)
Finish size of second oversize of bore, diamond honed.. ... ... 103,949/103,961 mm (4.0924/4.0929 in)
Surface finish... ... ... Ra 2,2 to 3,0 micrometers
Maximum ovality and taper.. ... ... 0,012 mm (0.0005 in)

Silicone carbide base hone

Hone angle (cross hatch) ... ... 35°
Finish size of standard bore, silicon carbide base hone.. ... ... 103,000/103,025 mm (4.0551/4.0561 in)
Finish size of first oversize of bore, silicon carbide honed .. .. 103,500/103,525 mm (4.0748/4.0757 in)
Finish size of second oversize of bore, silicon carbide honed. ... . 104,000/104,025 mm (4.0944/4.0954 in)
Surface finish... ... ... Ra 1,3 to 1,6 micrometers
Maximum ovality and taper.. ... ... 0,010 mm (0.0004 in)

Silicone carbide plateau hone

Final finish size of standard bore,
silicon carbide (plateau hone).. ... ... 103,000/103,025 mm (4.0551/4.0561 in)
Final finish size of first oversize of bore,
silicon carbide (plateau hone).. ... ... 103,500/103,525 mm (4.0748/4.0757 in)
Final finish size of second oversize of bore,
silicon carbide (plateau hone).. ... ... 104,000/104,025 mm (4.0944/4.0954 in)
Final surface finish grade ... ... Ra 0,65/1,3 micrometers

Turbocharger

The make and type of turbocharger fitted is marked on the turbocharger identification plate; as a general guide the make and type of turbocharger fitted are as follows:

4 Cylinder engines . ... Garrett T20
6 Cylinder engines . ... Garrett T32

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

The turbocharger part number is on the turbocharger identification plate, which is fitted to the body of the turbocharger.

Turbocharger part number	**Waste-gate pressure**		
	(kPa) (+/-5)	**(lbf/in^2) (+/-0.72)**	**(kgf/cm^2) (+/-0,05)**
2674A089	150	21.8	1,53
2674A092	150	21.8	1,53
2674A093	110	15.9	1,11
2674A094	105	15.2	1,07
2674A095	145	21.0	1,48
2674A096	150	21.8	1,53
2674A097	138	20.0	1,40
2674A098	96	13.9	0,97
2674A099	107	15.5	1,09
2674A304	105	15.2	1,07
2674A305	105	15.2	1,07
2674A306	138	20.0	1,40
2674A307	150	21.8	1,53
2674A308	96	13.9	0,97
2674A311	145	21.0	1,48
2674A313	96	13.9	0.97
2674A314	145	21.0	1,48
2674A315	150	21.8	1,53
2674A316	96	13.9	0,97
2674A318	110	15.9	1,11
2674A319	96	13.9	0,97
2674A326	105	15.2	1,07
2674A327	145	21.0	1,48
2674A328	96	13.9	0,97

Lubrication system

Oil filter

Type. ... ... Full flow, screw-on type canister
Pressure to open by-pass valve in filter... ... ... 55/83 kPa (8/12 lbf/in2) 0,6/0,8 kgf/cm^2
Pressure to open by-pass valve in oil cooler... ... ... 172 kPa (25 lbf/in^2) 1,8 kgf/cm^2

Lubricating oil pump - four cylinder engines

Type. ... ... .Differential rotor, gear driven
Number of lobes .. .. Inner rotor 6, outer rotor 7

Clearance of outer rotor to body:

- Without balancer unit. ... ... 0,15/0,34 mm (0.006/0.013 in)
- With balancer unit.. ... ... 0,31/0,45 mm (0.012/0.017 in)

Clearance of inner rotor to outer rotor . ... 0,04/0,13 mm (0.0015/0.0050 in)
End-float of rotor assembly.. ... ... 0,03/0,10 mm (0.001/0.004 in)

Lubricating oil pump - six cylinder engines

Type. ... ... .Differential rotor, gear driven

Number of lobes:

- Inner rotor.. 4
- Outer rotor 5

Clearance of outer rotor to body.. ... ... 0,15/0,34 mm (0.006/0.013 in)
Clearance of inner rotor to outer rotor . ... 0,04/0,13 mm (0.0015/0.0050 in)

End clearance (naturally aspirated engines)

- Inner rotor.. ... ... 0,05/0,12 mm (0.002/0.005 in)
- Outer rotor . ... 0,04/0,11 mm (0.0015/0.0044 in)

End clearance (turbocharged engines)

- Inner rotor.. ... ... 0,043/0,118 mm (0.0017/0.0046 in)
- Outer rotor . ... 0,031/0,106 mm (0.0012/0.0042 in)

Idler gear for lubricating oil pump

End float:

- Four cylinder engines ... ... 0,012/0,643 mm (0.0005/0.0253 in)
- Six cylinder engines .. .. 0,020/0,650 mm (0.0008/0.0256 in)

Inside diameter of bush (fitted) ... ... 22,23/22,26 mm (0.875/0.866 in)
Outside diameter of idler shaft. ... ... 22,19/22,21 mm (0.873/0.874 in)
Clearance of bush of idler gear on shaft.. ... ... 0,020/0,066 mm (0.0008/0.0026 in)

Oil pressure relief valve (standard)

Diameter of bore for plunger .. .. 18,24/18,27 mm (0.718/0.719 in)
Outside diameter of plunger... ... ... 18,16/18,18 mm (0.715/0.716 in)
Clearance of plunger in bore.. ... ... 0,06/0,11 mm (0.002/0.004 in)

Length of spring (fitted):

- Four cylinder engines .. ..59,8 mm (2.4 in)
- Six cylinder engines. ... ...55,6 mm (2.2 in)

Load on spring (fitted):

- Four cylinder engines .. .. 15,9/23,1 N (3.6/5.2 lbf) 1,6/2,4 kgf
- Six cylinder engines. ... ... 12,9/18,6 N (2.9/4.2 lbf) 1,3/1,9 kgf

Pressure to open valve (Four cylinder engines):

- Without piston cooling jets... ... ... 340/395 kPa (49/57 lbf/in^2) 3,4/4,0 kgf/cm^2
- With piston cooling jets ... ... 415/470 kPa (60/68 lbf/in^2) 4,2/4,8 kgf/cm^2
- Six cylinder engines. ... ... 345/414 kPa (50/60 lbf/in^2) 3,5/4,2 kgf/cm^2

Oil pressure relief valve (with balancer)

Diameter of bore for plunger .. .. 16,00/16,03 mm (0.630/0.631 in)
Outside diameter of plunger... ... ... 15,95/15,98 mm (0.628/0.629 in)
Clearance of plunger in bore.. ... ...0,02/0,08 mm (0.0008/0.003 in)
Length of spring (fitted) .. ..42,7 mm (1.7 in)
Load on spring (fitted) ... ... 34/38 N (7.6/8.5 lbf) 3,5/3,9 kgf
Pressure to open valve .. ..523 kPa (76 lbf/in^2) 5,3 kgf/cm^2

Fuel system

Bosch fuel injection pump

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

Lucas/Delphi fuel injection pump

Make .. .. Lucas/Delphi DP200 Series, pin timed, with a locking screw
Direction of rotation ... ... Clockwise from drive end

Stanadyne fuel injection pump

Type ... ...Stanadyne DB2 or DB4, pin timed
Direction of rotation from drive end ... ... Clockwise from drive end

Fuel lift pump - four cylinder engines

Type ... ... Diaphragm, A.C.Delco, type XD
Method of drive .. .. .Eccentric on camshaft of engine
Static pressure (no delivery) .. ..42/70 kPa (6/10 lbf/in^2) 0,4/0,7 kgf/cm^2
Test pressure (75% of minimum static pressure) .. .. .31 kPa (4.5 lbf/in^2) 0,32 kgf/cm^2

Fuel lift pump - Six cylinder engines

Type ... ...Diaphragm, A.C.Delco, type LU
Method of drive .. .. .Eccentric on camshaft of engine
Static pressure (no delivery) .. ..34,5/55,2 kPa (5/8 lbf/in^2) 0,35/0,56 kgf/cm^2
Test pressure (75% of minimum static pressure) .. ..26 kPa (3.75 lbf/in^2) 0,26 kgf/cm^2

Fuel filter

Type ... ... Twin parallel flow or single element

Atomiser service setting

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

Code	Holder	Nozzle	Set and reset pressure		
			atm	(lbf/in^2)	MP
KB	2645A308	2645A624	300	4410	30,4
KC	2645A309	2645A625	290	4263	29,4
KD	2645A310	2645A626	290	4263	29,4
KE	2645A311	2645A627	290	4337	29,9
KF	2645A311	2645A628	295	4337	29,9
KG	2645A314	2645A629	300	4410	30,4
KH	2645A314	2645A630	290	4263	29,4
KJ	2645A315	2645A631	250	3675	25,3
KK	2645A312	2645A632	300	4410	30,4
KL	2645A312	2645A633	300	4410	30,4
KM	2645A313	2645A634	300	4410	30,4
KN	2645A315	2645A635	290	4263	29,4
KP	2645A311	2645A636	290	4410	30,4
KR	2645A311	2645A608	290	4263	29,4
KT	2645A311	2645A638	290	4263	29,4
KS	2645A316	2645A637	290	4263	29,4
KU	2645A317	2645A627	290	4322	29,8
KV	2645A304	2645L615	250	3675	25,3
KW	2645A311	2645K609	290	4263	29,4
NX	2645L306	2645L617	290	4263	29,4
NY	2645L308	2645L618	290	4263	29,4
NZ	2645L307	2645L619	290	4263	29,4
PA	2645L309	2645L620	290	4263	29,4
PB	2645L310	2645L621	290	4263	29,4
PC	2645L310	2645L622	290	4263	29,4
PD	2645L310	2645L622	275	4043	27,9
RZ	0430 133 005	DSLA140P707	250	3675	25,3
SA	2645F316	2645F620	250	3675	25,3
SB	2645F316	2645F621	250	3675	25,3
SC	043013306	DSLA150PV3378123	250	3675	25,3

Cooling system

Coolant pump, early gear driven pump

Type ... . Centrifugal
Outside diameter of shaft... ... 18,95/18,96 mm (0.7460/0.7465 in)
Diameter of bore of drive gear ... ... 18,90/18,92 mm (0.7441/0.7449 in)
Interference fit of drive gear on shaft . ... 0,03/0,06 mm (0.0012/0.0024 in)
Diameter of bore of impeller... ... 15,87/15,89 mm (0.6249/0.6257 in)
Outside diameter of shaft for impeller ... ... 15,91/15,92 mm (0.6264/0.6268 in)
Interference fit of impeller on shaft. ... ... 0,02/0,05 mm (0.0007/0.0020 in)
Diameter of bore for bearing .. .. 38,06/38,08 mm (1.4983/1.4993 in)
Diameter of bearing ... ... 38,09/38,10 mm (1.4995/1.5000 in)
Interference fit of bearing in pump body ... ... 0,01/0,04 mm (0.0004/0.0016 in)
Dimension of impeller boss to front face of pump body (fitted).. ... ...7,7/8,0 mm (0.303./0.315 in)
Dimension of gear from rear flat face of pump body (fitted)... ... 21,0/21,5 mm (0.827/0.846 in)
Dimension of gear from rear face of bearing (fitted) .. .. 0,47/1,53 mm (0.018/0.060 in)

Coolant pump, latest gear driven pump

Type ... . Centrifugal

Coolant pump, belt driven

Type ... . Centrifugal
Outside diameter of shaft for pulley ... ... 24,587/24,600 mm (0.9679/0.9685 in)
Inside diameter of bore of pulley ... ... 24,628/24,648 mm (0.9696/0.9704 in)
Clearance fit of pulley on shaft... ... 0,03/0,06 mm (0.001/0.002 in)
Diameter of bore of impeller... ... 15,872/15,893 mm (0.6248/0.6257 in)
Outside diameter of shaft for impeller ... ... 15,9055/15,9182 mm (0.6263/0.6267 in)
Interference fit of impeller on shaft. ... ... 0,01/0,04 mm (0.0004/0.0016 in)
Impeller to body clearance. ... ... 0,69/0,89 mm (0.027/0.035 in)
Impeller to body clearance, engine type AS .. .. 0,20/0,60 mm (0.008/0.024 in)
Diameter of bearing ... .62,000 mm (2.440 in)
Diameter of bore for bearing .. ..62,019/62,000 mm (2.441/24.000 in)
Interference fit of bearing in pump body ... ... 0,01/0,04 mm (0.0004/0.0016 in)

Fan drive housing

Bore of housing for bearing ... ... 41,9655/41,9785 mm (1.6529/1.6522 in)
Outside diameter of bearing... ... ..41,987/42,00 mm (1.6535/1.6530 in)
Interference fit of bearing in housing.. ... ... 0,0085/0,0345 mm (0.00136/0.00033 in)
Bore of hub ... ... 21,938/21,958 mm (0.8637/0.8645 in)
Outside diameter of shaft... ... 21,987/22,000 mm (0.8656/0.8661 in)
Interference fit of shaft in hub ... ... 0,029/0,062 mm (0.0011/0.0024 in)
Maximum permissible end-float of shaft ... .0,200 mm (0.0079 in)

Thermostat

Type:

- Single ... ... Wax element, by-pass blanking
- Twin... ... ... 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
2485613	82 °C (180 °F)	77/85 °C (170/185 °F)	92/98 °C (198/208 °F)	9 mm (0.35 in)
2485604	82 °C (180 °F)	77/85 °C (170 /185 °F)	92/98 °C (198/208 °F)	9 mm (0.35 in)
2485C023	82 °C (180 °F)	80/84 °C (176/183 °F)	96 °C (205 °F)	9 mm (0.35 in)
2485C025	82 °C (180 °F)	80/84 °C (176/183 °F)	96 °C (205 °F)	9 mm (0.35 in)

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
362	14.25	0,23	0.009
410	16.14	0,25	0.010
448	17.63	0,28	0.011
511	20.11	0,30	0.012
584	22.99	0,36	0.014
648	25.51	0,41	0.016
787	30.98	0,48	0.019

Electrical equipment

Alternators

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

Make and type ... ... Lucas/Delphi, AC5RS / Magneti Marelli, A127 / Bosch KI and Bosch NI

Rating:

- Lucas/Delphi AC5RS 24V/55A
- Magneti Marelli A127 ... ... 12V/55A or 12V/65A or 12V/72A
- Bosch KI 12V/55A
- Bosch NI 24V/55A

Rotation... ... ... Clockwise from drive end

Starter motors

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

Make and type ... ...Lucas/Delphi S115 or Magneti Marelli M127 or Bosch JF

Voltage:

- Lucas/Delphi S115... ... ...12V or 24V
- Magneti Marelli M127 ... ... 12V
- Bosch JF... ... ...12V or 24V

Number of teeth on pinion... 10

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

- 12. ... ... 0.0017 ohms
- 24V ... ... 0.0034 ohms

Starting aids

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

Type ... ...Electrically operated heater, with a fuel supply

Voltage... ... ...12V (dropping resistor used on 24V system)

Flow rate of fuel through starting aid... ... ... 3,5/5,9 ml/min

Auxiliary equipment

Compressor

Type ... ...Bendix 1W150R or 1W250R

Number of teeth on compressor drive gear 28

Taper of compressor drive shaft ... ... 1 in 8

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 to the setscrews.

Standard torque tensions

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

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

Standard 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	33	4,5
M12 x 1,75	78	58	8,0
M14 x 2,00	124	91	12,6
M16 x 2,00	190	140	19,3

Standard torques for studs (metal end)

Thread size	Torque		
	Nm	lbf ft	kgf m
M6 x 1,00	5	4	0,5
M8 x 1,25	11	9	1,1
M10 x 1,50	18	14	1,8
M12 x 1,75	25	19	2,5

Standard torques for pipe unions, plugs, and adaptors

Thread size (Inches)	Torque		
	Nm	lbf ft	kgf m
1/8 PTF	9	7	0,9
1/4 PTF	17	13	1,7
3/8 PTF	30	23	3,0
3/4 PTF	45	35	4,5

Specific torque tensions

The torque tensions below apply to components lubricated lightly with 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				
Setscrews, cylinder head	1/2 UNF	see Operation 3-13		
Setscrews, cylinder head (Engine types AR and AS)	M10 1/2 UNF	see Operation 3-14		
Fasteners, rocker shaft brackets:				
- Aluminium brackets	M12	40	30	4,1
- Cast iron and sintered steel brackets	M12	75	55	7,6
Cap nuts, composite plastic rocker cover	M12	20	15	2,1
Cap nuts, aluminium rocker cover	M12	30	22	3,0
Setscrews, inlet manifold to cylinder head	M10	44	33	4,5
Setscrews, inlet manifold to cylinder head	M8	22	16	2,2
Setscrews, exhaust manifold to cylinder head	M10	33	24	3,4
Setscrews, engine lift bracket	M10	44	33	4,5
Piston and connecting rod assemblies				
Nuts, connecting rods	1/2 UNF	125	92	12,7
Setscrews, connecting rods	1/2 UNF	152	114	15,8
Banjo bolts, piston cooling jets	3/8 UNF	27	21	2,7
Crankshaft assembly				
Setscrews, main bearings	5/8 UNF	265	196	27,0
Setscrews, crankshaft pulley	7/16 UNF	115	85	11,8
Setscrews, viscous damper to crankshaft pulley	M12	75	55	7,6
Cap screws, viscous damper to crankshaft pulley	M8	35	26	3,6
Cap screws, crankshaft bonded damper to crankshaft pulley	M8	35	26	3,6
Setscrews, rear oil seal housing to cylinder block	M8	22	16	2,2
Cap screws, bridge piece to cylinder block	M6	16	12	1,6
Cap screws, rear oil seal housing to bridge piece	M6	13	10	1,3
Torxscrew, rear oil seal housing to bridge piece	M8	22	16	2,2
Setscrew, idler gear hub of balancer unit	M12	93	68	9,5
Nut, drive gear of balance weight	1/2 UNF	82	60	8,4
Setscrews, rear cover of balancer frame	M10	54	40	5,5
Setscrews, oil transfer plate (balancer unit)	M10	30	22	3,1
Setscrews, oil pump to balancer frame	M8	27	20	2,8
Setscrews, balancer to cylinder block	M10	54	40	5,5
Timing case and drive assembly				
Setscrews, timing case to cylinder block	M8	22	16	2,2
Setscrews, timing case to cylinder block	M10	44	33	4,5
Setscrews, hub of idler gear	M10	44	33	4,5
Setscrew, camshaft gear	M12	95	74	9,5
Setscrews, timing case cover to timing case	M8	22	16	2,2
Nuts, timing case cover to timing case	M8	22	16	2,2

Description	Thread size	Torque		
		Nm	lbf ft	kgf m
Cylinder block				
Setscrews, fitted instead of piston cooling jet(s)	3/8 UNF	27	21	2,7
Fuel system				
Nuts, high-pressure fuel pipes	M12	22	16	2,2
Bolt banjo, leak-off connection	M8	9	7	0,9
Gland nut, atomiser body	-	40	30	4,1
Setscrews, for the gear of the fuel injection pump	M10	28	20	2,8
Torxscrew, for the gear of the fuel injection pump	M10	28	20	2,8
Setscrews, fuel lift pump	M8	22	16	2,2
Nuts for flange of fuel injection pump	M8	22	16	2,2
Locking screw of Bosch VE fuel injection pump	M10	27	20	2,8
Locking screw of DP 200 fuel injection pump	10 A/F	10	7	1
Lubrication system				
Plug, lubricating oil sump	3/4 UNF	34	25	3,5
Setscrews, oil pump to front bearing cap	M8	22	16	2,2
Setscrews, cover for oil pump	M8	28	21	2,9
Fasteners, lubricating oil sump	M8	22	16	2,2
Cooling system				
Nut, drive pulley for coolant pump (Engine types AP, AQ, AS)	M8	22	16	2,2
Nut, water pump pulley	5/8 UNF	77	56	7.9
Setscrews, fan drive housing to timing case	M10	44	33	4,5
Setscrews, fan drive pulley to hub	M8	22	16	2,2
Setscrews, fan drive pulley to hub	M10	44	33	4,5
Setscrews, fan	M8	22	16	2,2
Connector, oil cooler to oil filter head	3/4 UNF	57	42	5,8
Setscrews, coolant pump to body of pump (Engine type AS)	M8	29	21	2,9
Screw, cassette type cooler to oil filter head	3/4 UNF	37	29	3,7
Temperature switch (plastic thermostat housing)	-	4	3	0,4
Plug (plastic thermostat housing)	1/2 NPSI	4	3	0,4
Plug (plastic thermostat housing)	3/4 NPSI	4	3	0,4
Flywheel and housing				
Setscrews, flywheel to crankshaft	1/2 UNF	105	77	10,7
Setscrews, cast iron flywheel housing to cylinder block: - Head stamped 8.8 - Head stamped 10.9 - Head stamped 10.9	M10 M12 M10 M12	44 75 63 115	33 55 46 85	4,5 7,6 6,4 11,7
Setscrews, aluminium flywheel housing to cylinder block	M10	70	52	7,1
Setscrews, flywheel housing to cylinder block (paper joint)	M10	70	52	7,1
Aspiration system				
Nuts, turbocharger to manifold	M10	44	33	4,5

Description	Thread size	Torque		
		Nm	lbf ft	kgf m
Electrical equipment				
Nut, alternator pulley:				
- CAV AC5RA and AC5RS	5/8 UNF	55	40	5,6
- Thin nut A127, and motorola pulley, 22 mm A/F	M17	80	59	8,2
- Thick nut A127, and motorola pulley, 24 mm A/F	M17	80	59	8,2
- Bosch 55A	M14	50	37	5,1
- Bosch 55A	M16	50	37	5,1
- Butec 5524	5/8 UNF	55	40	5,6
Setscrew, adjusting lever to alternator	M8	11	8	1,1
Setscrew, adjusting lever to bracket	M8	11	8	1,1
Nut, adjusting lever retaining	3/8 UNF	37	29	3,7
Setscrew, adjusting lever alternator	3/8 UNF	37	29	3,7
Bolt, alternator to bracket	7/16 UNF	60	44	6,1
Nut, alternator retaining	7/16 UNF	60	44	6,1
Fuelled start aid to induction manifold	7/8 UNF	31	23	3,1
Port heater to induction manifold	M22	60	44	6,1
Nut/screw, starter motor	3/8 UNF	30	23	3,0
Auxiliary equipment				
Nut, compressor drive gear to compressor crankshaft	5/8 UNF	120	93	12,0
Nut, (30 A/F) Compressor gears	M20	130	101	13,0
Cap screw, bracket to idler hub	M10	60	47	6,0
Cap screw, bracket to timing case	M8	35	27	3,5
Setscrew, RHS power take off blanking plate (composite)	M10	16	12	1,6

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/in^2) 21,0/35,0 kgf/cm^2 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/in^2) 3,5 kgf/cm^2, 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 3-6 for four cylinder engines or Operation 3-7 for six cylinder engines.

2 Remove the atomisers.

3 Fit a suitable gauge into the atomiser hole of the cylinder to be tested.

Caution: *Ensure that the engine cannot start:*

4 Disconnect the stop solenoid or put the stop control in the no-fuel position.

5 Operate the starter motor and note the pressure indicated on the gauge.

6 Repeat 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 cylinder head assembly has two valves fitted for each cylinder, each fitted with single valve springs.

The ports for the inlet and exhaust are on the right side of the cylinder head.

The face angle of the valves is either 45° or 30°. The angle of the valve seats in the cylinder head is either 46° or 31°.

The valves move in phosphated steel guides which can be renewed. The exhaust valve guide has a counterbore to prevent seizure of the valve stem caused by a build up of carbon under the head of the valve.

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

The engines have steel valve seat inserts fitted in the cylinder head for both inlet and exhaust valves.

Rocker cover

To remove **Operation 3-1**

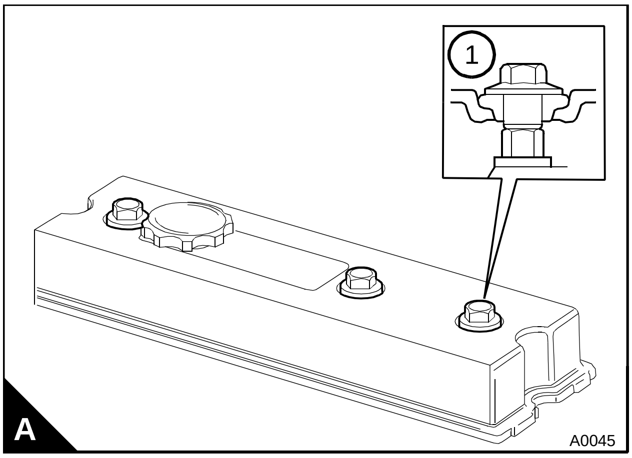
Note: Engines are supplied with rocker covers (A or B) made of a plastic material or aluminum.

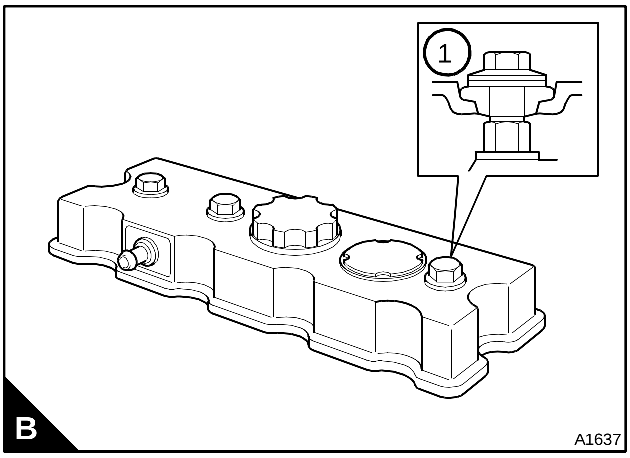
1 Disconnect the breather pipe.

2 Remove the cap nuts and rubber seal (A1 or B1) from the top of the rocker cover and remove the heat shield, if one is fitted.

3 Lift off the rocker cover and the joint.

Caution: *When the rocker cover is fitted, the cap nuts are tightened onto the nuts of the rocker brackets. During removal of the cap nuts, it is possible to loosen the nuts of the rocker brackets. The nuts of the rocker brackets should be tightened to the correct torque every time the cover is removed.*





To fit

Operation 3-2

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

1 Check the seal of the oil filler cap (A1 or B4) and the sealing washers (A3 or B3) for the cap nuts (A2 or B1).

Warning! *The rocker cover joint may be made from viton, see "Viton seals" on page 6 for safety precautions.*

2 Check the condition of the rocker cover joint (A4). If necessary, the joint can be removed and renewed.

3 Clean the joint face of the cylinder head and fit the rocker cover.

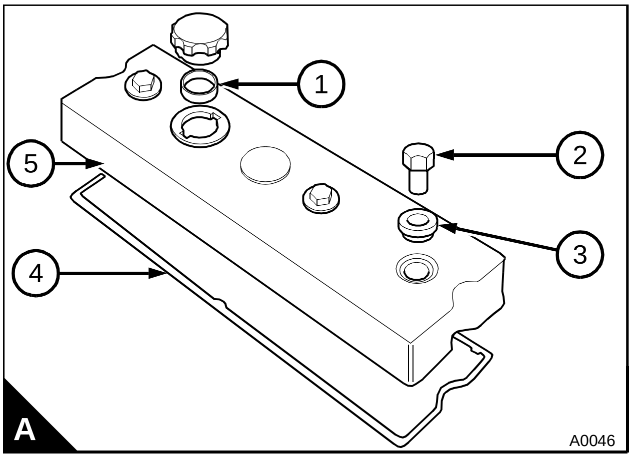
4 Fit the sealing washers, the heat shield, if one is fitted, and the cap nuts.

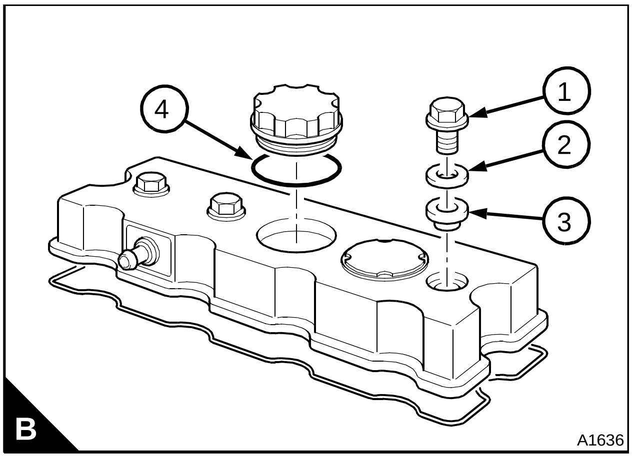
Caution: *Damage to the sealing washer can occur if the cap nut is not tightened centrally through the sealing washer and the rocker cover. If the sealing washer is damaged, it must be renewed.*

5 Tighten the rocker cover cap nuts to:

- 20 Nm (15 lbf ft) 2,1 kgf m for plastic covers
- 30 Nm (22 lbf ft) 3,0 kgf m for aluminium covers.

6 Fit the breather pipe.





Rocker assembly

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

To remove

1 Remove the rocker cover, see Operation 3-1.

2 Release evenly and gradually the fasteners of the rocker shaft brackets; begin with the end brackets and move toward the centre. Remove the fasteners and lift off the rocker assembly.

3 Remove the rubber oil seal (A) from the oil supply connection or from the oil supply hole in the cylinder head.

To fit

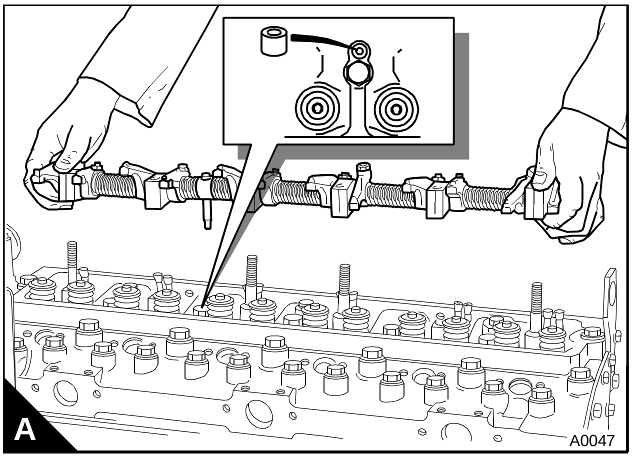
1 Fit a new rubber oil seal in the oil supply hole in the cylinder head.

2 Check that the push rods fit correctly in the sockets of the tappets. Fit the rocker assembly; ensure that the oil supply connection is fitted correctly into the oil seal. Check that the ends of the adjustment screws fit correctly in the sockets of the push rods.

3 Fit the fasteners of the rocker shaft brackets and tighten the fasteners evenly and gradually; begin with the inner fasteners and work towards the end fasteners. Tighten the fasteners evenly to the correct torque according to the material of the rocker shaft brackets:

Type	Torque		
	Nm	lbf ft	kgf m
Aluminium	40	30	4,1
Cast iron	75	55	7,6
Sintered steel	75	55	7,6

4 Check and adjust the valve tip clearances, see Operation 3-6 for four cylinder engines or Operation 3-7 for six cylinder engines.



To dismantle and to assemble **Operation 3-4**

To dismantle

1 Remove the clips from both ends of the rocker shaft. Ensure that the ends of the rocker shaft are not damaged. Release the location screw (A1) for the oil supply connection.

2 Dismantle the assembly and make a note of the position of each component to ensure that they can be assembled more easily.

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 with the arrows (A2) on the pedestals in the position shown. Ensure that the location screw (A1) for the oil supply connection is fitted correctly in the rocker shaft. Fit the clips to the ends of the rocker shaft.

To inspect and to correct **Operation 3-5**

To inspect

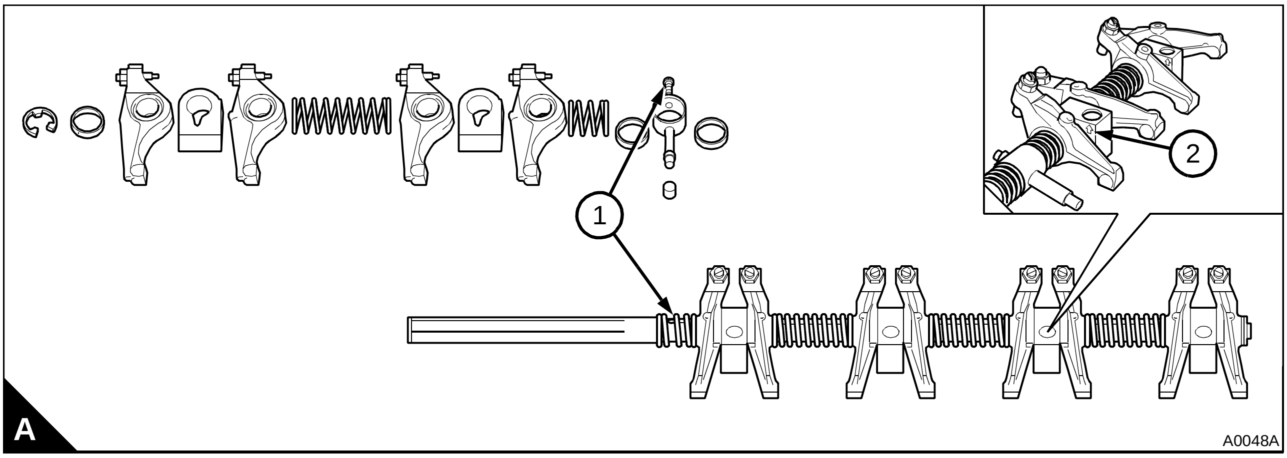
1 Clean and inspect all the components for wear and any other damage. Check the clearance of the rocker levers on the rocker shaft. If the clearance is larger than 0,13 mm (0.005 in), renew the rocker lever bush and/ or the rocker shaft.

To correct

1 To renew the rocker lever bush, press out the old bush with a suitable mandrel.

2 Align the lubrication hole of the new bush on the same side as the rocker lever lubrication hole and press the bush into position.

3 Ream the bush in the rocker lever to give a clearance on the rocker shaft of 0,03/0,09 mm (0.001/0.004 in). Clean thoroughly the bush and check that the oil hole is free from debris.



Valve tip clearances

To check and to adjust (four cylinder engines) — Operation 3-6

Notes:

- The valve tip clearance is measured between the top of the valve stem and the rocker lever (A). With the engine hot or cold, the correct clearances are 0,20 mm (0.008 in) for the inlet valves and 0,45 mm (0.018 in) for the exhaust valves. The valve positions are shown at (B).
- The sequence of valves from number 1 cylinder is shown in the table below. Number 1 cylinder is at the front of the engine.
- The adjusting screws on early engines have a screwdriver slot, later engines have a female Torx drive. Both types are interchangeable.

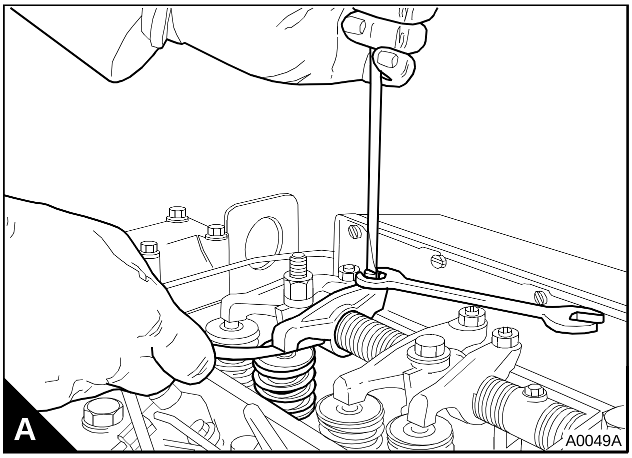
1 Rotate the crankshaft in the normal direction of rotation until the inlet valve (B7) of number 4 cylinder has just opened and the exhaust valve (B8) of the same cylinder has not closed completely. Check the clearances of the valves (B1 and B2) of number 1 cylinder and adjust them, if necessary.

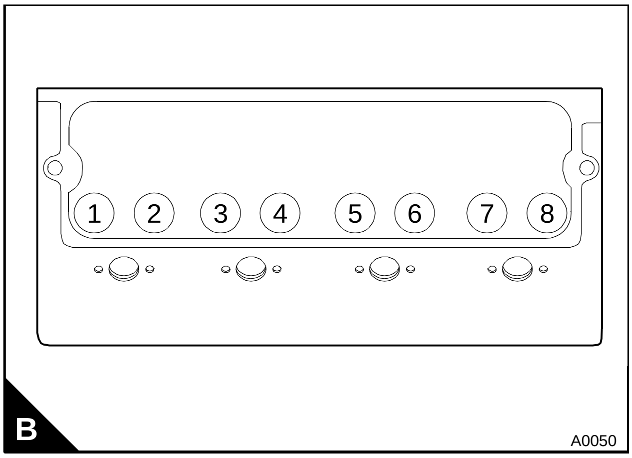
2 Set the valves (B3 and B4) of number 2 cylinder as indicated above for number 4 cylinder. Then check / adjust the clearances of the valves (B5 and B6) of number 3 cylinder.

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.

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





To check and to adjust (six cylinder engines) **Operation 3-7**

Notes:

- The valve tip clearance is measured between the top of the valve stem and the rocker lever (A). With the engine hot or cold, the correct clearances are 0,20 mm (0.008 in) for the inlet valves and 0,45 mm (0.018 in) for the exhaust valves. The valve positions are shown at (B).
- The sequence of valves from number 1 cylinder is shown in the table below. Number 1 cylinder is at the front of the engine.
- The adjusting screws on early engines have a screwdriver slot, later engines have a female Torx drive. Both types are interchangeable.

1 Rotate the crankshaft in the normal direction of rotation until the inlet valve (B11) of number 6 cylinder has just opened and the exhaust valve (B12) 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.

2 Set the valves (B3 and B4) of number 2 cylinder as indicated above for number 6 cylinder. Then check / adjust the clearances of the valves (B9 and B10) of number 5 cylinder.

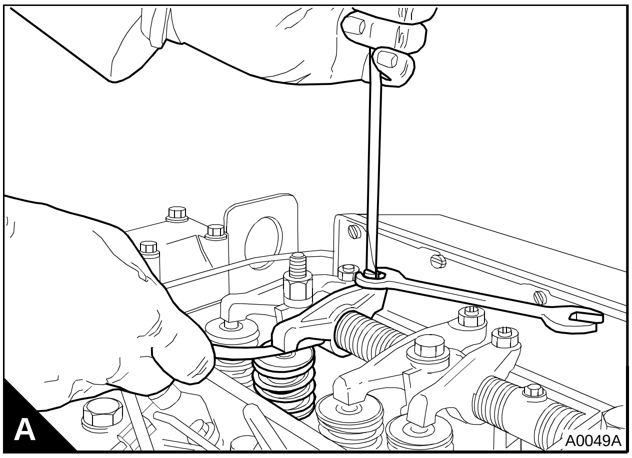
3 Set the valves (B7 and B8) of number 4 cylinder. Then check / adjust the clearances of the valves (B5 and B6) of number 3 cylinder.

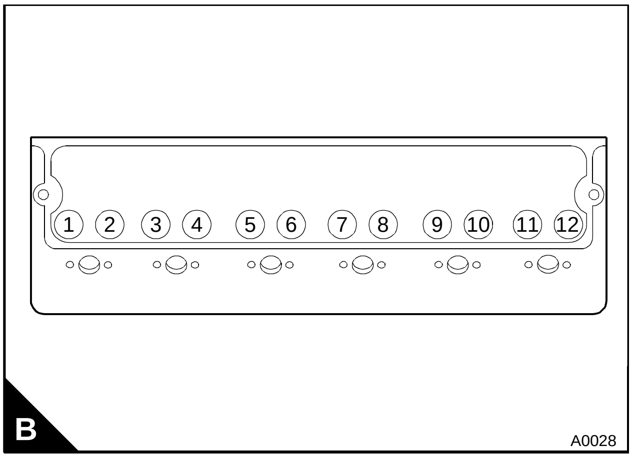
4 Set the valves (B1 and B2) of number 1 cylinder. Then check / adjust the clearances of the valves (B11 and B12) of number 6 cylinder.

5 Set the valves (B9 and B10) of number 5 cylinder. Then check / adjust the clearances of the valves (B3 and B4) of number 2 cylinder.

6 Set the valves (B5 and B6) of number 3 cylinder. Then check / adjust the clearances of the valves (B7 and B8) of number 4 cylinder.

Cylinder and Valve number	**1**		**2**		**3**		**4**		**5**		**6**	
	1	2	3	4	5	6	7	8	9	10	11	12
Valve I = Inlet E = Exhaust	I	E	I	E	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	21825932
Stud adaptor used with 21825666	21825931		

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

Warning! *Wear eye protection during this operation.*

1 Remove the rocker cover, see Operation 3-1.

2 Rotate the crankshaft in the normal direction of rotation until the inlet valve of the relevant cylinder has just opened and the exhaust valve has not fully closed. In this position the piston will be at approximately top dead centre (TDC).

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

4 Fit the valve spring compressor (A1) and the relevant adaptor (A2 or A3).

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

Caution: *Do not rotate the crankshaft while the valve springs are removed.*

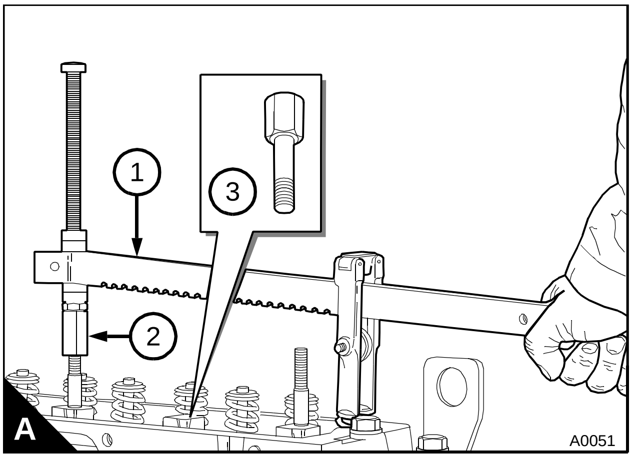
6 Release the valve spring compressor and remove the valve spring caps and valve spring.

Caution: *The outer diameter of the exhaust valve guide is 1 mm larger than the inlet valve guide. To prevent leakage past the inlet valve stem it is important that the larger exhaust valve seal is not fitted onto the inlet guide. The seals have a colour code for identification.*

7 Fit new valve stem seals on the valve guides. Ensure that the brown seal is fitted to the exhaust valve and the green seal is fitted to the inlet valves.

8 Put the new valve springs in position.

Continued



9 Fit the valve spring caps.

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

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

11 Fit the rocker assembly, see Operation 3-3.

12 Check the valve tip clearances, see Operation 3-6 for four cylinder engines or Operation 3-7 for six cylinder engines.

13 Fit the rocker cover, see Operation 3-2.

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:

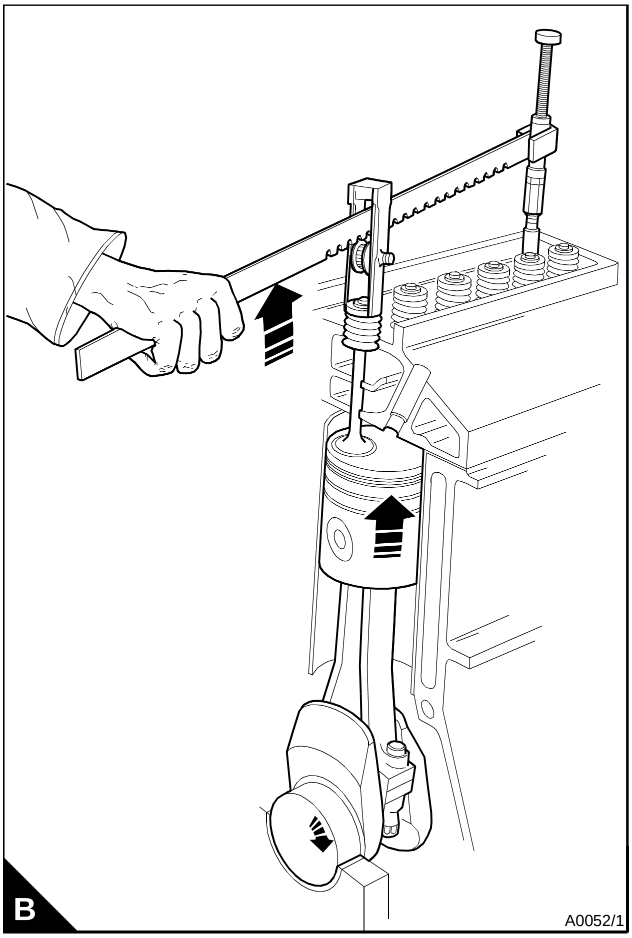
- For 4 cylinder engines: 1 and 4, 2 and 3
- For 6 cylinder engines: 1 and 6, 2 and 5, 3 and 4.

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.

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).



Manifolds

Introduction

The exhaust manifolds fitted to these engines have large clearance holes for the setscrews. It is important that these manifolds are fitted correctly.

A new three-piece exhaust manifold has been introduced for some turbocharged six cylinder engines with side mounted turbochargers. The exhaust manifold is in three pieces to allow for expansion.

Intake manifolds fitted to engine types AR and AS, are in two pieces sealed together with a liquid joint. The two pieces are joined together with setscrews. In service the liquid joint is replaced with a paper joint.

Caution: *If a setscrew for the exhaust manifold has become loose or has to be loosened, all of the setscrews must be loosened and then tightened. If this is not done the manifold could be damaged when it becomes hot.*

To remove and to fit an intake manifold — Operation 3-9

Special requirements

Consumable products	
Description	**Part number**
POWERPART Threadlock and nutlock	21820117

To remove

1 Loosen the securing clips and remove the air intake hose.

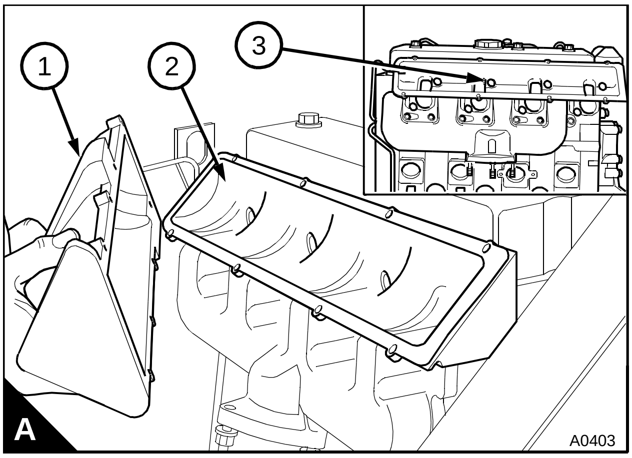
2 Remove the pipe which is fitted between the fuelled starting aid in the intake manifold and the fuel filter. Disconnect the electrical connection.

3 For engines fitted with a boost control device: Remove the boost control pipe which is fitted between the intake manifold and the top of the fuel injection pump.

4 Release the intake manifold fasteners and remove the manifold from the cylinder head.

For intake manifolds fitted to engine types AR and AS: The top half of the intake manifold (A1) in production is sealed to the bottom half (A2) with a liquid joint and fastened together by setscrews. In service the liquid joint is replaced with a paper joint.

The top half of the manifold must be removed to obtain access to the manifold fasteners (A3), fitted inside the manifold. These fasteners retain the bottom half of the manifold to the cylinder head.



To fit

Caution: *Do not scratch or damage the flange faces of the intake manifold.*

Notes:

- 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.
- The manifold joint is fitted without jointing compound.

1 Fit a new intake and exhaust joint to the cylinder head (if required).

The latest joints for both four and six cylinder engines are supplied as one-piece.

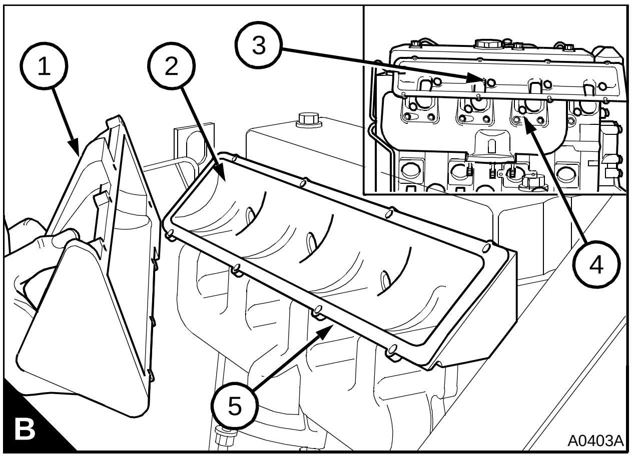
2 Fit the intake manifold and tighten the setscrews.

For engine types AR and AS: Remove any sealant from the top and bottom sections of the intake manifold. Fit the bottom half (B2) to the cylinder head and tighten the setscrews. Fit a new paper joint (B5) to the bottom half of the intake manifold the paper joint is fitted dry. Fit the top half of the intake manifold (B1) and tighten the setscrews.

3 For engines fitted with a boost control device: Fit the boost control pipe which is fitted between the intake manifold and the top of the fuel injection pump.

4 Fit the pipe which is fitted between the fuelled starting aid in the intake manifold and the fuel filter. Connect the electrical connection.

5 Fit the air intake hose and tighten the securing clips.



To remove and to fit an exhaust manifold (one-piece) **Operation 3-10**

Special requirements

Consumable products	
Description	**Part number**
POWERPART Retainer high strength	21820638

To remove

1 For engines fitted with turbochargers: Disconnect all connections to the turbocharger and remove the turbocharger, see Operation 9-1.

2 Remove the intake manifold, see Operation 3-9.

3 Release the exhaust manifold fasteners and remove the manifold from the cylinder head.

To fit

***Cautions*:**

- *Only use the approved setscrews as they are made of a material to withstand high temperatures.*
- *Do not fasten brackets, that are not approved by Perkins, to the exhaust manifold as the manifold could be damaged when it becomes hot.*

Notes:

- 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 Retainer high strength to the setscrews.
- New exhaust manifolds are supplied with plastic ferrules fitted to ensure correct alignment. The position of the ferrules varies according to the exhaust exit port in the manifold. The ferrules are only necessary to align a new exhaust manifold. If the manifold is to be removed and then fitted again, the manifold can be aligned by eye.

Continued

1 If fitting a new manifold, ensure that the ferrules are fitted correctly.

On four cylinder engines with a top exit port (A1), the ferrules are in positions 3 and 6. Those with a side exit port (A2), the ferrules are in positions 2 and 5.

On six cylinder engines with a top exit port (B1), the ferrules are in positions 9 and 12. Those with a side exit port (B2), the ferrules are in positions 8 and 11.

2 Fit a new intake and exhaust manifold joint.

Note: The manifold joint is fitted without jointing compound.

The latest joints for both four and six cylinder engines are supplied as one-piece.

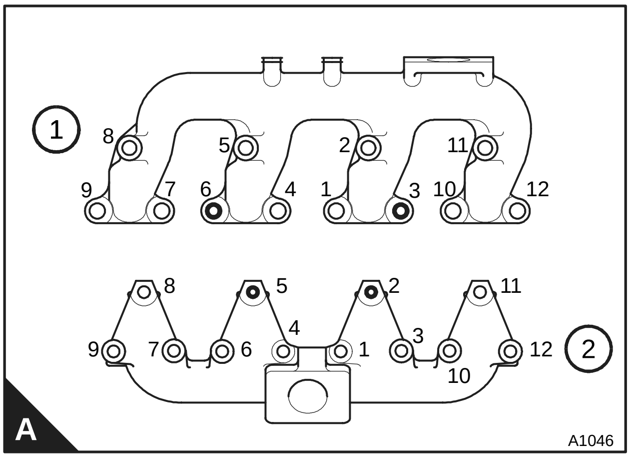
3 Fit the manifold to the cylinder head, use two of the setscrews through the ferrules to align the manifold correctly to the cylinder head. Fit the remaining setscrews and tighten to finger tight.

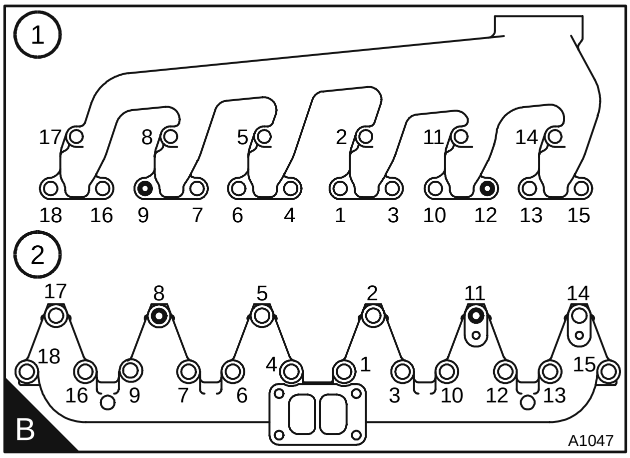
Caution: *Damage to the exhaust manifold can occur if it is not aligned correctly.*

4 Tighten the manifold setscrews gradually and evenly to 33 Nm (24 lbf ft) 3,4 kgf m, in the sequences shown in (A and B). Use the same sequences to tighten the setscrews again to the same torque tension.

5 Fit the intake manifold, see Operation 3-9.

6 If removed fit the turbocharger, see Operation 9-2.





To remove and to fit an exhaust manifold (three-piece) **Operation 3-11**

Special requirements

Consumable products	
Description	**Part number**
POWERPART Retainer high strength	21820638

To remove

1 For engines fitted with turbochargers: Disconnect all connections to the turbocharger and remove the turbocharger, see Operation 9-1.

2 Remove the intake manifold, see Operation 3-9.

3 Release the exhaust manifold fasteners and remove the manifold from the cylinder head.

To fit

***Cautions*:**

- *Only use the approved setscrews as they are made of a material to withstand high temperatures.*
- *Do not fasten brackets, that are not approved by Perkins, to the exhaust manifold as the manifold could be damaged when it becomes hot.*

Notes:

- 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 Retainer high strength to the setscrews.
- New three-piece manifolds are not supplied with ferrules. The manifold is aligned by the use of guide studs.

1 Make four guide studs that have an M10 x 1,5 mm thread and are 65 mm (2.5 in) long.

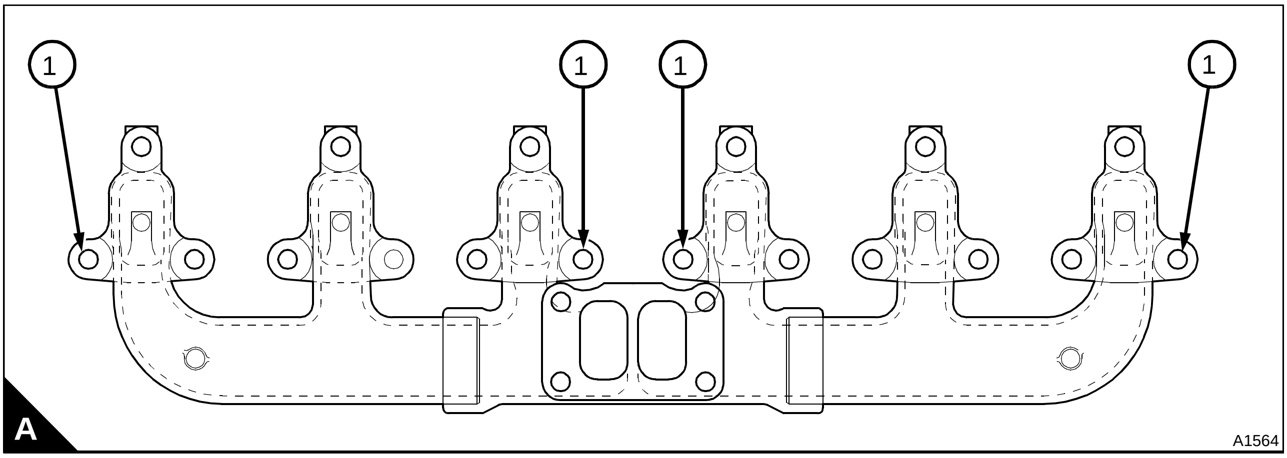
2 Fit the guide studs to the cylinder head in the positions shown (A1).

3 Fit a new intake and exhaust manifold joint on to the guide studs.

Note: The manifold joint is fitted without jointing compound.

4 Assemble the three-piece exhaust manifold as shown in (A). Fit the assembly on to the guide studs.

Continued



Note: If a side mounted turbocharger support bracket (B2) is fitted, fit the two longer setscrews (B1).

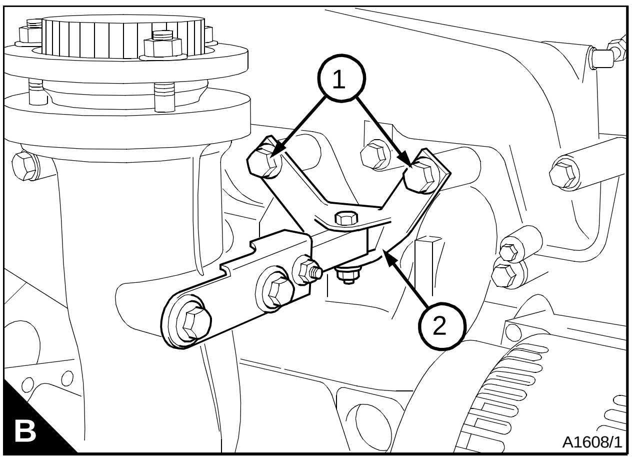
5 Fit the remaining setscrews and tighten them finger tight.

6 Remove the guide studs and fit the remaining setscrews.

7 Tighten all of the setscrews gradually and evenly to 33 Nm (24 lbf ft) 3,4 kgf m.

8 Fit the intake manifold, see Operation 3-9.

9 If removed fit the turbocharger, see Operation 9-2.



To remove **Operation 3-12**

1 Drain the cooling system.

2 Disconnect the battery terminals.

3 For engines fitted with turbochargers: Disconnect all connections to the turbocharger and remove the turbocharger, see Operation 9-1.

4 Remove the intake manifold, see Operation 3-9.

5 Remove the exhaust manifold, see Operation 3-10 or Operation 3-11.

6 Remove the low-pressure fuel pipes which are fitted between the fuel injection pump and the fuel filter.

Note: Where a Bosch fuel injection pump is fitted, keep the fuel outlet banjo bolt with the fuel injection pump.

Remove the fuel pipe fitted between the fuel lift pump and the fuel filter. Remove the fuel filter bracket together with the 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.*

7 Remove the high-pressure fuel pipes.

8 Remove the atomiser leak-off pipe.

9 Remove the atomisers, see Operation 11-4. Fit suitable covers to the nozzles and the open connections.

10 If a compressor is fitted: Remove the coolant pipe which is fitted between the cylinder head and the compressor. Then remove the coolant pipe which is fitted between the by-pass connection and the compressor.

Continued

11 Release the clip of the coolant by-pass hose at the cylinder head. Release the setscrews and remove the coolant by-pass connection and the hose.

12 Disconnect the coolant temperature sender unit.

13 Four cylinder engines: Remove the oil cooler if it is integral with the cylinder block, see Operation 12-21.

14 Remove the rocker cover, see Operation 3-1.

15 Remove the rocker assembly, see Operation 3-3.

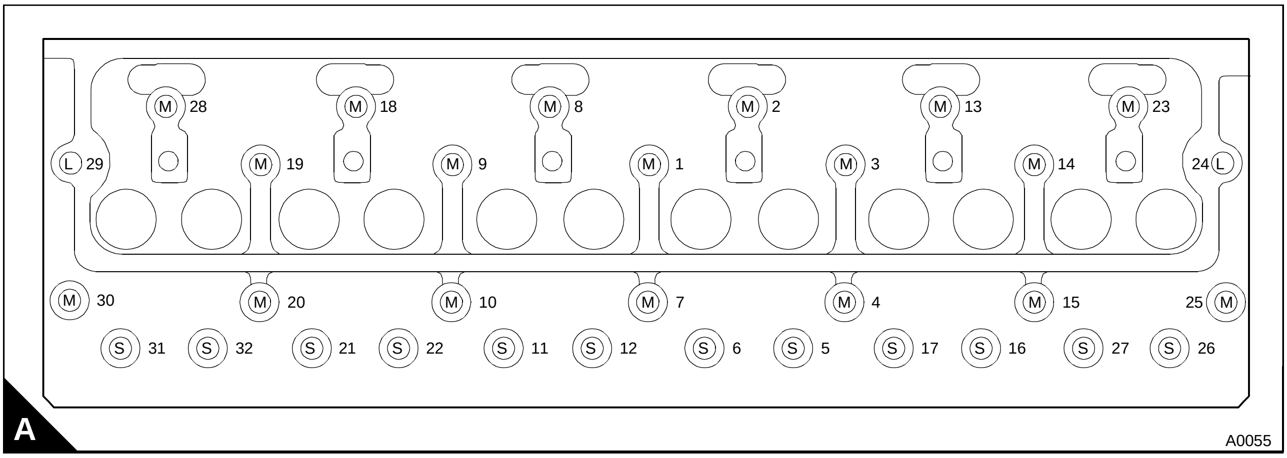
16 Remove the push rods.

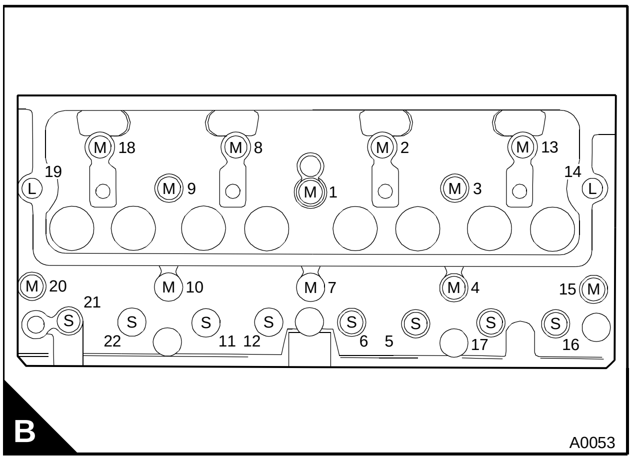
17 Release the cylinder head setscrews evenly and gradually in the reverse sequence to that shown in (A or B).

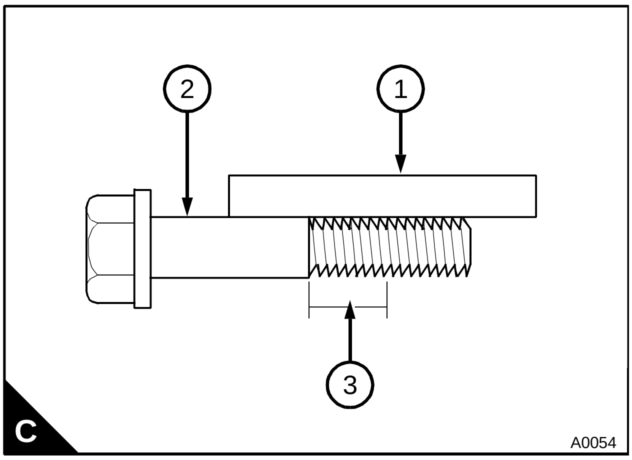
18 Check the setscrews for distortion with a straight edge (C1) held along the setscrew (C2). If there is a visual reduction in the diameter of the thread (C3) that has not been in engagement with the cylinder block, the setscrew must be discarded.

Caution: *Do not use a lever to separate the cylinder head from the cylinder block.*

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







To fit (engine types AJ to AQ and YG to YK) **Operation 3-13**

Special requirements

Special tools	
Description	**Part number**
Angle gauge, to tighten cylinder head setscrews	21825607

Note: See Operation 3-14 for AR and AS engine types

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

Note: The engines have two location pins (A3), one at each end of the cylinder head, pressed into the cylinder block to hold the cylinder head and cylinder head joint in the correct position when the cylinder head is fitted.

***Cautions*:**

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

2 Put the cylinder head joint in position; It is stamped "FRONT TOP" (A2) for correct assembly.

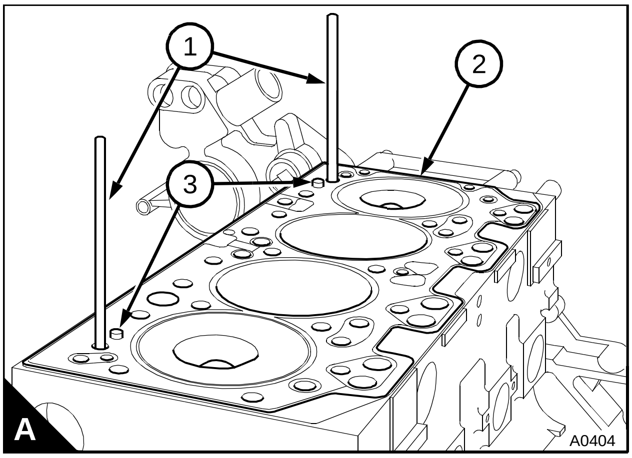
3 To ensure the cylinder head is fitted into the correct position, fit two suitable 1/2 UNF guide studs (A1) or (B1) in positions 16 and 21 (Operation 3-12 illustration B) or positions 25 and 30 (Operation 3-12 illustration A). Put the cylinder head in position. Ensure that the two location pins are fully engaged in the cylinder head.

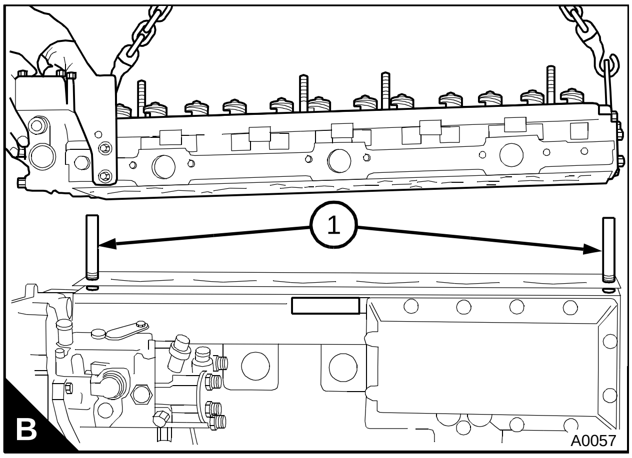
4 Lightly lubricate the threads of the cylinder head setscrews and the thrust faces of the setscrew heads. Engage some of the setscrews in their correct positions and remove the guide studs. Engage the remainder of the setscrews in their correct positions.

5 Gradually and evenly tighten the setscrews to 110 Nm (80 lbf ft) 11,1 kgf m in the sequence shown in Operation 3-12, illustrations A or B.

6 Repeat step 5 to ensure that all the setscrews are tightened to the correct torque.

Continued





7 Tighten the setscrews, in the correct sequence, a further part of a turn according to the length of the setscrews (refer to Operation 3-12 illustrations A or B). Short setscrews (S) must be turned a further 150° (2.5 flats). Medium length setscrews (M) must be turned a further 180° (3 flats). Long setscrews (L) must be turned a further 210° (3.5 flats). 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 3-3.

10 Set the valve tip clearances, see Operation 3-6 for four cylinder engines or Operation 3-7 for six cylinder engines.

11 Fit the atomisers, see Operation 11-5.

12 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.*

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

14 Fit the coolant by-pass connection; tighten the setscrews and hose clip.

15 Fit the coolant temperature sender unit.

16 If a compressor is fitted: Fit the coolant pipe between the cylinder head and the compressor. Then fit the pipe between the coolant by-pass and compressor.

17 Four cylinder engines: Fit the oil cooler if it is integral with the cylinder block, see Operation 12-22.

18 Fit the exhaust manifold, see Operation 3-10 or Operation 3-11.

19 Fit the intake manifold, see Operation 3-9.

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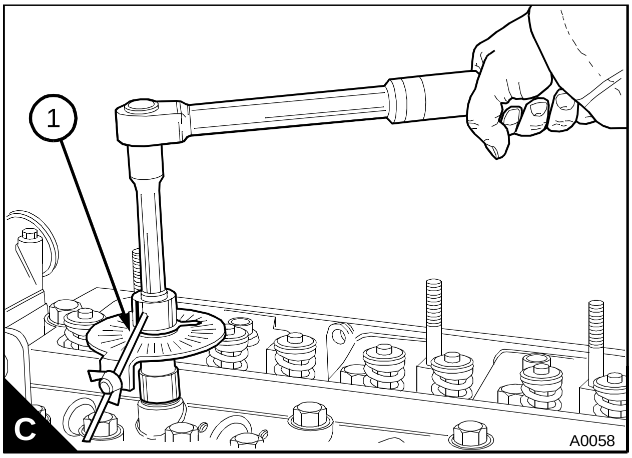

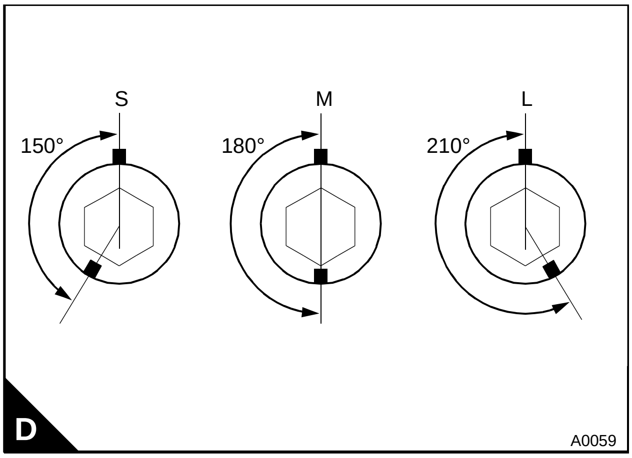

20 For engines fitted with turbochargers: Fit the turbocharger, see Operation 9-2.

21 Fit the fuel pipe between the fuel filter and the fuel lift pump.

22 Fill the cooling system.

23 Connect the battery.

24 Eliminate air from the fuel system, see Operation 11-20.

25 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 3-2.

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

To fit (engine types AR and AS) **Operation 3-14**

Special requirements

Special tools	
Description	**Part number**
Angle gauge, to tighten cylinder head setscrews	21825607

Note: See Operation 3-13 for AJ to AQ and YG to YK engine types.

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

Note: The engines have two location pins (A3), one at each end of the cylinder head, pressed into the cylinder block to hold the cylinder head and cylinder head joint in the correct position when the cylinder head is fitted.

***Cautions*:**

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

2 Put the cylinder head joint in position; it is stamped "FRONT TOP" (A2) for correct assembly.

3 To ensure the cylinder head is fitted into the correct position, fit two suitable M10 guide studs (A1) in positions 16 and 21 (B). Put the cylinder head in position. Ensure that the two location pins are fully engaged in the cylinder head.

4 Lightly lubricate the threads of the cylinder head setscrews and the thrust faces of the setscrew heads. Engage some of the setscrews in their correct positions and remove the guide studs. Engage the remainder of the setscrews in their correct positions. The four 1/2 UNF setscrews are fitted in positions 2, 8, 13 and 18, refer to (B).

5 Gradually and evenly tighten all of the setscrews to 45 Nm (33 lbf ft) 4,5 kgf m in the sequence shown in (B).

6 Repeat step 5 to ensure that all the setscrews are tightened to the correct torque.

7 Gradually and evenly tighten the four 1/2 UNF setscrews, to 110 Nm (80 lbf ft) 11,1 kgf m in the sequence 2, 8, 13 and 18, shown in (B).

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

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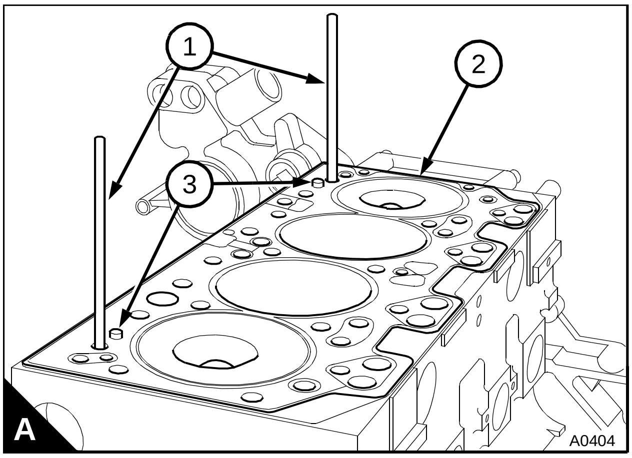

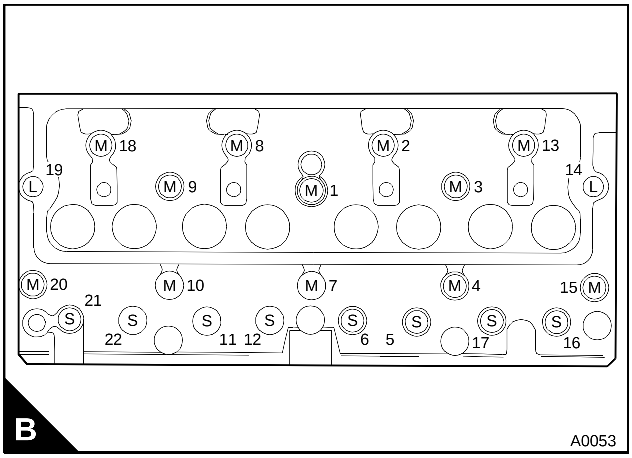

9 Tighten the M10 setscrews, in the correct sequence, a further part of a turn according to the length of the setscrews, see (C) and (D). Short setscrews (S) must be turned a further 120° (2 flats). Medium length setscrews (M) must be turned a further 120° (2 flats). Long setscrews (L) must be turned a further 150° (2.5 flats). The four 1/2 UNF setscrews in positions 2, 8, 13 and 18 must be turned 180° (3 flats).

A special tool (E) can be used to tighten all of the setscrews, instead of the method described in step 9. Fit the tool between the socket and the handle. Position the stop (E1) 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.

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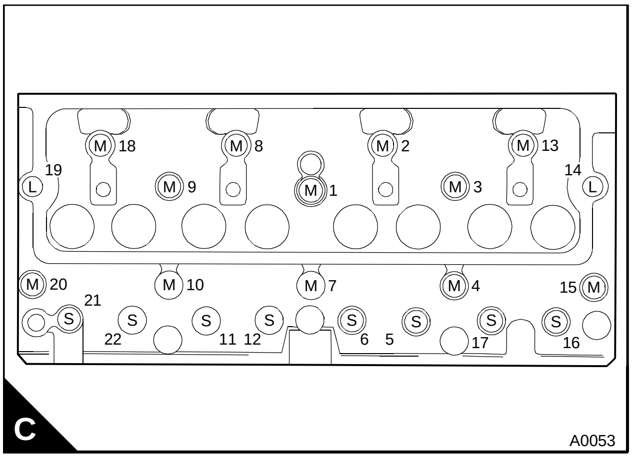
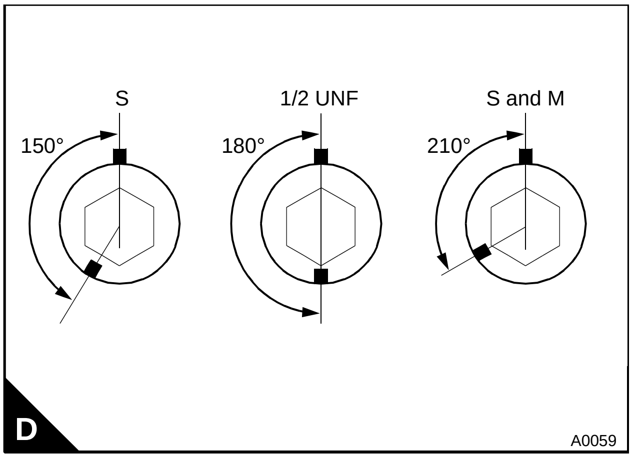
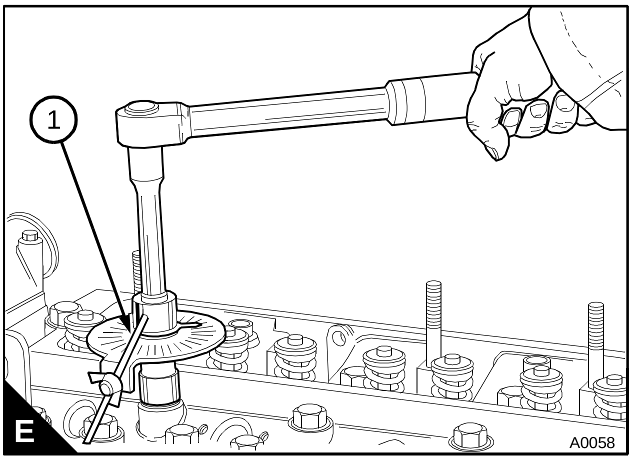






10 Put the push rods in position. Ensure that the end of each push rod fits correctly in the tappet socket.

11 Fit the rocker assembly, see Operation 3-3.

12 Set the valve tip clearances, see Operation 3-6 for four cylinder engines or Operation 3-7 for six cylinder engines.

13 Fit the atomisers, see Operation 11-5.

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

16 Fit the coolant by-pass connection; tighten the setscrews and hose clip.

17 If a compressor is fitted: Fit the coolant pipe between the cylinder head and the compressor. Then fit the pipe between the coolant by-pass and compressor.

18 Fit the coolant temperature sender unit.

19 Fit the oil cooler if it is integral with the cylinder block, see Operation 12-22.

20 Fit the exhaust manifold, see Operation 3-10 or Operation 3-11.

21 Fit the intake manifold, see Operation 3-9.

22 Fit the fuel pipe between the fuel filter and the fuel lift pump.

23 Fit the fuel pipe between the fuel filter and the fuelled starting aid in the intake manifold. Connect the electrical connection to the cold start device.

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

25 Fill the cooling system.

26 Connect the battery.

27 Eliminate air from the fuel system, see Operation 11-20.

28 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 3-2.

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 3-15**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Valve spring compressor	21825666	Setscrew adaptor used with 21825666	21825932
Stud adaptor used with 21825666	21825931		

Warning! *Wear eye protection during this operation.*

1 Remove the cylinder head, see Operation 3-12.

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 3-17.

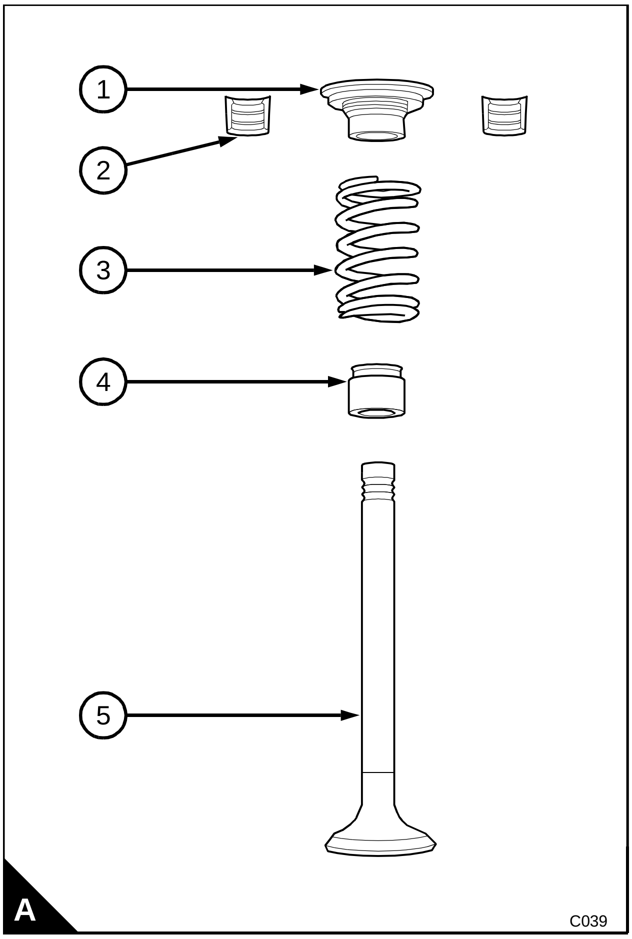
3 Make a suitable mark on the heads of the valves to ensure that the valves can be fitted in their original positions, if they are to be used again.

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

4 Use the valve spring compressor and the relevant adaptor to compress the valve spring (A3) and remove the collets (A2).

5 Release the valve spring compressor and remove the valve spring cap (A1), valve spring and valve stem seal (A4).

6 Repeat steps 4 and 5 for the other valves.



To fit **Operation 3-16**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Valve spring compressor	21825666	Setscrew adaptor used with 21825666	21825932
Stud adaptor used with 21825666	21825931		

Warning! *Wear eye protection during this operation.*

Note: The components of the valve assembly are shown in (A).

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

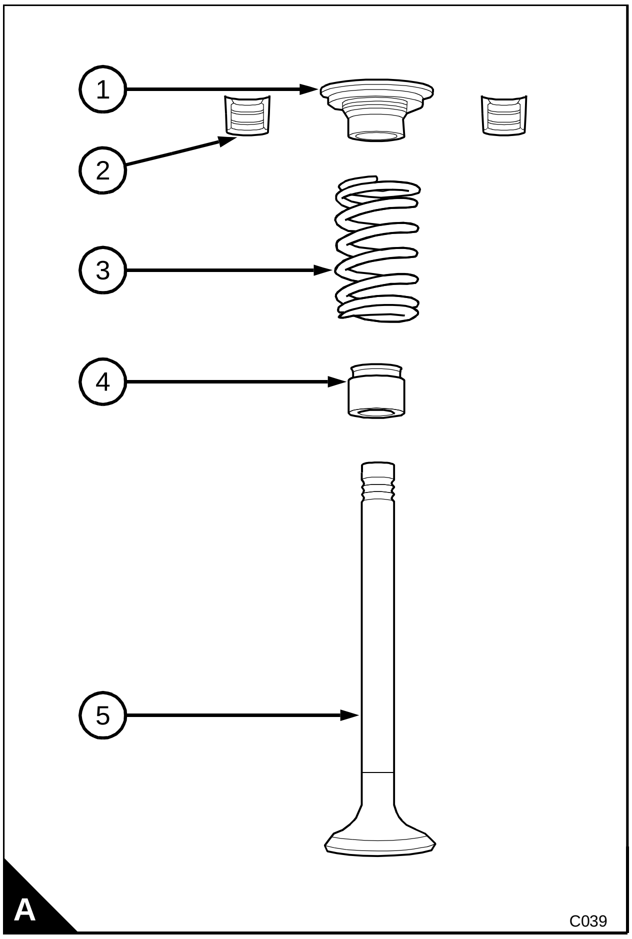
Caution: *The outer diameter of the exhaust valve guide is 1 mm larger than the inlet valve guide. To prevent leakage past the inlet valve stem it is important that the larger exhaust valve seal is not fitted onto the inlet guide. The seals in the service kit have different colours for identification.*

2 Fit new valve stem seals on the valve guides. It is important that all lubricant is removed from the outer diameter of inlet and exhaust valve guides before the valve seal is fitted. Ensure that the brown seal is fitted to the exhaust valve and the green seal is fitted to the inlet valves.

3 Put the valve springs in position, they can be fitted with either end to the cylinder head. Fit the valve spring caps.

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 and fit the collets.



To inspect and to correct **Operation 3-17**

Special requirements

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

1 Check the depth of the valves below the face of the cylinder head before the valve springs are removed.

2 Ensure that the heads of the valves and the bottom face of the cylinder head are clean.

3 Put the valve depth gauge on the face of the cylinder head and zero the dial gauge.

4 Carefully put the valve depth gauge in position over the head of each valve (A) and make a note of the measurement. For the maximum depth, in service, refer to the Data and dimensions for "Inlet and exhaust valves" on page 13.

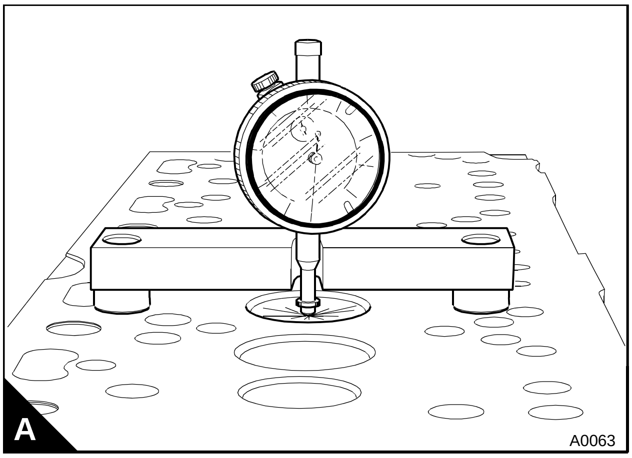
5 If a valve is below the depth limit, check the valve depth with a new valve in position. If the valve depth is still below the limit and a valve seat insert is fitted, the insert must be renewed.

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

Caution: *Renew damaged valves, the special heat resistant layer on the face of the valve will be destroyed if valves are lapped.*

7 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.

8 Check that the load on the valve springs is correct at their fitted length, see "Valve guides and valve springs" on page 17. Fit new valve springs at every complete engine overhaul.



Valve guides

Note: Later engines have an improved exhaust valve guide (B1), with a groove (B2) to retain the valve seal (B3).

To inspect **Operation 3-18**

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 0,100 mm (0.008 in) for inlet valves and 0,121 mm (0.011 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:

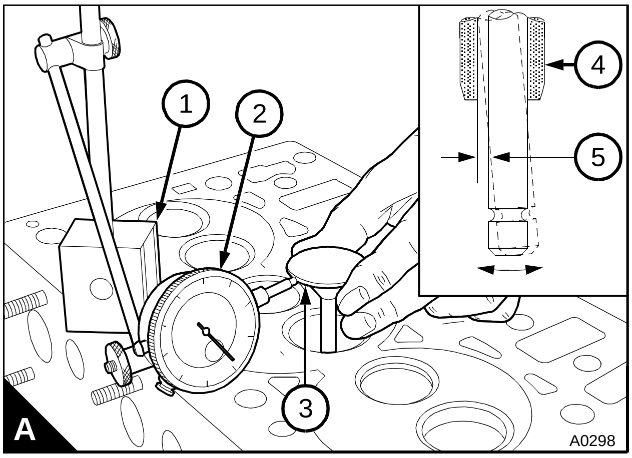
1 Put a new valve in the valve guide.

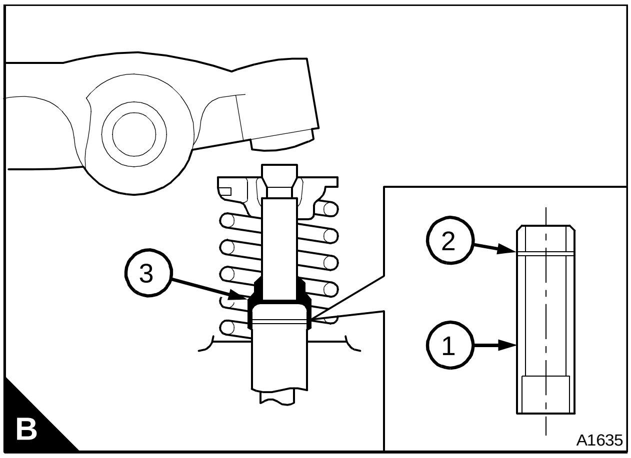
2 Put a dial test indicator with a magnetic base (A1) onto the face of the cylinder head.

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.

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, see Operation 3-22. 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.





To remove **Operation 3-19**

Special requirements

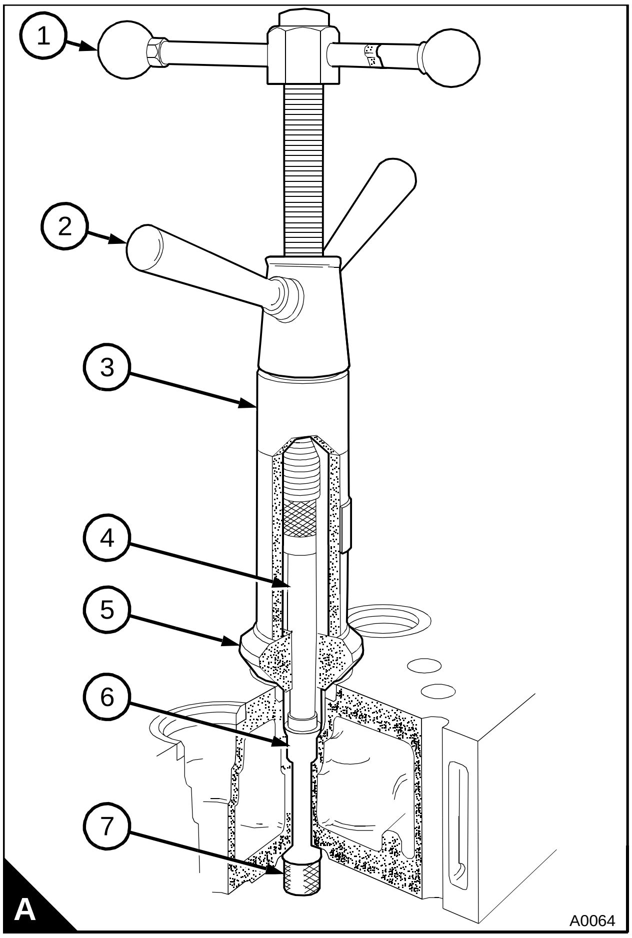
Special tools			
Description	**Part number**	**Description**	**Part number**
Valve guide remover and replacer	21825478	Adaptor used with 21825478	27610019

1 Fit the adaptor (A4) into the remover/replacer tool (A3).

2 With the adaptor fitted to the tool, put the spacer (A5) in position on the tool. Pass the adaptor through the valve guide (A6) and put the spacer and tool in position on the valve seat.

3 Fit the attachment (A7) to secure the adaptor to the valve guide.

4 Hold the top handle (A1) and turn the bottom handle (A2) clockwise to pull the valve guide out of the cylinder head.



To fit **Operation 3-20**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Valve guide remover and replacer	21825478	Distance piece, inlet guide, used with 21825478, and 27610019	21825482
Adaptor used with 21825478, 21825482 and 27610029	27610019	Distance piece, exhaust guide, used with 21825478 and 27610019	27610029

1 Clean the parent bore in the cylinder head for the valve guide.

2 Lubricate the outer surface of the new valve guide (A6) with clean engine lubricating oil.

3 Fit the adaptor (A5) into the remover/replacer tool (A3).

4 With the adaptor fitted to the tool, put the spacer (A4) in position on the tool. Pass the adaptor through the cylinder head and put the spacer and tool assembly in position on the valve seat.

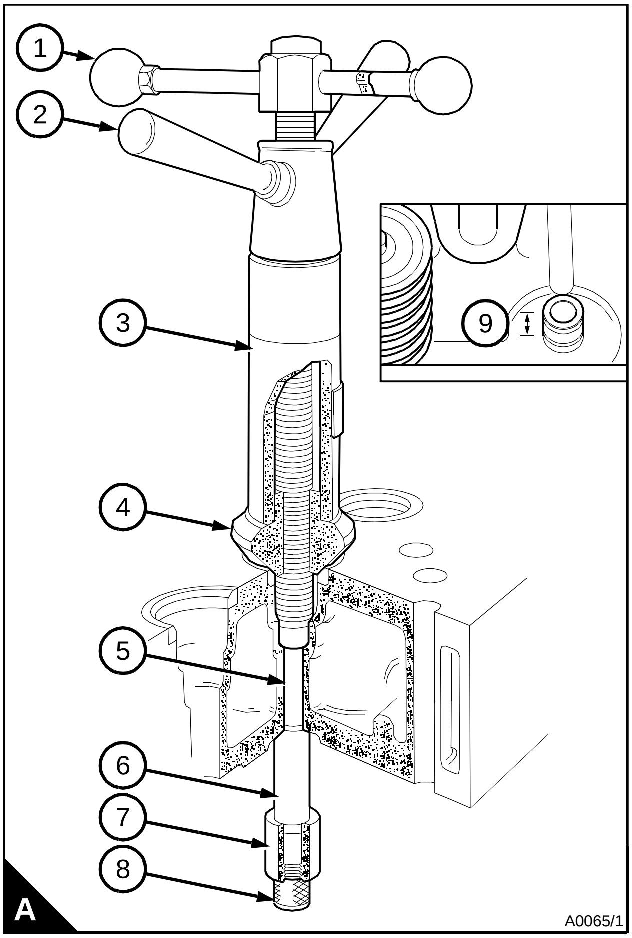
5 Put the valve guide in position on the adaptor and fit the distance piece (A7), 21825482 for inlet valve guides and 27610029 for exhaust valve guides. Fit the attachment (A8) to secure the valve guide to the adaptor.

Note: The internal recess in the valve guide must be towards the tool.

6 Hold the top handle (A1) and turn the bottom handle (A2) clockwise to pull 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 (A9) of 14,85/ 15,15 mm (0.585/0.596 in) above the valve spring seat.

8 Ream the valve guide to the finished size, see Operation 3-22.



To inspect and to correct **Operation 3-21**

1 Remove the cylinder head assembly, see Operation 3-12.

2 Remove the thermostat housing.

3 Inspect the cylinder head for signs of gas or coolant leakage.

4 Remove the valve springs and the valves, see Operation 3-15.

5 Clean the face of the cylinder head and the passages for coolant and for lubricating oil. The water jacket can be cleaned with a special solvent which must be used in accordance with the manufacturer's instructions.

6 Test the cylinder head for leaks, refer to the Data and dimensions for "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.

8 Use a straight edge and feeler gauges to check the cylinder head for distortion across and along its bottom face. If the distortion is more than the permissible limit, the bottom face can be machined, refer to the Data and dimensions for "Maximum permissible distortion of cylinder head" on page 12.

***Cautions*:**

- *Remove only the minimum material and ensure that the thickness of the cylinder head will not be less than 102,48 mm (4.035 in) after the cylinder head has been machined.*
- *After the cylinder head has been machined the valve seats must be corrected to give the correct valve head depth. Work to the minimum limit to allow for later wear.*

9 Check the valve seats for wear and for damage.

10 Before any work is done on the valve seats, new valve guides must be fitted, see Operation 3-19 and Operation 3-20.

11 More badly damaged valve seats can be corrected by use of the cutter tool, see Operation 3-22, or new inserts can be fitted, see Operation 3-23.

To correct a valve seat with a valve seat cutter **Operation 3-22**

Special requirements

Special tools	
Description	**Part number**
Cutter (31° or 46°) for inlet and exhaust valve seats and valve guide reamer	27610030

Caution: *Valves must not be lapped.*

The valve seats are cut and the valve guides are reamed in one operation with a special tool (A). 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 guides must be fitted each time a new seat insert is fitted. Valves must not be lapped.

1 Before any work is done on the valve seats, new valve guides must be fitted, see Operation 3-19 and Operation 3-20.

Caution: *Ensure that the correct cutter is fitted, 31° or 46° valve seats may be fitted.*

2 Select the relevant valve seat cutter, 31° or 46°, (A2) and the valve guide reamer (A3). Set the blades of the cutters to the diameter of the valve seat to be cut. 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 grub screw (A1) and tighten the grub screw to secure the reamer to the handle. The blades of the reamer must not cut the valve guide when the seat is cut.

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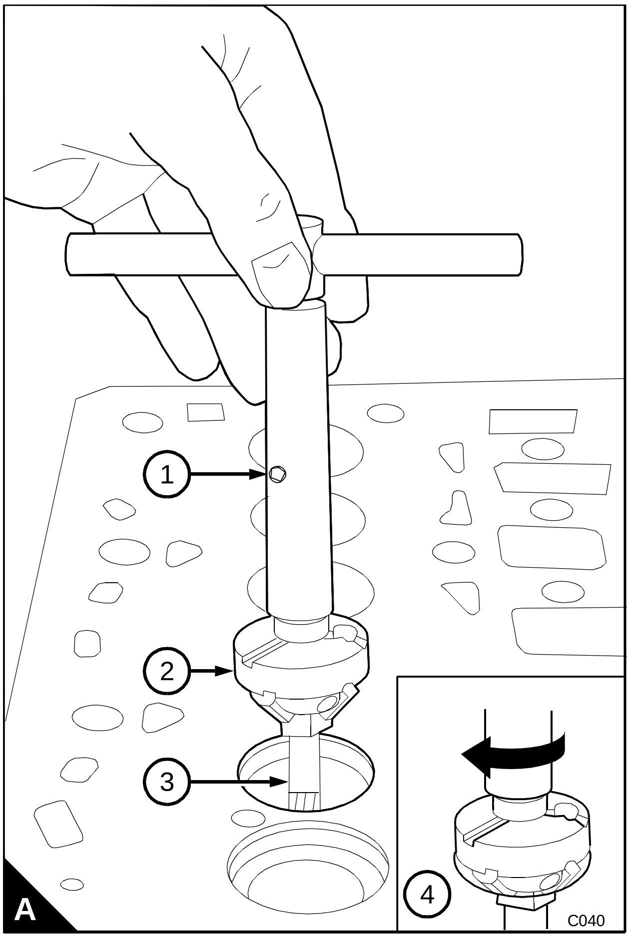


Caution: *Ensure that the valve seat cutter is not allowed to fall on to the seat as this can damage the blades.*

3 Fit the reamer/cutter assembly into the valve guide. Carefully turn the handle in a clockwise direction (B4) and gradually move the reamer into the valve guide until the valve guide is reamed to the finished size. A lubricant is not necessary.

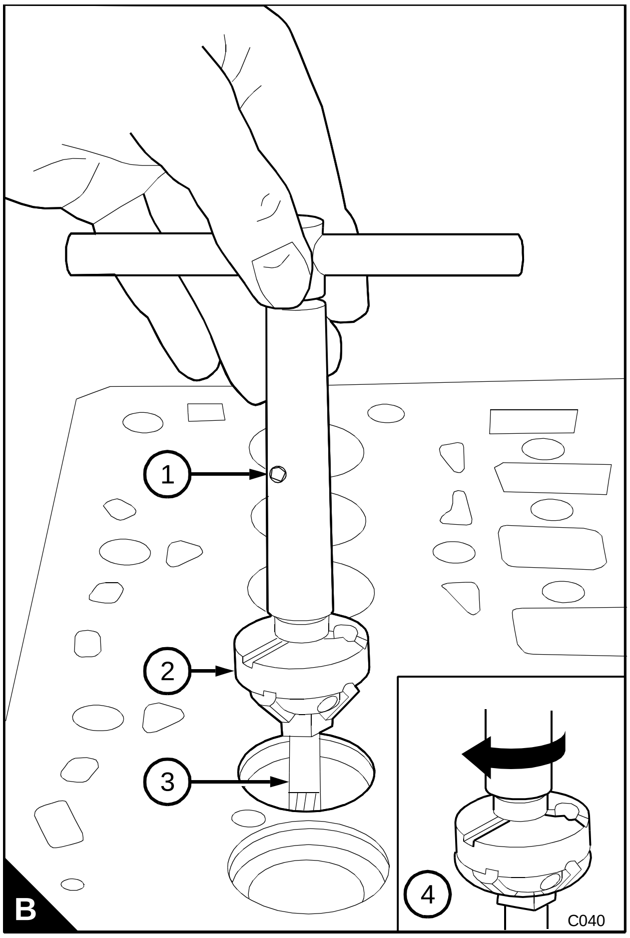
4 Continue to turn the handle in a clockwise direction to cut the valve seat. Remove only the minimum material to ensure a good valve seat. Keep the seat as narrow as possible.

5 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.

6 Fit the valve.

7 Check that the valve depth is within limits, refer to the Data and dimensions for "Inlet 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 3-23. 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 3-23**

1 Remove the valve guide and clean the bore into which the guide is to be fitted.

2 Fit new partially finished valve guides, see Operation 3-19.

3 With the bore of the new partially finished valve guide used as a pilot, machine the recess in the cylinder head to the correct dimensions, refer to the Data and dimensions for "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. For the dimensions of the valve seat insert tool, refer to the Data and dimensions "Valve seat insert tool" on page 15. 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 88° for 46° valve seats or 118° for 31° valve seats, see Operation 3-22. Ensure that the depth of the valve head below the face of the cylinder head is within the production limits, refer to the Data and dimensions "Inlet and exhaust valves" on page 13 for the production limits. Work as near as possible to the minimum figure to allow for future wear on the valve seat.

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Piston and connecting rod assemblies

General description

The pistons used in the New 1000 Series engines have a "Fastram" combustion chamber in the top of the piston (A). The piston (B) for engine types AR and AS has two recesses in the top face for the valves. 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.

Note: Engine types AR and AS have only one cooling jet fitted to spray the number one piston.

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. In production, there are six grades of connecting rods that can be fitted to the engines. In service for engines fitted with serrated connecting rods, there are four grades of connecting rod and one piston available to obtain the correct piston height. For engines fitted with flat faced connecting rods there are two grades of connecting rod and one piston available 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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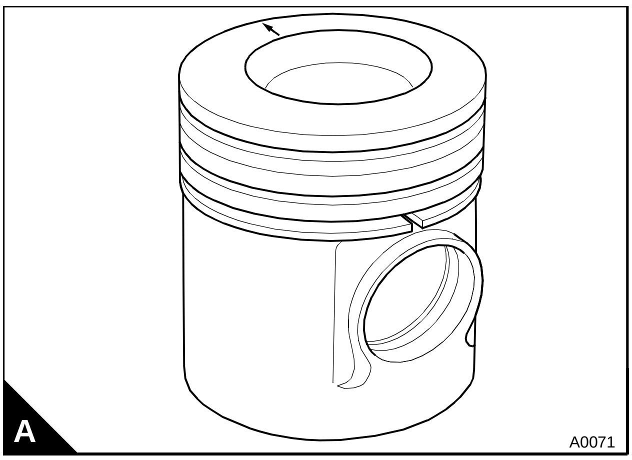
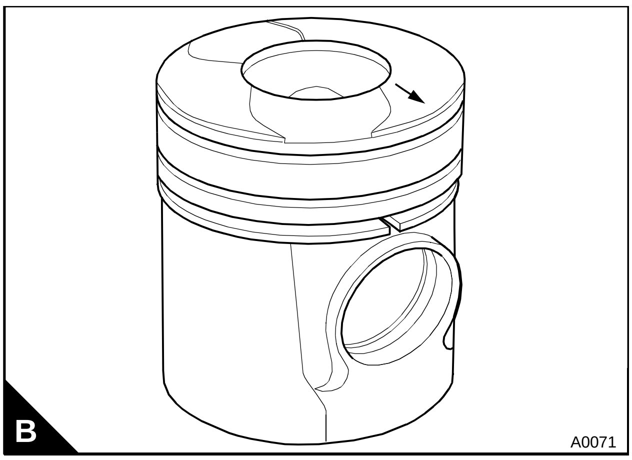




In service, a partially finished small-end bush is available, which can be fitted to the original connecting rod and machined to obtain the correct length grade, see Operation 4-14. Specialist equipment and personnel with the correct training are needed to machine the partially finished small-end bush.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

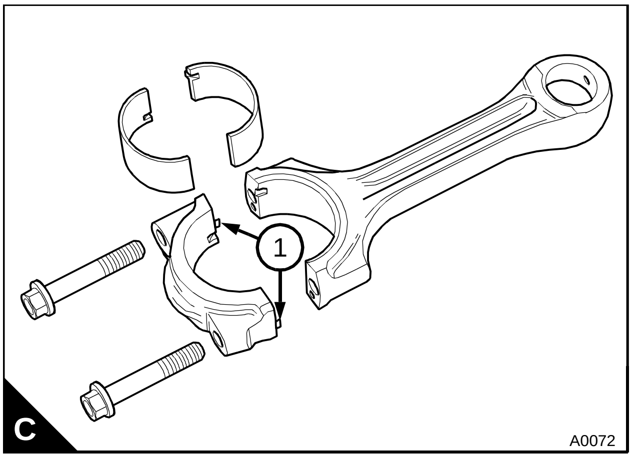
Notes:

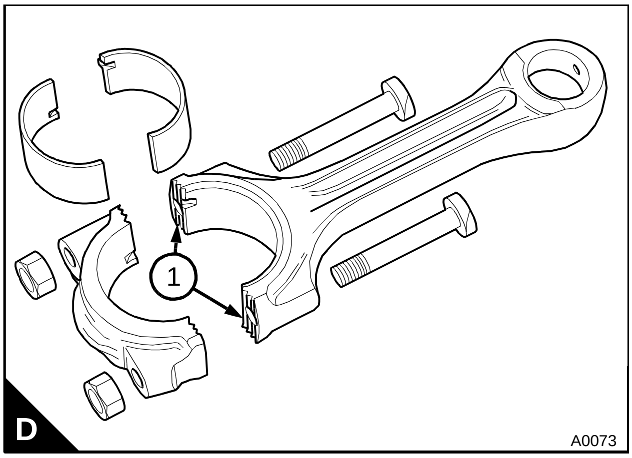
- If the crankshaft or the cylinder block is to be renewed, it may be necessary to change the grade of the connecting rods, see Operation 4-11. This will occur if the correct piston height above the cylinder block face cannot be maintained with the original connecting rod assemblies, see Operation 4-6.
- Engine types AR and AS do not have cylinder liners fitted and the cylinder bores must be machined oversize to correct a worn cylinder bore. Two oversize pistons and piston rings are available in service 0,5 mm (0.020 in) and 1,00 mm (0.040 in).
- Always use the engine identification number to order new parts.

The connecting rods are machined from "H" section forgings of molybdenum steel. They have wedge shaped small ends.

Location of the bearing cap to the connecting rod is made by dowels (C1) fitted in the bearing cap. The faces of the connecting rods and caps are flat and the caps are retained by two setscrews.

Some engines have bearing caps with serrations (D1) which are used to ensure the correct location of the bearing caps to the connecting rods. These caps are retained by two nuts and bolts.





Big end bearing

To remove **Operation 4-1**

Notes:
- There are location thimbles (B1) fitted to the latest bolts used with connecting rods that have serrated faces.
- The location thimbles are used in the factory to prevent movement of the bolts when the nuts for the big end cap are tightened by automatic equipment.
- When the connecting rods are fitted in service it is not necessary to use the location thimbles and they can be discarded.

1 Drain the engine lubricating oil.

2 Remove the lubricating oil sump, see Operation 10-3.

3 Remove the lubricating oil strainer and suction pipe, see Operation 10-4 or remove the balancer unit, see Operation 5-18.

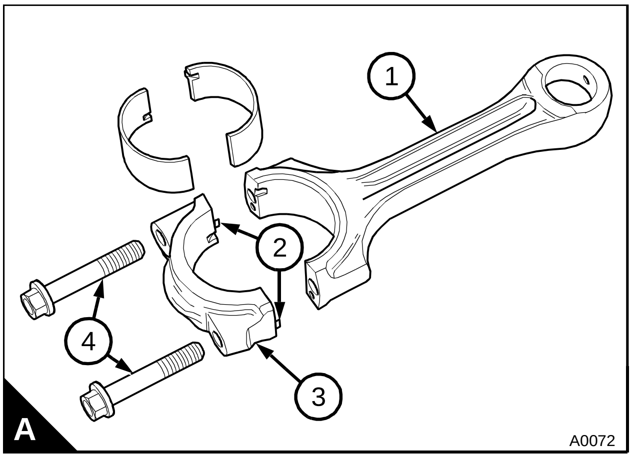
4 Rotate the crankshaft until the relevant connecting rod is at its lowest position.

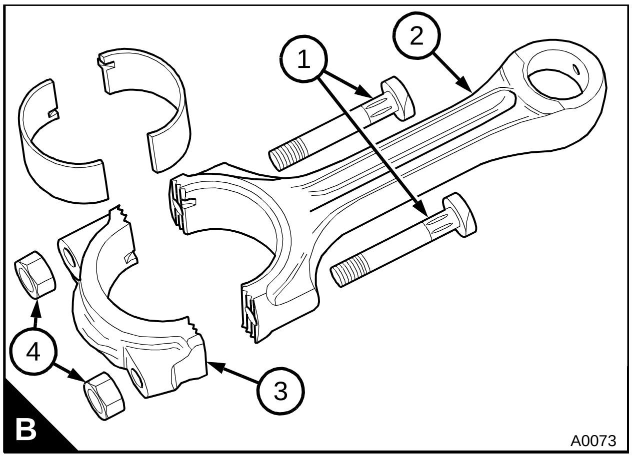
5 Release the nuts (B4) and remove the bearing cap (B3). Remove the bolts from the connecting rod (B2). If the bearing cap is retained by setscrews (A4), the location of the bearing cap (A3) will be by two dowels (A2). To remove these bearing caps, release the setscrews by approximately four turns. Lightly hit the heads of the setscrews with a soft face hammer to separate the connecting rod (A1) from the bearing cap. Remove the setscrews and the bearing cap.

6 Remove the lower half of the shell bearing from the cap, but keep it with its relevant cap.

7 Carefully push the connecting rod up the cylinder bore just enough to allow access to the upper half of the shell bearing. Remove the bearing from the connecting rod. Keep the bearings from the connecting rod and cap together.

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.

2 Ensure that the protrusion for the location dowels is 3,0/4,5 mm (0.12/0.18 in) above the cap faces. Clean the complete bearing and lubricate the bearing surface and the crank pin with clean engine lubricating oil.

Fit the upper half of the shell bearing to the connecting rod; ensure that the location tag is fitted correctly in its recess (A1). Fit the connecting rod to the crank pin; ensure that the assembly number on the connecting rod is on the same side as the other connecting rods.

Note: If the bearing cap is secured by nuts and bolts, new nuts must be fitted.

3 Clean, lubricate and fit the lower half of the shell bearings into the cap; ensure that the location tag is fitted correctly in its recess (A1). Fit the cap to the connecting rod. Ensure that the assembly number on the cap is the same as that on the connecting rod and that both of the assembly numbers are on the same side (B1).

4 Tighten the fasteners gradually and evenly to the recommended torque of 155 Nm (114 lbf ft) 15,8 kgf m for setscrews, or 125 Nm (92 lbf ft) 12,7 kgf m for nuts.

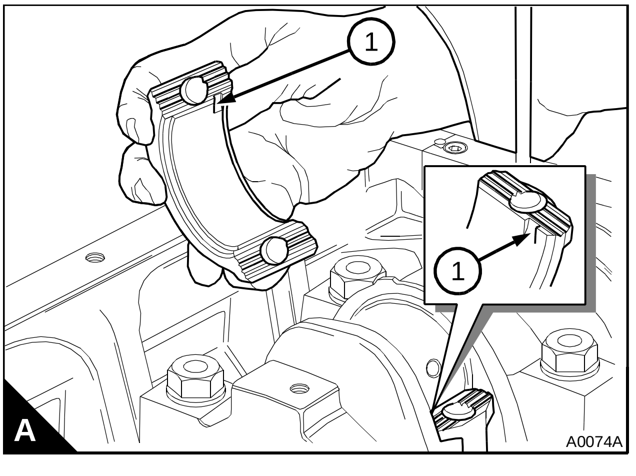
5 Ensure that the crankshaft rotates freely.

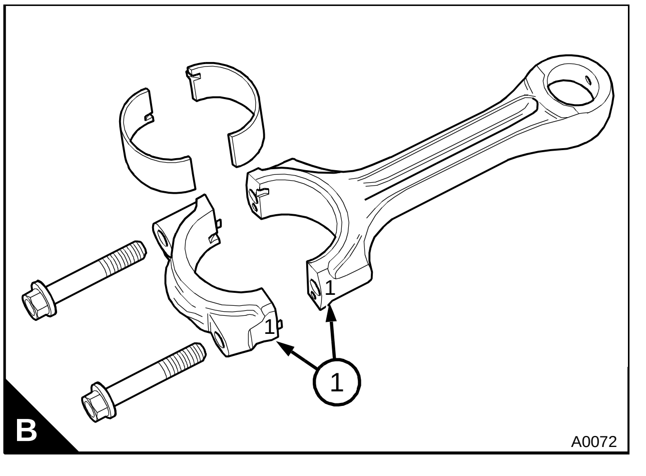
6 Fit the lubricating oil strainer and suction pipe, see Operation 10-4 or fit the balancer unit, see Operation 5-18.

7 Fit the lubricating oil sump, see Operation 10-3 and fill the sump to the correct level with lubricating oil of an approved grade.

To inspect **Operation 4-3**

Check the bearings and the crank pin for wear or other damage, renew if necessary.





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 3-12.

3 Remove all carbon from the top of the bores of the cylinder liners.

4 Remove the lubricating oil sump, see Operation 10-3.

5 Remove the lubricating oil strainer and suction pipe, see Operation 10-4, or the balancer unit, see Operation 5-18.

Caution: *The pistons and connecting rods are matched to the relevant cylinder. Note the position of each connecting rod and piston for 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, check its alignment, see Operation 4-16, and 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 block. 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	21855615

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

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

3 Fit the upper half of the shell bearing to the connecting rod. Ensure that the location tag is fitted correctly in its recess. 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 as the connecting rod assembly is fitted.*

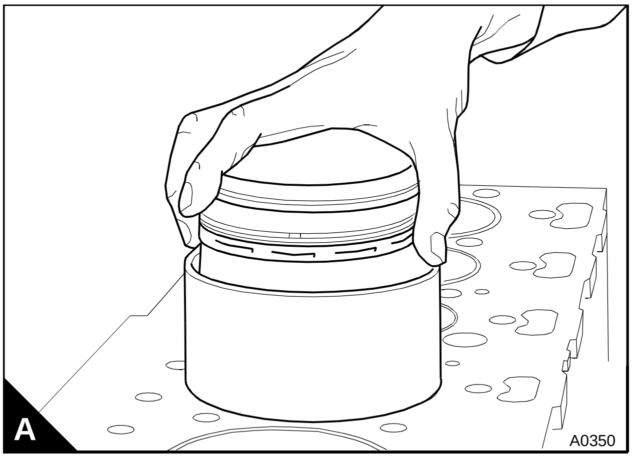
6 Push the piston and connecting rod assembly through the piston replacer tool (A) and onto the crank pin. The piston and connecting rod assembly must be rotated to ensure that the connecting rod will not hit the piston cooling jet as the assembly is fitted. When the connecting rod has passed the piston cooling jet, rotate the connecting rod until the arrow mark on top of the piston is towards the front of the engine.

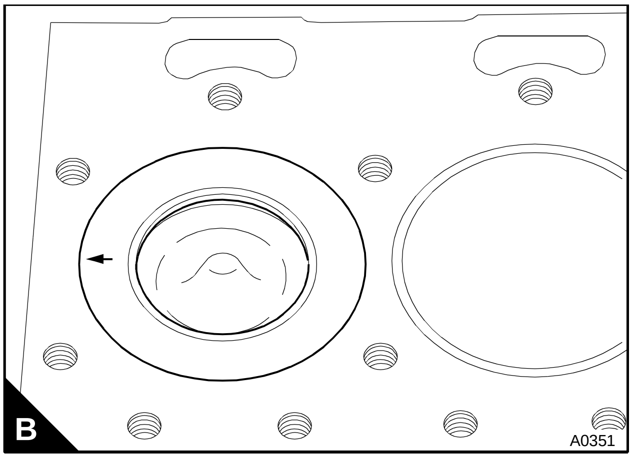
Note: If the bearing cap is secured by nuts and bolts, new nuts must be fitted.

7 Clean the connecting rod cap and the lower half of the shell bearings. Fit the bearing to the cap, ensure that the location tag is fitted correctly in its recess. 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 to the recommended torque of 155 Nm (114 lbf ft) 15,8 kgf m for setscrews, or 125 Nm (92 lbf ft) 12,7 kgf m for nuts.

8 Check that the crankshaft will rotate freely.

Continued





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

10 Fit the lubricating oil strainer and suction pipe, see Operation 10-4, or the balancer unit, see Operation 5-18.

11 Fit the lubricating oil sump, see Operation 10-3.

12 Fit the cylinder head assembly, see Operation 3-13 or Operation 3-14.

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

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 and valve depth gauge	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.*

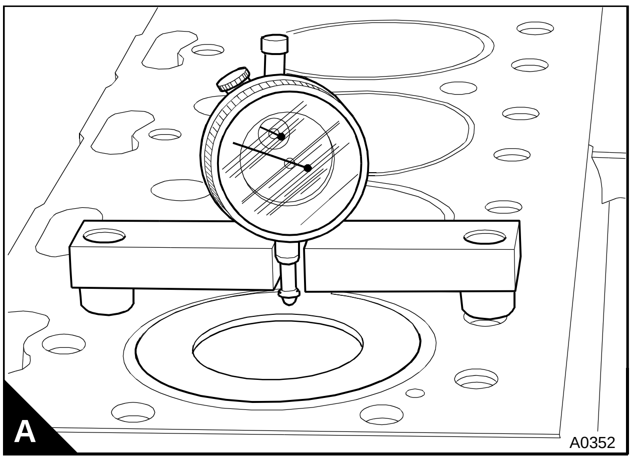
Put the piston height tool (A) on the face of the cylinder block and rotate the gauge dial to the zero position. Rotate the crankshaft until the piston crown is approximately at top dead centre (TDC). Carefully put the tool over the top of the piston with the plunger of the gauge in contact with the 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 0,36/0,50 mm (0.014/0.020 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.*

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 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 (B3) or (C3). Ensure that the ring gap is at 180° to the latch pin.

Note: A small taper has been added to the oil control rings for engine types AR and AS. This is to reduce the oil consumption during the early life of the engine. When new oil control rings are fitted, the blue mark must be fitted to the left of the piston ring gap. The word ‘TOP’ will then be toward the top of the piston.

2 Fit the cast iron ring with the taper face into the second groove, with the word "TOP" towards the top of the piston.

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

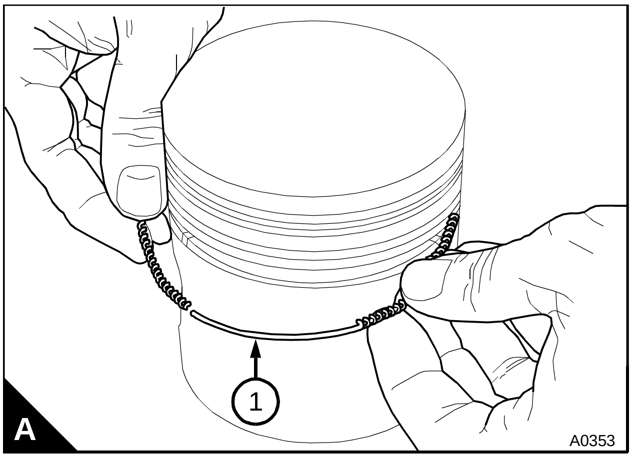
The second ring has a step (B2) or (C2) at the bottom of the tapered face.

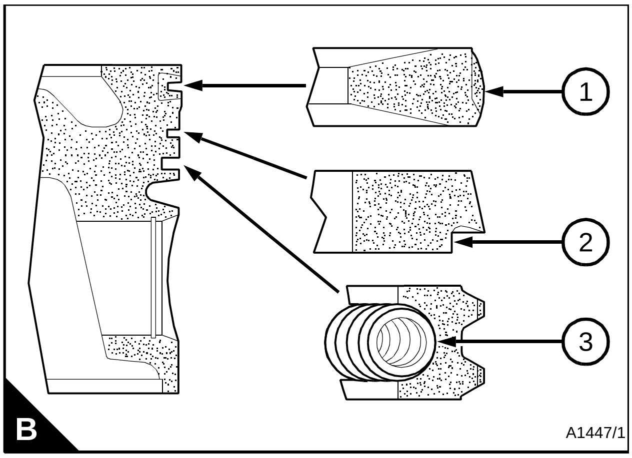
3 Fit the tapered, top ring (B1) or (C1) with the word 'TOP' towards the top of the piston.

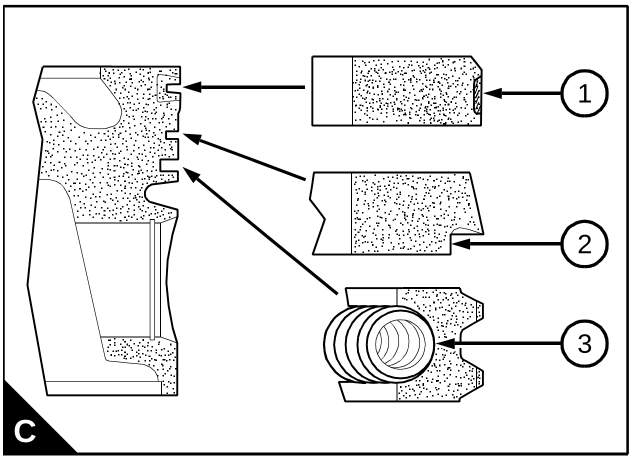
Note: The top ring (C1) of engine types AR and AS is parallel.

New top rings have a red identification mark which must be on the left of the ring gap when the ring is fitted and the piston is upright.

4 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.

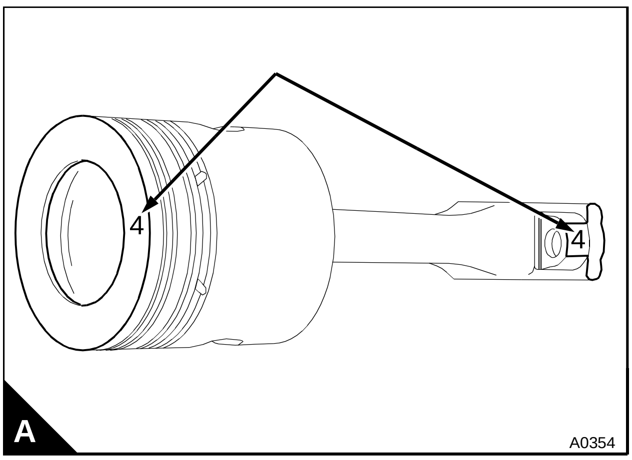
2 Remove the circlips which retain the gudgeon pin.

Caution: *Make a temporary mark on the piston. 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.

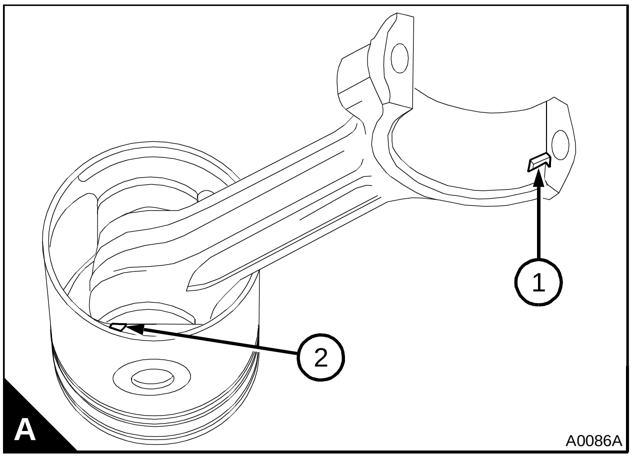
2 Fit a new circlip in the circlip groove of one of the gudgeon pin bosses. Ensure that it fits correctly in the groove.

3 With the piston upside down, put the connecting rod in position with the recess for the location of the big end bearing (B1) on the same side as the recess in the gudgeon pin boss (B2). If the original piston is used, ensure that it is assembled to the correct connecting rod and is used in the original cylinder. If a new 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*:**

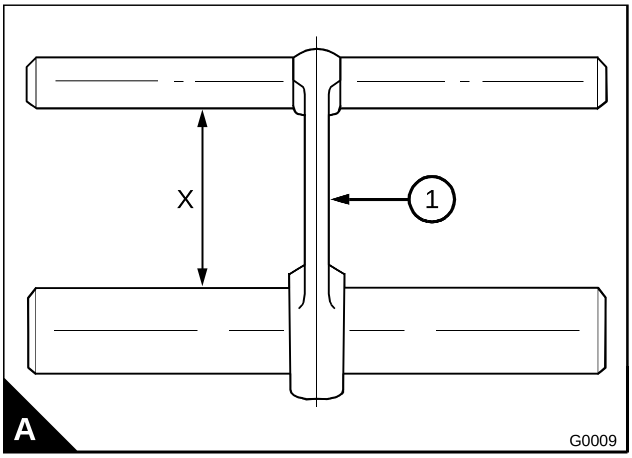
- *It is important that the piston does not contact the cylinder head. Ensure that the piston height above the cylinder block is correct.*
- *Ensure that the connecting rods are fitted in the correct cylinder. Record the position of the connecting rod and its relevant cylinder when it is removed from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

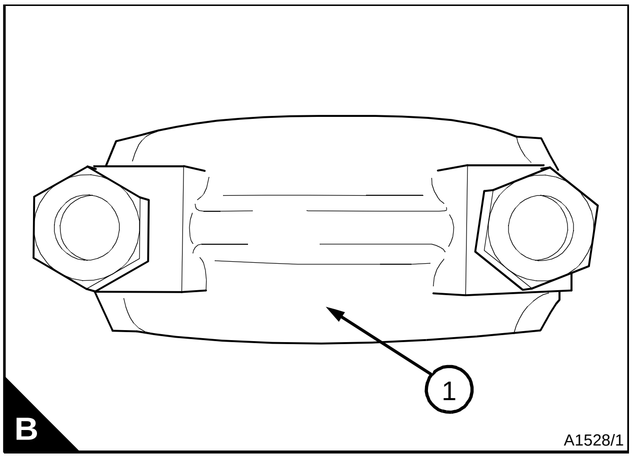
To ensure that the piston height above the cylinder block is correct, the engine may have up to six length grades (F to L) of connecting rods fitted. In service for engines fitted with serrated connecting rods, there are four grades of connecting rod (H,J,K and L) and one piston available to obtain the correct piston height. For engines fitted with flat faced connecting rods there are two grades of connecting rod (H and L) and one piston available to obtain the correct piston height.

Identification of the length grade is by a colour marked either on the side of the connecting rod (A1) or on later engines at the top of the big end cap (B1). In the table below the letter H is the longest grade of connecting rod and letter L is the shortest grade. The difference between each grade is 0,046 mm (0.0018 in).

If the grade colour on the side of the connecting rod or at the top of the big end cap cannot be seen, the length can be checked by the measurement of the dimension (X) shown in (A) on both sides of the connecting rod. Measure as close as possible to the connecting rod. Calculate the average of the two measurements to find the length of the connecting rod. 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 4-14. The length is checked with the big end bearing removed and the original small end bush fitted. The dimensions for the service grades are listed in the table below:

Grade letter	Colour code	Length (mm)
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.

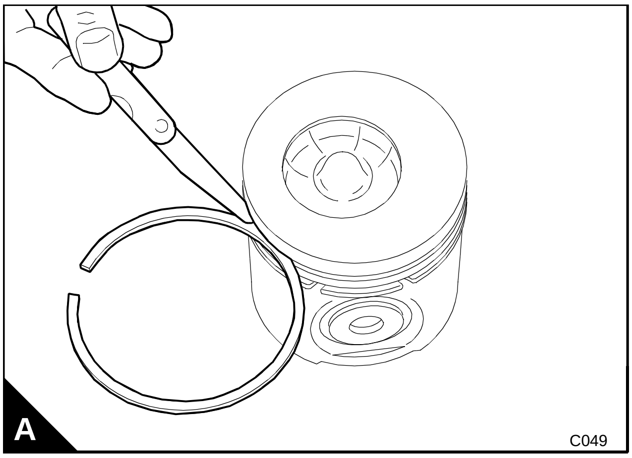
2 Check that the piston rings are free to move in their grooves and that the rings are not broken.

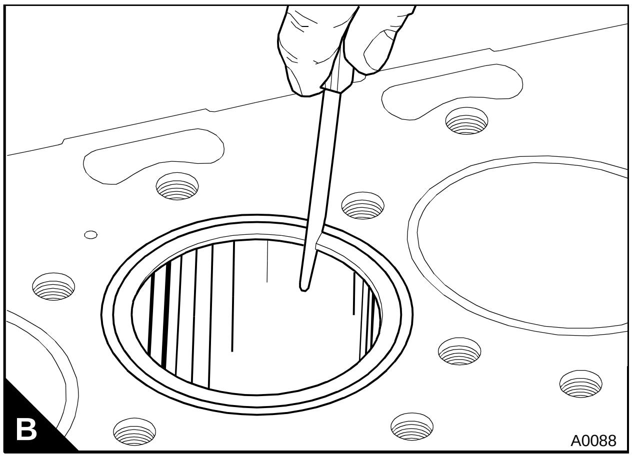
3 Remove the piston rings, see Operation 4-7, and clean the piston ring grooves and the piston rings.

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, refer to the Data and dimensions for "Pistons and piston cooling jets" on page 18, and renew the piston, if necessary.

Note: The pistons have a tapered top groove and the piston ring is wedge shaped, refer to Operation 4-8 (B). The top piston ring clearance cannot be checked by this method.

5 Clean all carbon from the top of the cylinder liners. Fit each piston ring in the top part of the cylinder liner 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. For piston ring gaps on new components, refer to the Data and dimensions for "Piston rings" on page 18.





Connecting rod

To inspect **Operation 4-13**

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

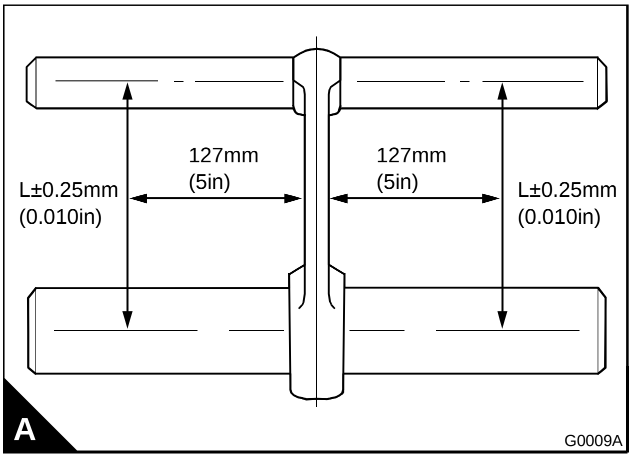
Note: Connecting rod kits are available with a new small-end bush fitted and finished to the correct grade, see Operation 4-11 to identify the correct connecting rod grade.

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 (A). Refer to the Data and dimensions for "Connecting rods and big end bearings" on page 19 to identify the correct mandrel sizes.

Note: The large and small end bores must be square and parallel with each other within the limits of ± 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 ± 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 Data and dimensions for "Gudgeon pins and small end bushes" on page 19.



Partially finished small end bush

To remove and to fit **Operation 4-14**

1 Press out the old bush with a suitable adaptor.

2 Clean the parent bore of the connecting rod and remove any sharp edges.

3 Press in the partially finished bush. Ensure that the lubrication hole in the bush is on the same side as, and is aligned with, the hole in the top of the connecting rod.

Caution: *Do not use a reamer, specialist equipment and personnel with the correct training are needed to machine the partially finished small end bush. For further information refer to your nearest Perkins distributor.*

4 Machine the partially finished bush. To obtain the correct connecting rod grade, see Operation 4-11, and the Data and dimensions for "Connecting rods and big end bearings" on page 19.

To obtain the correct clearance between the gudgeon pin and the bush, refer to the Data and dimensions for "Gudgeon pins and small end bushes" on page 19.

Note: The small end is wedge shaped. After the small end bush has been fitted, machine the bush to the shape of the small end and remove any sharp edges.

Caution: *Do not use a letter stamp to mark the connecting rod.*

5 Check that the grade letter on the connecting rod is correct, if necessary, delete the letter and etch a new letter on to the side of the rod.

Piston cooling jets

To remove and to fit **Operation 4-15**

To remove

Release the valve assembly and remove the piston cooling jet assembly (A).

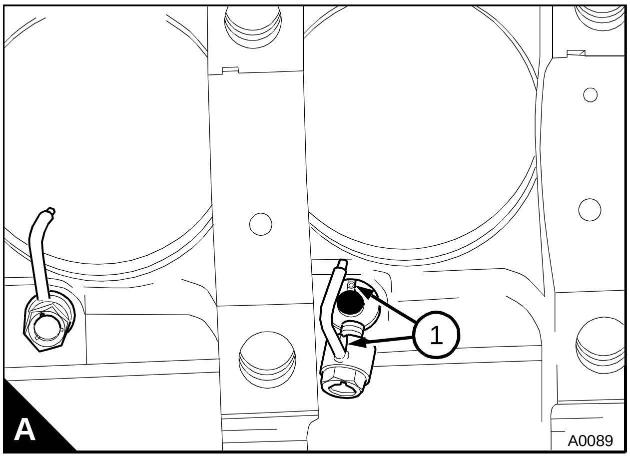
Notes:

- The crankshaft is removed in (A) to show clearly the piston cooling jet.
- Engine types AR and AS have a single piston cooling jet, fitted to the number one cylinder position. The piston cooling jet positions for cylinders 2, 3 and 4 have a blanking plug fitted.

To fit

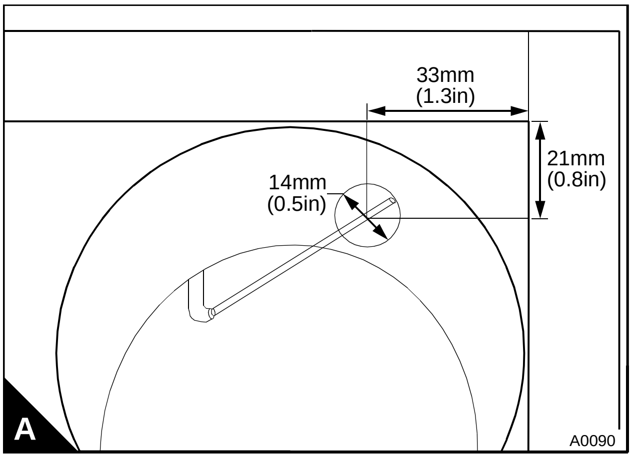
1 Check that the ball moves freely against spring pressure in the valve assembly and that the jet tube is not damaged. Renew the valve assembly and/or the body as necessary.

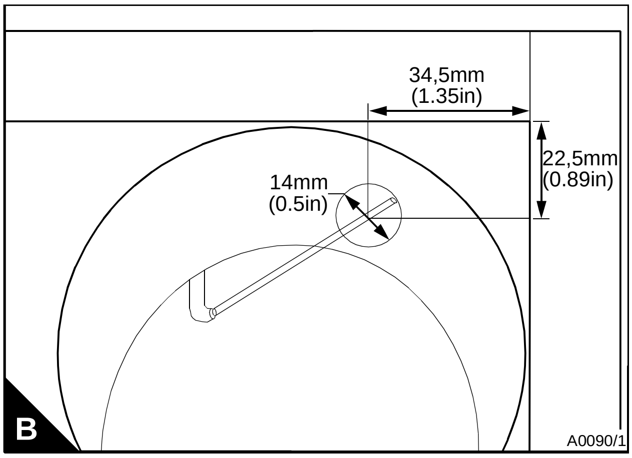
2 Fit the piston cooling jet; ensure that the assembly is fitted correctly on the dowel in the cylinder block. Tighten the valve assembly to 20 Nm (15 lbf ft) 2,0 kgf m.



To check the jet alignment **Operation 4-16**

Insert a 1,70 mm (0.067 in) diameter rod, of suitable 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). For engine types AR and AS use the dimensions shown in (B).





5

Crankshaft assembly

General description

The crankshaft is a chrome-molybdenum forging which has five main journals for four cylinder engines and seven main journals for six cylinder engines.

End-float is controlled by thrust washers on both sides of the centre main bearing.

The main bearings have steel backs with an aluminium/tin bearing material except the centre main bearing of six cylinder engines, which has a bearing material of lead bronze with a lead finish. The main bearing caps are made of cast iron or spheroidal graphite (SG) iron.

The front and the rear oil seals on early engines are Viton lip seals with a dust lip to the outside of the main lip and with oil return grooves on the face of the main lip. The rear end oil seal on later engines is a one-piece assembly.

Warning! *Read the safety precautions for "Viton seals" on page 6.*

The crankshaft pulley (A3) of the four cylinder engine, usually fitted without a damper, is held in position by a plain thrust block (A1) and three setscrews (A2). The nose of the crankshaft is serrated for location.

The location of the front pulley of six cylinder engines is by a key in the crankshaft nose and the pulley is held in position by a tapered rings arrangement (B).

An integral damper, with a rubber insert (B6) is built into the pulley of six cylinder engines and some four cylinder engines.

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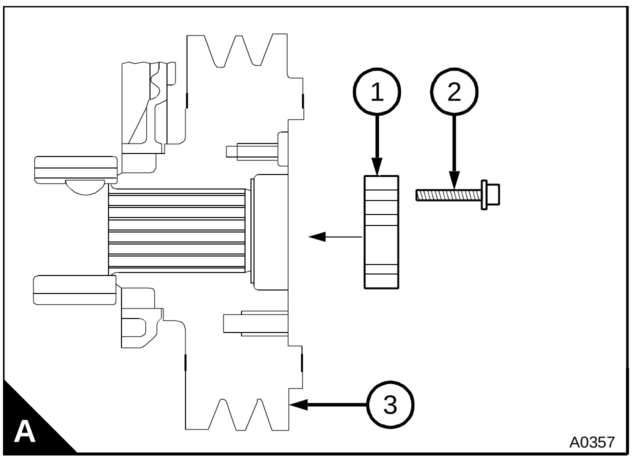
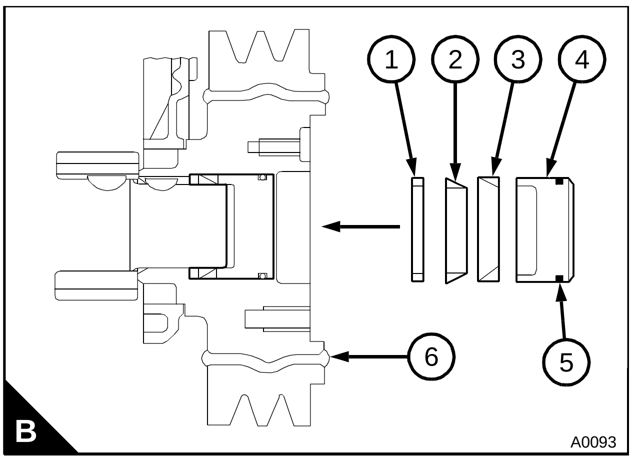
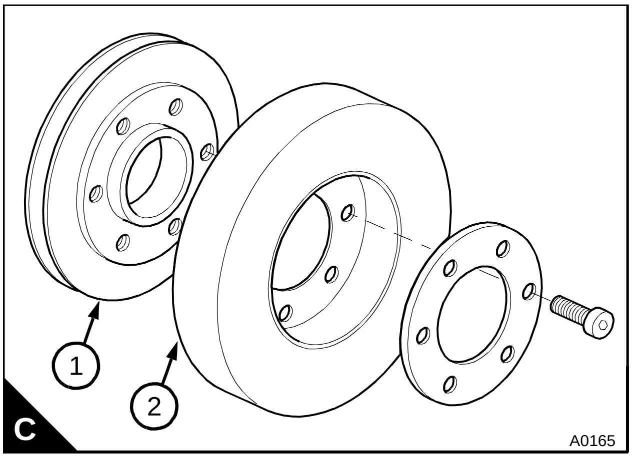




Six cylinder engines have a viscous damper (C2) which is fastened to the front or rear face of the pulley (C1). All of the dampers are designed for the suppression of torsional vibrations in the engine crankshaft.

A balancer unit is fitted to certain four cylinder engines which have rigid mountings or which are part of the chassis or frame. The purpose of the balancer unit is to reduce the effect of the out-of-balance forces.



Crankshaft pulley

To remove and to fit (four cylinder engines) **Operation 5-1**

To remove

1 Remove the drive belt(s), see Operation 14-3.

2 Release the three setscrews (A2) which hold the pulley and remove the setscrews, the thrust block (A1) and the pulley (A3).

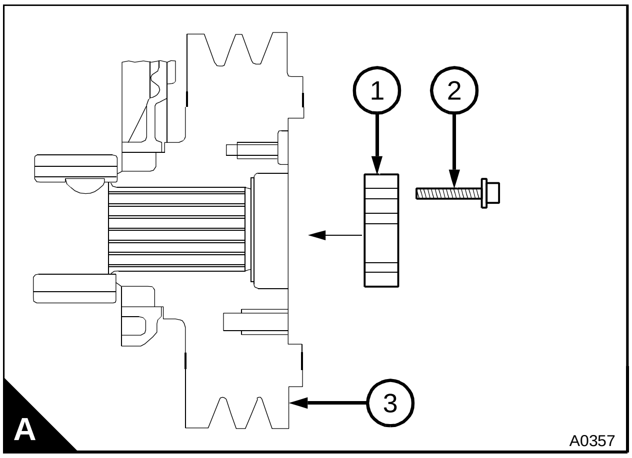
3 Clean the components and check for damage. Renew damaged components.

To fit

1 Put the pulley in position on the crankshaft. Lubricate lightly the threads of the setscrews with engine lubricating oil. Lubricate the main lip of the seal with clean engine oil. Fit the thrust block and the setscrews and tighten the setscrews gradually and evenly 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.



Crankshaft pulley and damper

To remove (six cylinder engines) **Operation 5-2**

Caution: *A viscous damper (A1) should be renewed if there is impact damage to the outer casing or if there is leakage of the viscous fluid from the cover plate. Check for damage in the area around the holes for the damper fasteners.*

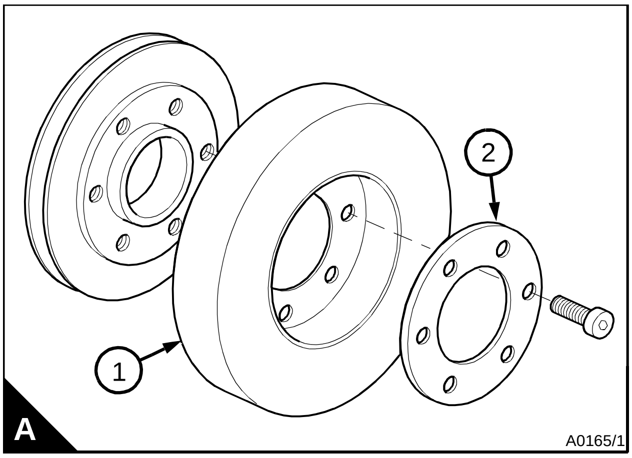
1 Remove the drive belts, see Operation 14-3.

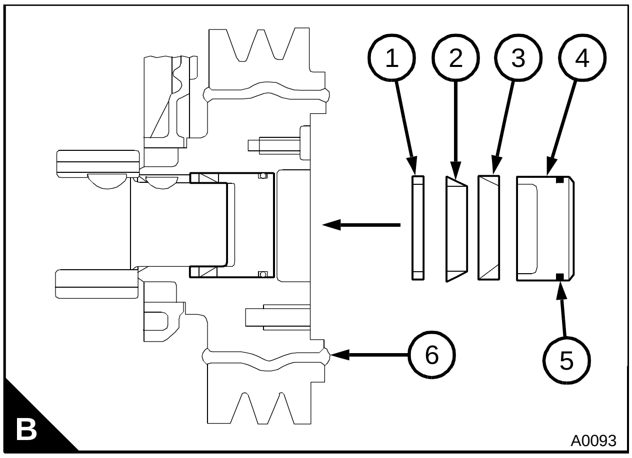
Warning! *The crankshaft pulley and damper assembly is heavy and must be given support before removal.*

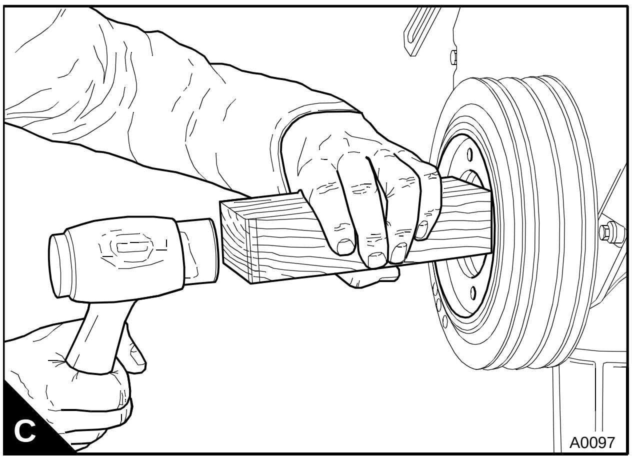
2 Release the fasteners which secure the clamp ring (A2) for the damper to the pulley, if one is fitted, and remove the damper.

Caution: *Do not use an extractor to remove the pulley.*

3 Remove the three setscrews and the thrust block (B4). If the pulley is not free. Hold a wooden block against the inner hub of the pulley and with a hammer, lightly hit the wooden block towards the rear (C) to loosen the tapered rings (B2 and B3).







To fit (six cylinder engines) **Operation 5-3**

Special requirements

Consumable products	
Description	**Part number**
POWERPART Retainer (oil tolerant)	21820603

1 If the damper is fitted to the rear face of the pulley, fit the damper to the pulley with its inner flange against the rear face of the pulley. If a viscous damper is fitted, put the damper in position on the face of the pulley (A1). Fit the clamp ring (A3) or the washers.

Notes:
- On some engines the viscous damper is fitted to the rear of the pulley.
- If a clamp ring with a chamfer on the outside edge of the ring is used, ensure that the chamfer is towards the damper when the ring is fitted. Clamp rings may be fitted to viscous or plate dampers.

Apply POWERPART Retainer (oil tolerant) to the cap screws (A4) for the clamp ring and tighten the cap screws gradually and evenly to 35 Nm (26 lbf ft) 3,6 kgf m. For viscous dampers fitted with M12 setscrews tighten the fasteners to 75 Nm (55 lb ft) 7,6 kgf m.

Caution: *Do not use a degreasing solution.*

2 Clean thoroughly the nose of the crankshaft, the bore of the pulley and the tapered rings components. Do not expand the tapered rings.

3 Put the pulley on the crankshaft with the key engaged and push the pulley towards the rear.

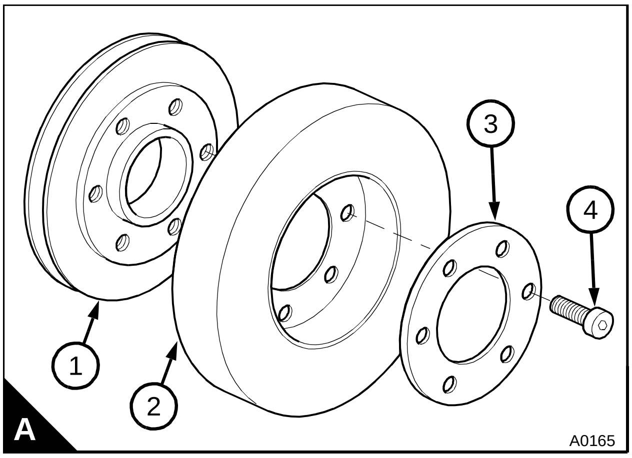
4 Fit the spacer (B1), then the inner ring (B2) and then the outer ring (B3). Ensure that the ring gaps are not aligned.

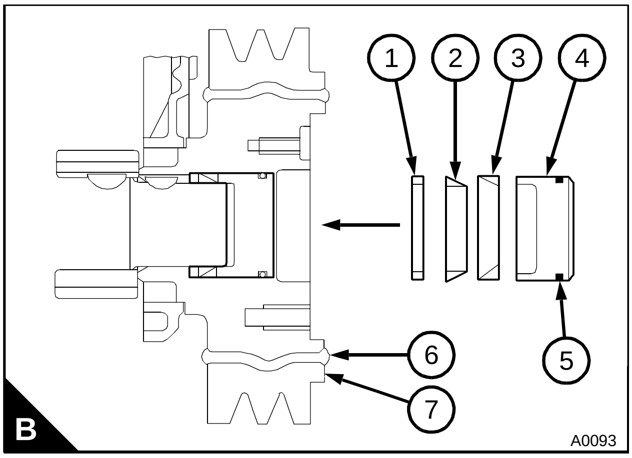
Caution: *It can be very difficult to remove the pulley if the tapered rings are not fitted correctly.*

5 Lubricate lightly the "O" ring (B5) and the threads and the thrust faces of the setscrews with clean engine oil. Put the thrust block (B4) and setscrews in position.

6 While the pulley is pressed to the rear, tighten the setscrews gradually and evenly to 115 Nm (85 lbf ft) 11,8 kgf m. Apply the torque again to ensure the pulley is fully tightened.

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





To inspect **Operation 5-4**

1 When an integral pulley and damper (A) is fitted, the assembly should be renewed if:

- The rubber insert (A1) between the hub and the outer ring is split
- The rubber insert is damaged by oil or solvents
- There is movement of the pulley or outer ring on the hub.

Check for cracks or wear in the area around the holes for the damper fasteners.

Caution: *Do not use excessive force to lever the damper away from the engine.*

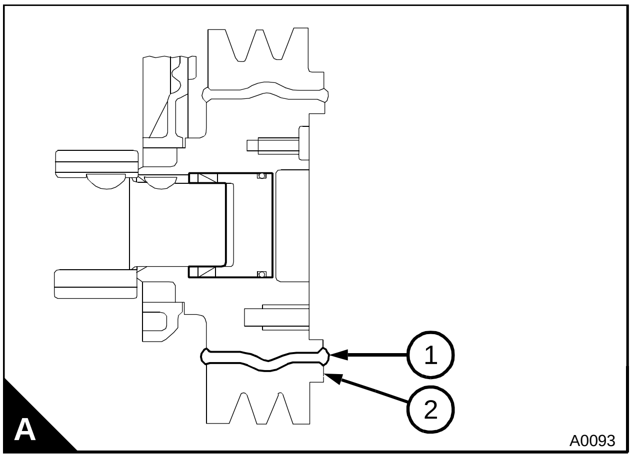
2 Remove any paint or dirt in four positions 90° apart on the face (A2) of the damper, above the rubber insert. Use a lever to move the damper forward and eliminate the crankshaft end-float. Fit a dial test indicator on the front cover of the timing case. Measure the alignment of the damper face at four locations, 90° apart. The maximum permissible difference between the maximum and minimum figures obtained is 0,18 mm (0.007 in).

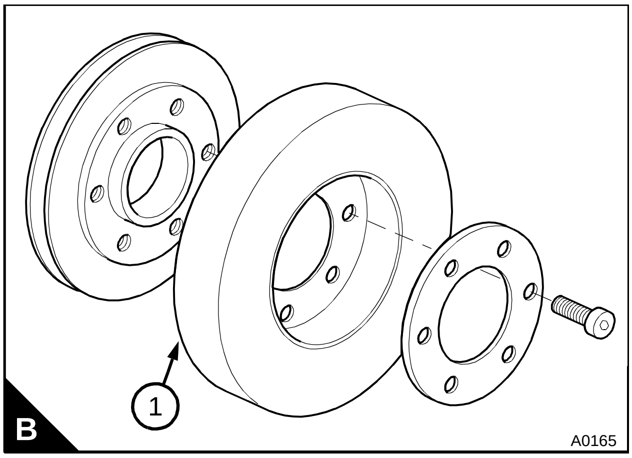
3 Remove any paint or dirt from the circumference of the damper. Fit a dial test indicator on the front cover of the timing case.

4 Rotate the crankshaft slowly one complete revolution and measure for run-out on the circumference of the damper with the dial test indicator. The maximum permissible difference between the maximum and minimum figures obtained is 0,12 mm (0.005 in).

5 If the alignment or the run-out is in excess of the permissible limit, renew the pulley.

6 A viscous damper (B1) must be renewed if there is impact damage to the outer casing or if there is leakage of the viscous fluid from the cover plate. Check for damage in the area around the holes for the damper fasteners.





Rear oil seal assembly

Introduction

Early engines have a two-piece rear end oil seal assembly, the oil seal can be renewed and fitted to different depths in the housing to allow for wear on the crankshaft palm, see Operation 5-7.

Later engines have a one-piece rear end oil seal assembly, the oil seal can not be renewed in the housing, 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 5-8.

Note: The rear end oil seal assembly must be replaced with the same type of assembly, they are not interchangeable as the machining of the cylinder block and bridge piece are not the same.

To remove and to fit (one-piece assembly) **Operation 5-5**

Notes:

- The seal for the (one-piece) assembly fitted to later engines cannot be renewed, if the seal needs to be renewed, 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 5-8.
- An alignment tool is required to fit this rear end oil seal assembly, see page 101 illustration (D).

Caution: *The new rear end oil seal assembly includes a plastic sleeve (A2) that is fitted to the inside of the seal (A3). This 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 seal is fitted. When the seal is fitted, the plastic sleeve will be pushed out of the oil seal housing. The plastic sleeve must be discarded after the seal is fitted. Because 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.*

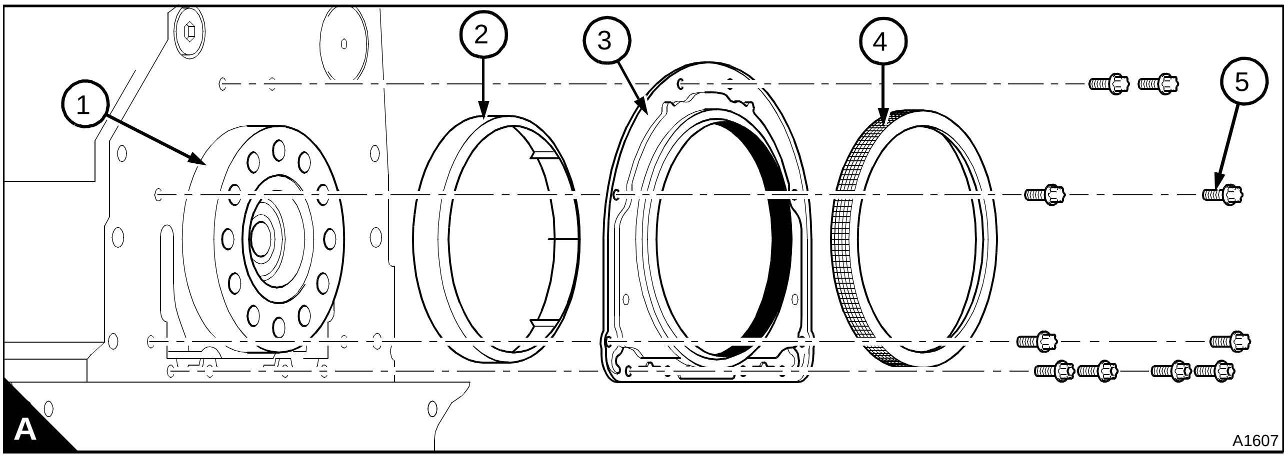
To remove

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 setscrews (A5) from the housing and remove the assembly.

4 Inspect the seal for wear or for damage to the main lip and renew the assembly, if necessary. If there is only a small scratch across the lip, renew the assembly.



To fit

1 Ensure that all parts and surfaces of the engine block are clean and free from oil, grease and dirt.

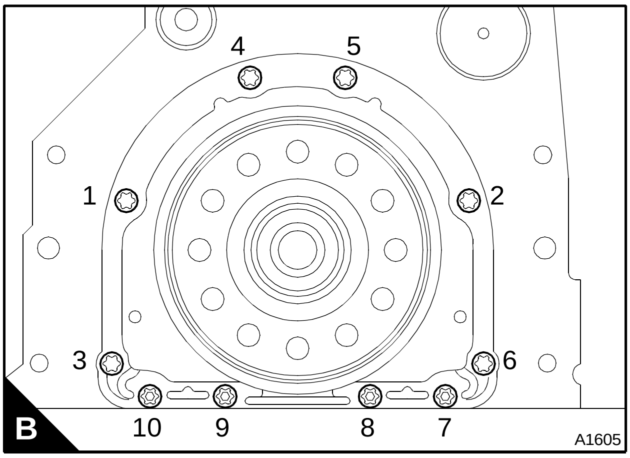
2 Place the new rear assembly onto the crankshaft palm, push the seal on until the seal housing contacts the cylinder block face.

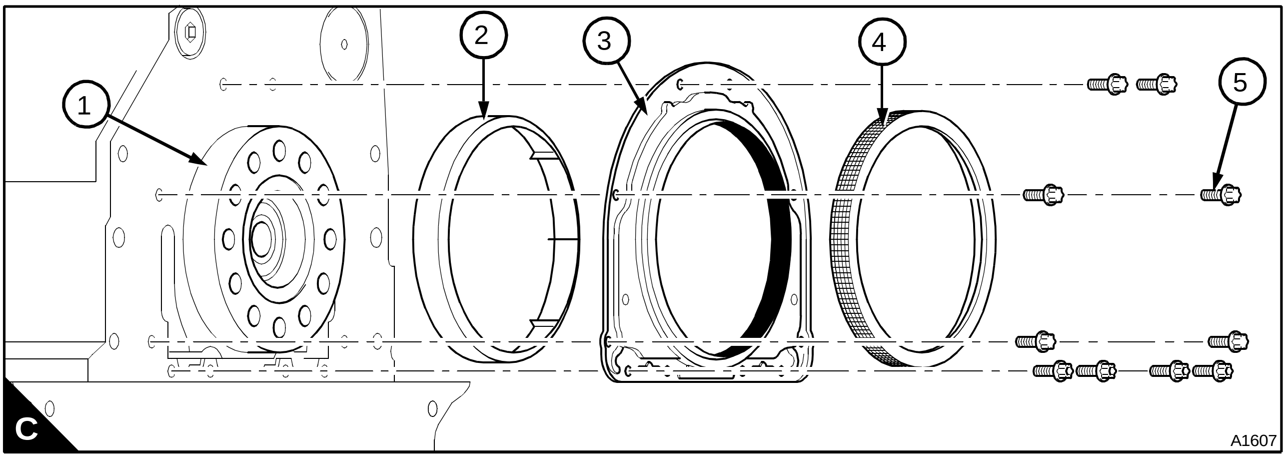
3 Place the alignment tool (C4) over the oil seal assembly housing (C3), this will centralise the seal to the crankshaft palm.

4 With the alignment tool in position fit the setscrews (C5). Tighten screws 1 and 2 (B) to 22 Nm (16 lbf 2.2 Kgf m), remove the alignment tool, tighten the remaining screws in sequence (B) to 22 Nm (16 lbf 2.2 Kgf m).

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

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

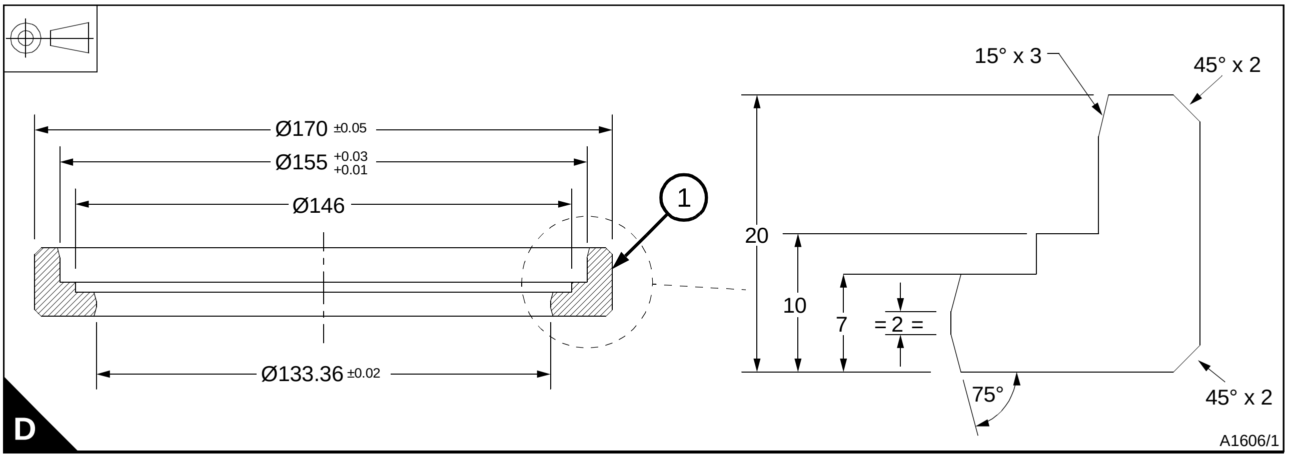




Alignment tool

The alignment tool is not currently available and must be manufactured locally to the following specifications:

1 Outer surface (D1) to be knurled
2 All sharp edges to be removed
3 All dimensions in millimetres
4 To be made from material EN 32, harden 0.5 mm deep.



To remove and to fit (two-piece assembly) **Operation 5-6**

Special requirements

Special tools		Consumable products	
Description	**Part number**	**Description**	**Part number**
Crankshaft rear oil seal adaptor	21825540	POWERPART Threadlock and nutlock	21820117
		POWERPART Silicone rubber sealant	1861108

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 setscrews and the cap screws from the housing and remove the housing and seal assembly.

4 Inspect the seal for wear or for damage to the main lip and renew the seal, if necessary. If there is only a small scratch across the lip, renew the seal.

To fit

1 Clean the faces of the cylinder block, the oil seal housing and the crankshaft flange.

2 Check that the seal and the outer circumference of the crankshaft flange are not damaged. Where a new seal has been fitted, check that it is in the correct position in the housing.

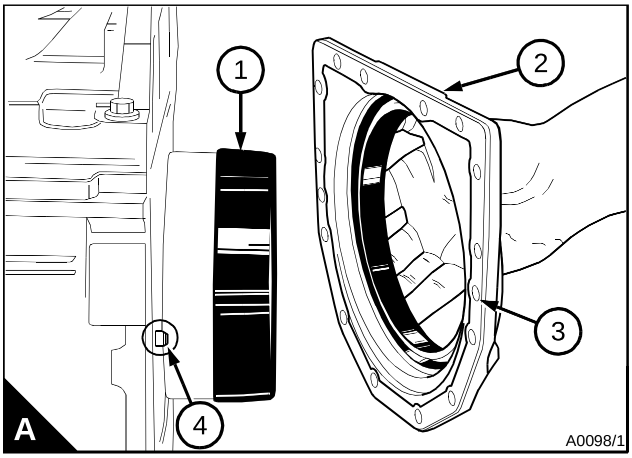
3 Ensure that the two dowels (A4) are fitted in the cylinder block. Put a new joint (A3) in position on the dowels, no jointing compound is necessary.

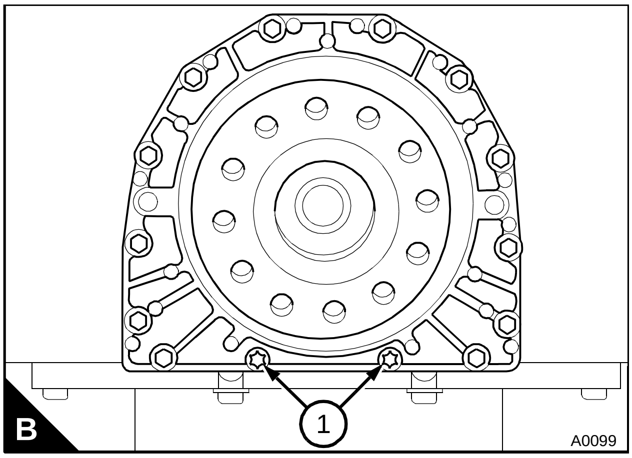
4 Put the seal replacer tool on the crankshaft flange. Lubricate the crankshaft flange, the main lip of the seal and the seal replacer tool with clean engine lubricating oil. The lubrication of the seal is necessary to prevent damage to the seal when the engine is first started.

5 Put the seal and housing (A2) on the replacer tool (A1) and carefully push the assembly into position on the crankshaft flange and onto the dowels. Remove the tool, fit the setscrews and the torx screws (B1). Tighten the setscrews and the torx screws to 22 Nm (16 lbf ft) 2,2 kgf m.

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

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





To renew the rear end oil seal (two-piece assembly) **Operation 5-7**

Special requirements

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

Note: The oil seal of the one-piece rear end oil seal assembly cannot be renewed, the complete assembly must be renewed, see Operation 5-5.

For the two-piece assembly there are three positions in which the seal can be fitted in the housing (A).

- Position "1" (A1) is used when a new seal is first fitted in service.
- Position "2" (A2) is used when a new seal is fitted in service and the crankshaft flange is worn in position "1".
- Position "3" (A3) can be used with a new seal in service, if a wet clutch is not used and the crankshaft is new or the crankshaft palm area has been corrected. Ensure that the seal is fitted square in the housing.

If all positions have been used it is permissible to grind the crankshaft flange, refer to the Data and dimensions for "Crankshaft" on page 20.

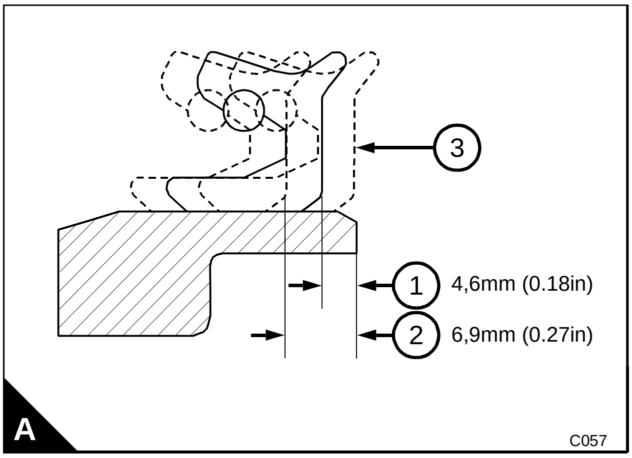
1 Remove the seal and housing assembly, see Operation 5-6.

2 Put the engine side of the housing on a suitable support and press out the seal with a suitable adaptor.

3 Lubricate the outer circumference of the new seal and the bore of the seal housing with clean engine lubricating oil.

4 Put the engine side of the housing on a suitable support. Put the seal into position on the flywheel end of the bore with the spring of the seal towards the housing.

5 Use a press and the replacer tool, 21825540, to fit the seal to the correct depth. The special tool has two sides and is used in accordance with either position "1" or "2". Press the seal into the housing to the correct position with the relevant side of the tool.



To remove and to fit a wear sleeve **Operation 5-8**

To remove

1 Remove the rear end oil seal, see Operation 5-5, or Operation 5-6.

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 spots 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).

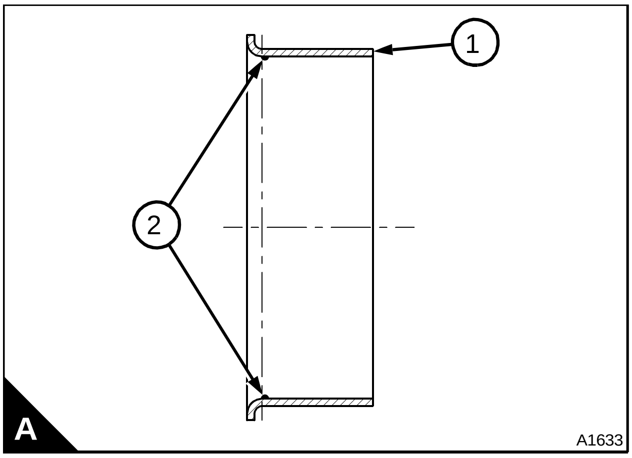
Caution: *The wear sleeve must be fitted within five minutes of applying the sealant.*

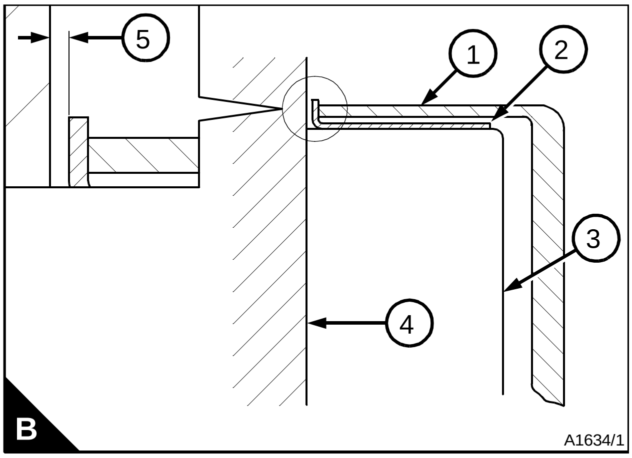
4 Ensure that the crankshaft is fully forward in the engine.

5 Place the wear sleeve on to 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 (A) in two places 180° apart. The correct gap is 0,4/0,6 mm (0.016/0.024 in).

7 Fit a new rear end oil seal, see Operation 5-5 or Operation 5-6.





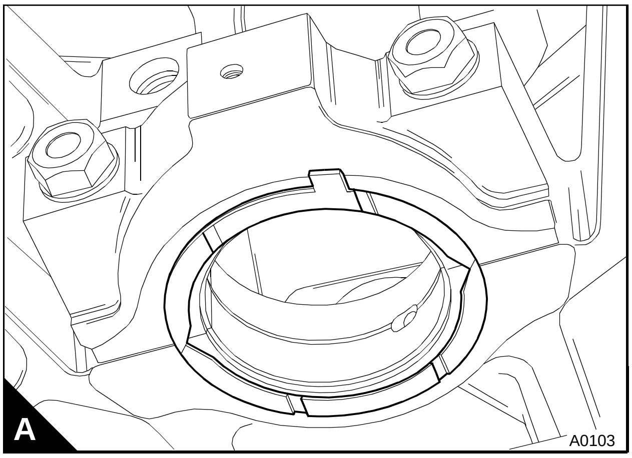
To check crankshaft end-float **Operation 5-9**

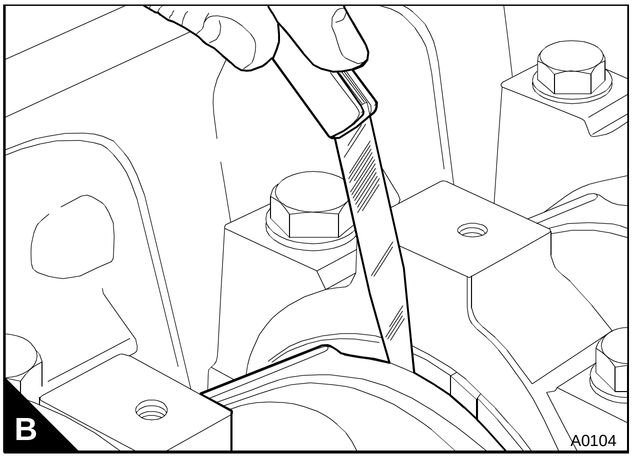
The axial movement of the crankshaft is controlled by thrust washers fitted both sides of the centre main bearing (A).

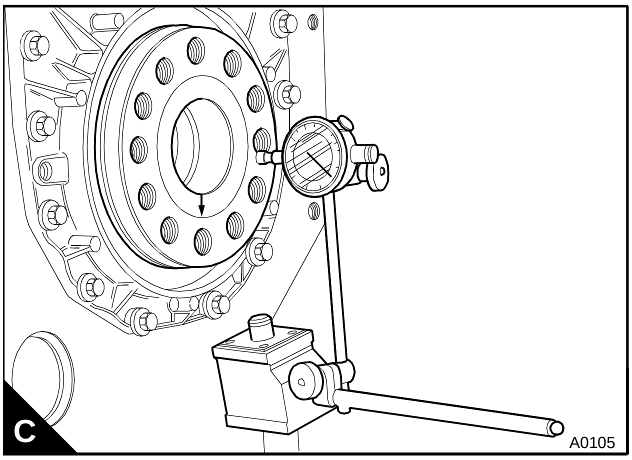
The end-float can be checked with a feeler gauge between a thrust washer and the crankshaft (B), or with a dial test indicator on one end of the crankshaft to check the movement (C).

If the end-float is more than the tolerance, refer to the Data and dimension for "Crankshaft thrust washers" on page 23 then 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 5-10**

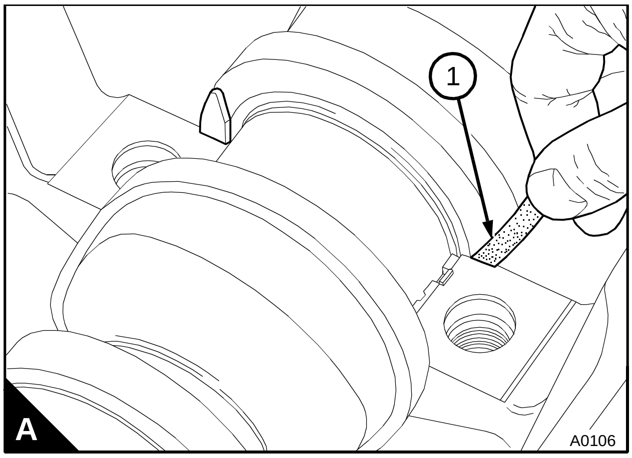
1 Drain the lubricating oil and remove the lubricating oil sump, see Operation 10-3.

2 If necessary, remove the balancer unit, see Operation 5-18.

3 If necessary, remove the lubricating oil strainer and suction pipe, see Operation 10-4.

4 Release the setscrews of the centre main bearing and remove the main bearing cap complete with the lower halves of the thrust washers.

5 Use a suitable tool (A1) made of a soft material to push 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 5-11**

1 Lubricate the thrust washers with clean engine lubricating oil.

2 Slide 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 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.

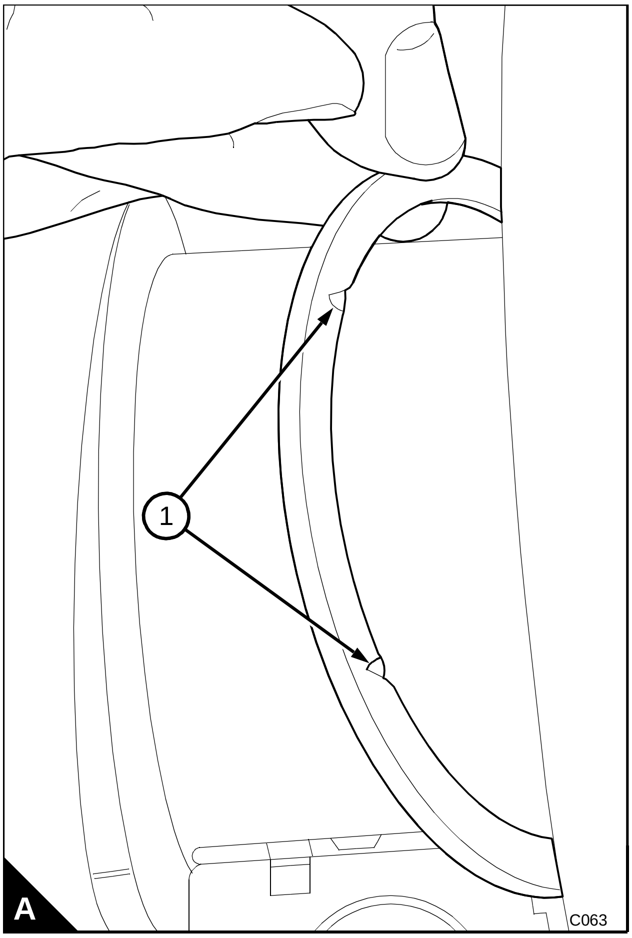
6 Fit the cap with the location tags of both halves of the shell bearings to the same side (B1). Tighten the main bearing setscrews gradually and evenly to 265 Nm (196 lbf ft) 27,0 kgf m.

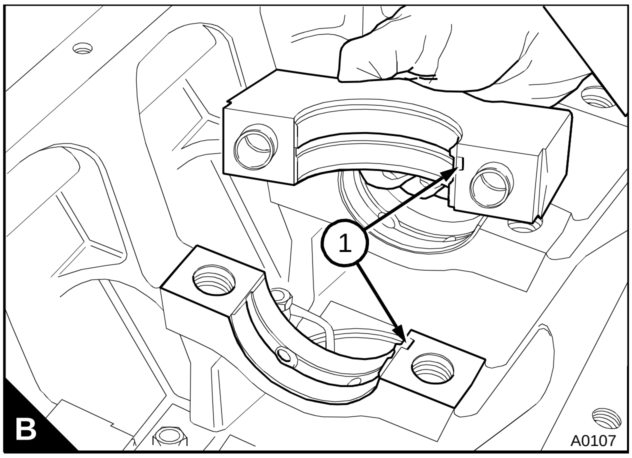
7 Check the crankshaft end-float, see Operation 5-9.

8 If necessary, fit the balancer unit, see Operation 5-18.

9 If necessary, fit the lubricating oil strainer and the suction pipe, see Operation 10-4.

10 Fit the lubricating oil sump, see Operation 10-3, and fill it to the correct level with an approved lubricating oil.





Main bearings

To remove (with the crankshaft in position) **Operation 5-12**

Notes:

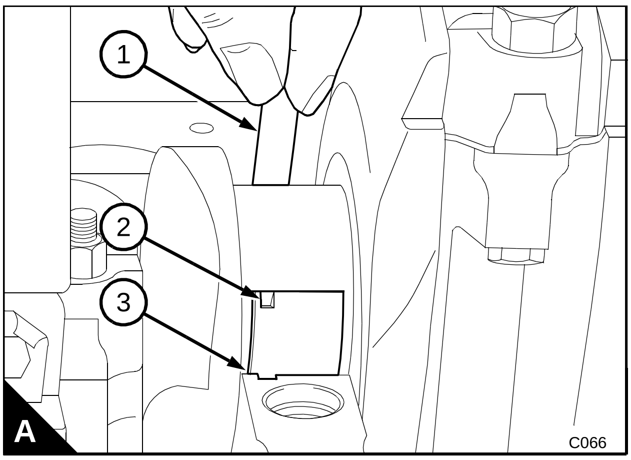
- If the rear main bearing is to be removed with the crankshaft in position, the flywheel, the flywheel housing, the rear oil seal housing and the bridge piece will have to be removed.
- Except for engines with a balancer unit fitted, the front main bearing can only be removed if a suitable spanner is available that will enable the torque to be applied correctly to the setscrews of the main bearing cap. If a suitable spanner is available, the front main bearing cap can be removed together with the oil pump. For six cylinder engines, it will be necessary to remove the suction pipe and strainer and the delivery pipe. For four cylinder engines, either the balancer unit or the suction pipe and strainer, the delivery pipe and the relief valve will have to be removed.

1 Drain the lubricating oil and remove the sump, see Operation 10-3.

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. Keep the bearing halves in their relevant positions.



To fit **Operation 5-13**

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 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 gradually and evenly to 265 Nm (196 lbf ft) 27,0 kgf m.

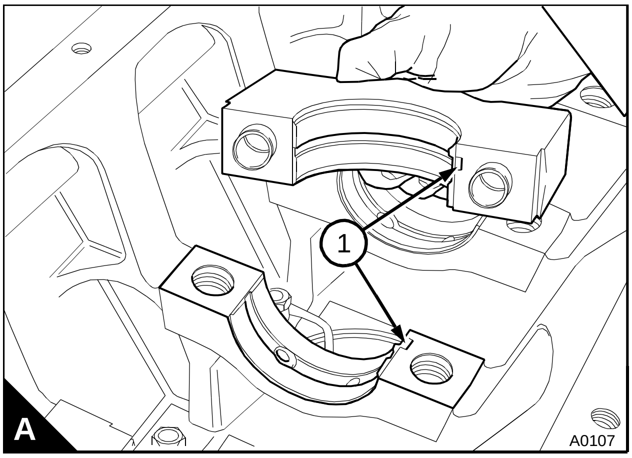
7 Ensure that the crankshaft turns freely. If the thrust washers have been removed and fitted, check the crankshaft end-float, see Operation 5-9.

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

9 Fit the lubricating oil sump, see Operation 10-3 and fill it to the correct level with an approved lubricating oil.

To inspect **Operation 5-14**

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.



To remove **Operation 5-15**

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 10-3.

3 Remove the fan, the drive belts, the fan drive pulley and housing and the coolant pump, see Chapter 12, Cooling system.

4 Remove the fuel injection pump:

- For Bosch fuel injection pumps, see Operation 11-10
- For Lucas/Delphi DP200 Series fuel injection pumps, see Operation 11-13
- For Stanadyne fuel injection pumps, see Operation 11-17.

5 Remove the crankshaft pulley, see Operation 5-1 or Operation 5-2.

6 Remove the alternator and its mounting bracket, see Operation 14-4.

7 Remove the compressor and its drive assembly, see Operation 15-1, or remove the exhauster, see Operation 15-15.

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 oil seal assembly, see Operation 5-5 or Operation 5-6.

12 If a balancer unit is fitted, remove it, see Operation 5-18. If a balancer unit is not fitted, remove the lubricating oil suction pipe and strainer, the lubricating oil pump, the delivery pipe and the relief valve (four cylinder engines) and the lubricating oil crossover pipe, if fitted, see Chapter 10, Lubrication system.

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 of their bores.

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.

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

To fit **Operation 5-16**

Special requirements

Consumable products	
Description	**Part number**
POWERPART Silicone rubber sealant	1861108

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.

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 (as shown by the position number stamped on the top of the cap) with the location tags of the bearings on the same side. In this position the serial numbers stamped on the bearing caps will be in line. The serial number stamped on the bearing caps must be the same as the number stamped on the bottom face of the cylinder block. The third and fifth bearing caps of six cylinder engines are not stamped with a serial number.

8 Fit the setscrews to the main bearing caps and tighten them gradually and evenly to 265 Nm (196 lbf ft) 27,0 kgf m.

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.

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

It may be necessary to stop the sealant at one side of the lower groove in order to ensure it will flow from the opposite side of the groove.

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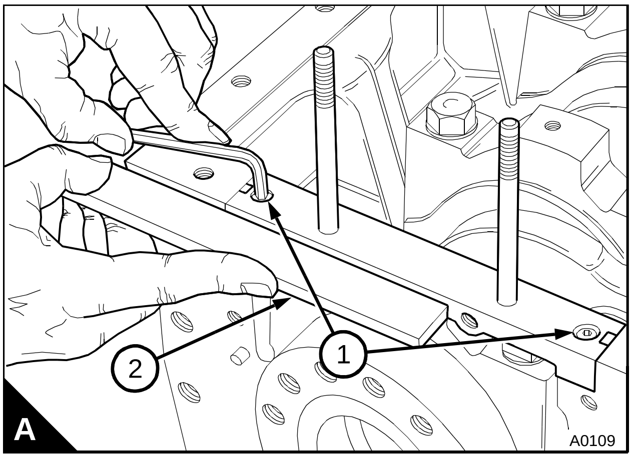
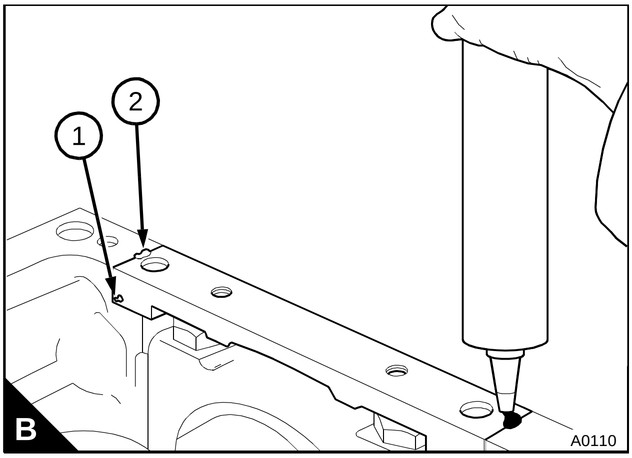




11 Fit the connecting rod caps, see Operation 4-2. Rotate the crankshaft two turns to ensure free movement.

12 On four cylinder engines, if necessary, fit the balancer unit, see Operation 5-18. If a balancer unit is not used, fit the lubricating oil pump, the lubricating oil suction pipe and strainer, the delivery pipe and the relief valve (four cylinder engines) and if necessary, the lubricating oil crossover pipe, see Chapter 10, Lubrication system on page 187.

13 Fit the rear oil seal assembly, see Operation 5-5 or Operation 5-6.

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 compressor and its drive assembly, see Operation 15-2, or fit the exhauster, see Operation 15-15.

18 Fit the alternator and its mounting bracket, see Operation 14-4.

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

20 Fit the fuel injection pump:

- For Bosch fuel injection pumps, see Operation 11-11
- For Lucas/Delphi DP200 Series fuel injection pumps, see Operation 11-14
- For Stanadyne fuel injection pumps, see Operation 11-18.

21 Fit the coolant pump, the fan drive pulley and housing, the drive belts and the fan, see Chapter 12, Cooling system.

22 Fit the lubricating oil sump, see Operation 10-3.

23 After the engine has been installed, fill the lubricating oil sump to the correct level with an approved oil. Fill the cooling system.

To inspect **Operation 5-17**

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 some standard size crank shafts can be machined to 0,25mm (0.010 in), 0,50mm (0.020 in) or 0,75 mm (0.030 in) undersize on diameter, refer to the Data and dimensions for "Crankshaft overhaul" on page 20. Special undersize bearings are available.

If a two-piece rear end oil seal has been used in all of the service positions, the crankshaft palm can be machined to remove the wear marks, refer to the Data and dimensions for "Crankshaft overhaul" on page 20 for further information.

Note: Some engines may be fitted with a new crankshaft that has been hardened with a “Nitreg” process. The new crankshaft is stronger and has an improved surface finish. It is not possible to regrind this crankshaft. For further details, refer to the Data and dimensions for "Crankshaft overhaul" on page 20.

Balancer unit

To remove and to fit **Operation 5-18**

To remove

1 Drain the lubricating oil from the sump and remove the sump, see Operation 10-3.

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

2 Provide a support for the balancer unit before the setscrews are released from the engine.

3 Release the setscrews and lower carefully the balancer unit. Make a note of the positions of the setscrews of different lengths.

To fit

1 Ensure that the contact faces of the cylinder block and of the balancer unit are clean and that the two thimbles (A1) are fitted correctly to the cylinder block.

2 Set the piston of number 1 cylinder to TDC, see Operation 8-1 or Operation 8-2.

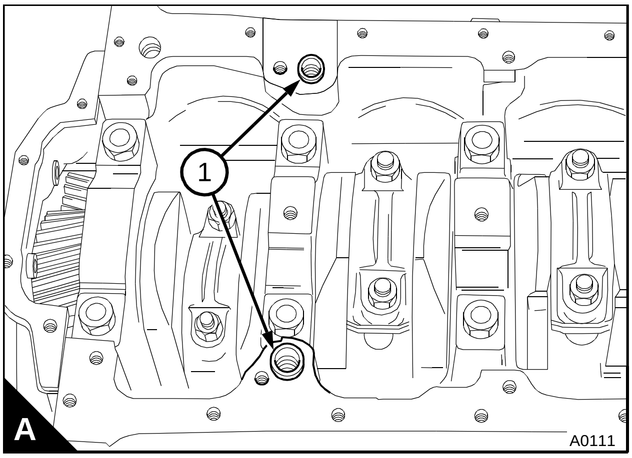
3 Before the balancer unit is fitted, ensure that the flat faces of the balance weights are level with each other (B1) and the weights hang down away from the cylinder block (B2). The timing of the balance weights to the drive shaft is correct when the large hole and small hole in the front of the drive shaft gear are in the positions shown in the illustration (B).

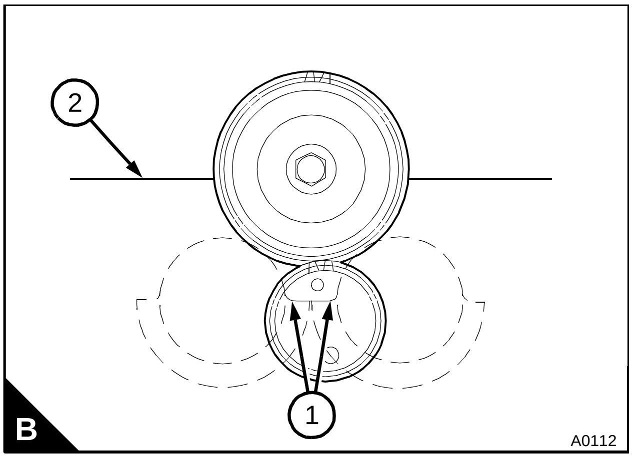
Note: If the gear position shown in (B) cannot be obtained, then the balancer must be partially dismantled and the timing corrected, see Operation 5-19 and Operation 5-20.

4 Fit the balancer unit to the cylinder block with the correct screws in the centre positions of the balancer frame. Ensure, when the idler and crankshaft gears are in mesh, that the flat faces of the balance weight are level with each other and that they are towards the cylinder block. Check that the balancer unit is fitted correctly on the thimbles and fit the remainder of the setscrews in their correct position. Tighten the setscrews to 54 Nm (40 lbf ft) 5,5 kgf m.

5 Rotate the crankshaft through two turns to ensure that it is free to rotate.

6 Fit the lubricating oil sump, see Operation 10-3 and fill the sump to the correct level with an approved oil.





To dismantle **Operation 5-19**

1 Remove the balance weight cover (A8).

2 Release the setscrew and remove the idler gear assembly (A1). Keep the components together as an assembly to protect the needle roller bearing.

3 Prevent movement of the drive shaft (A2) and loosen the nut (A4) of the drive gear for the balance weights (A3). Put a suitable flat distance piece in position between the nut and the balancer frame. Turn the nut until it is against the face of the distance piece. Continue to turn the nut with a suitable spanner until the Loctite seal on the splines of the drive shaft is broken and the gear is loose on the shaft. Remove the nut and the drive gear and remove the drive shaft. Ensure that the needle roller bearings are not damaged when the drive shaft is removed.

4 Release the setscrews which hold the lubricating oil pump and the suction pipe (A10 and A9) to the balancer frame and remove the lubricating oil pump and the suction pipe.

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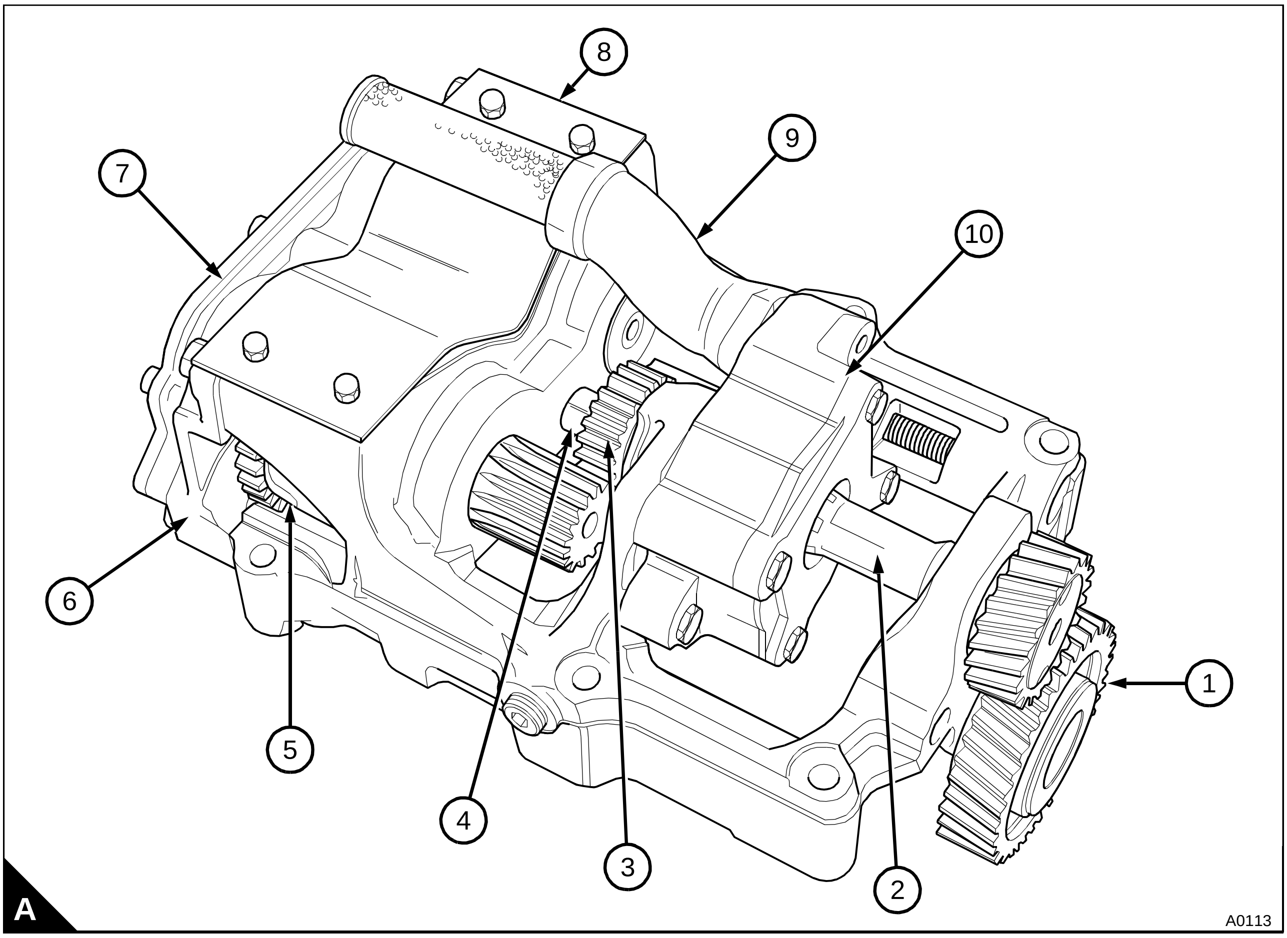


5 Release the setscrews and remove the oil transfer plate and joint from the rear of the balancer unit. Make a note of the position of the direction arrows on the outside of the transfer plate (B or C) to ensure that it can be assembled correctly.

Notes:

- The latest oil transfer plate is fitted without a joint or sealant; always give the correct engine number when parts are needed.
- There are two plugs in the balancer frame, a short tapered plug with a hexagonal socket head and a long plug with a square socket head. These plugs control the flow of oil through the balancer frame. The position of the plugs is decided by which side of the engine the filter is fitted. When the filter is fitted on the left side, the short plug is fitted in the side of the balancer and the long plug is fitted in the bottom. When the filter is fitted on the right side of the engine, the short plug is fitted in the bottom of the balancer and the long plug is fitted in the side.

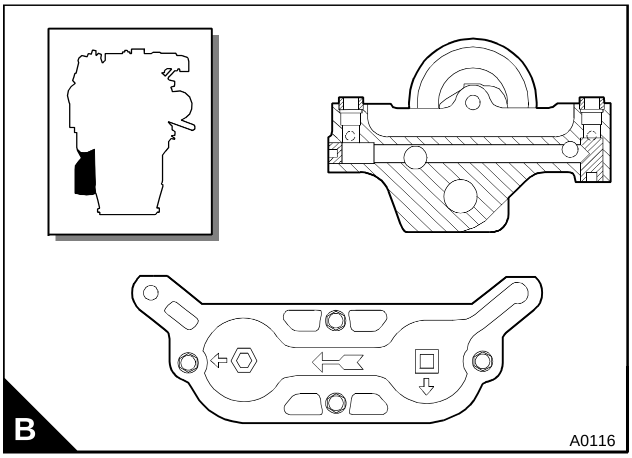
Caution: *Removal of these plugs can cause damage to the threads in the balancer frame and a new balancer frame will be needed. When a balancer unit is to be fitted, ensure that the lubricating oil flow through the balancer frame is correct for the position of the lubricating oil filter.*

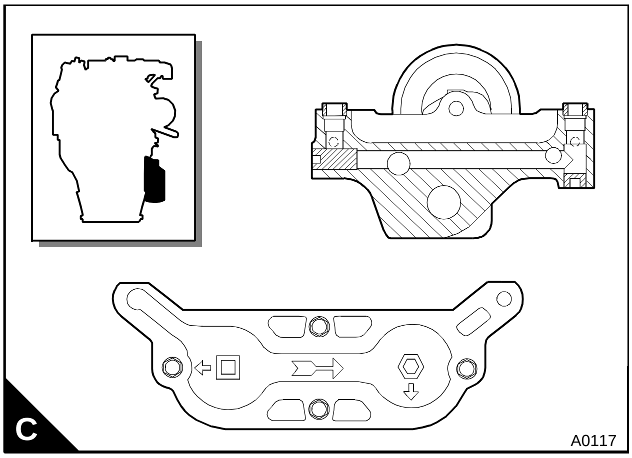
6 Release the setscrews and remove the rear cover of the balancer frame (illustration (A6) on page 115). A hammer and a suitable drift will be necessary to remove the rear cover from the dowels.

7 Remove the balance weights (illustration (A5) on page 115). Ensure that the gear of the driven weight does not damage the bush in the balancer frame.

8 Dismantle the lubricating oil relief valve, see Operation 10-13.

9 Clean the lubricating oil passages with an approved kerosene cleaning solution and dry them with low pressure compressed air.





To assemble **Operation 5-20**

Special requirements

Consumable products	
Description	**Part number**
POWERPART Threadlock and nutlock	21820117

1 Ensure that the location spigot (A8) on the rear face of the lubricating oil pump is clean. Clean the contact faces of the lubricating oil pump and the balancer frame. Fit the lubricating oil pump (A16) to the balancer frame and tighten the setscrews to 27 Nm (20 lbf ft) 2,8 kgf m.

2 Assemble the lubricating oil relief valve, see Operation 10-13.

3 Lubricate the needle roller bearings (A7 and A10) with clean engine lubricating oil. Fit the drive shaft (A9) and engage the splines for the lubricating oil pump with the pump rotor. Ensure that the needle roller bearing at the front of the balancer frame is not damaged by the splines on the drive shaft.

4 Clean and dry the splines (A6) and the thread on the end of the drive shaft. Apply a small amount of POWERPART Threadlock and nutlock to the splines and to the thread. Fit the drive gear of the balance weights (A1) with the flat face of the gear towards the rear of the balancer unit. Fit and tighten the nut (A2) to 82 Nm (60 lbf ft) 8,4 kgf m. To tighten the nut, a peg spanner must be made to fit into the two holes in the front of the drive shaft and be suitable for use with a torque wrench. Fit the peg spanner to the front of the drive shaft. Hold the nut with a suitable spanner and apply the torque to the peg spanner.

5 Ensure that the drive shaft turns freely. Check the end-float of the drive shaft with feeler gauges between the front face of the drive gear for the balance weights and the frame.

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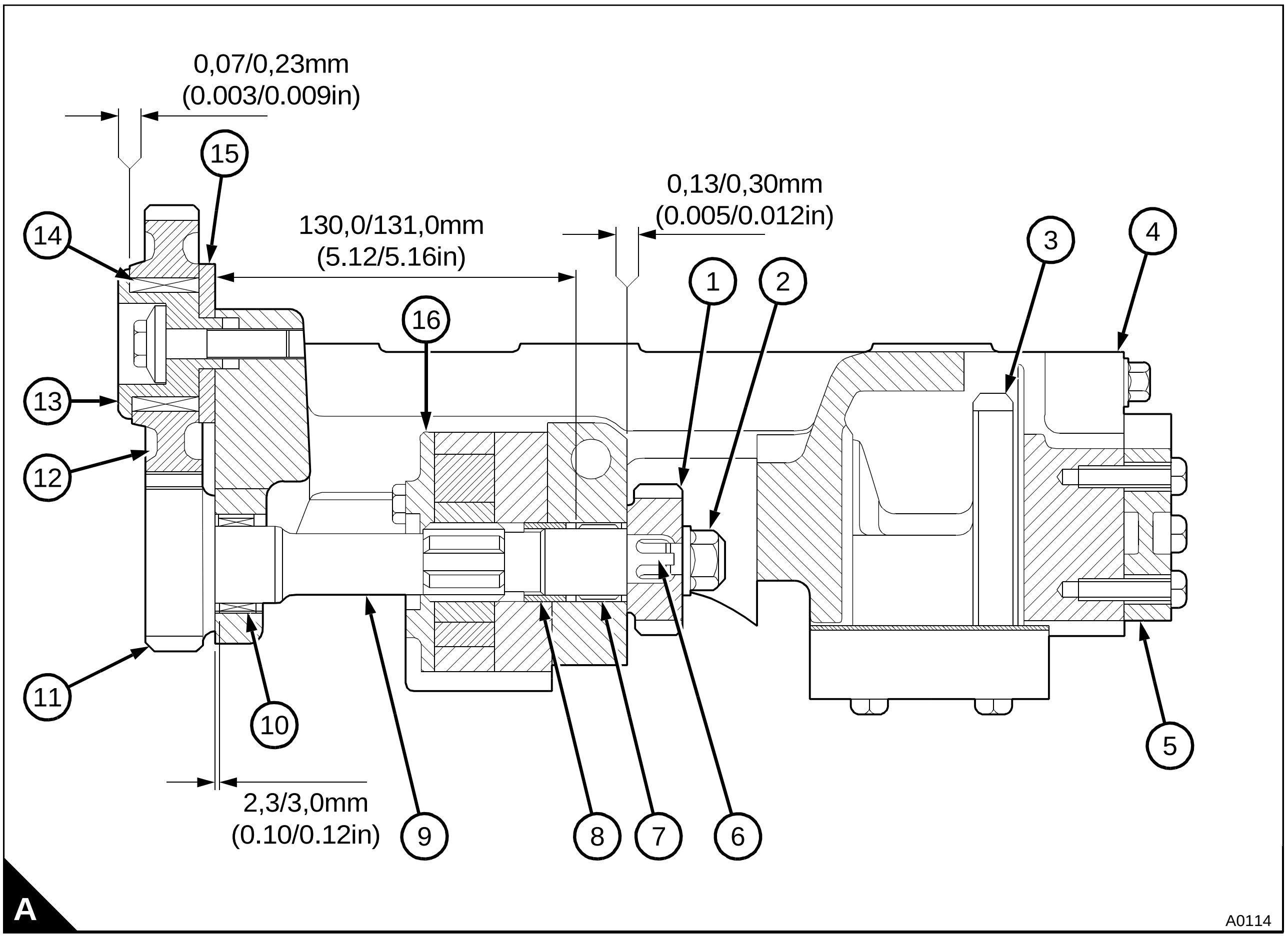

6 Put the balancer frame upside down on the bench (B1). Turn the gear of the drive shaft (B3) until the larger of the two outer holes (B2) - in the front face of the drive gear - is in the position shown in (B). Ensure that the drive shaft will not move from this position. Lubricate the bushes in the rear of the balancer frame with clean engine lubricating oil and fit the balance weights in the position shown in (B). Ensure that the flats on the balance weights are level with each other (B4). With the balance weights in the correct position, check that the drive shaft is still in the correct position.

7 Fit the two dowels to the rear face of the balancer frame. Lubricate the bushes in the rear cover of the balance frame with clean engine lubricating oil. Put the rear cover (illustration (A4) on page 117) in position with the rear spigots of the balance weights in the bushes of the cover. Hit lightly the rear cover with a soft face hammer to fit the cover onto the dowels. Fit the cover setscrews and tighten them to 54 Nm (40 lbf ft) 5,5 kgf m. Check the end-float of the balance weights with feeler gauges between the rear face of the balance weights and the front face of the rear cover (illustration (B) on page 122). The correct end-float is given in the data and dimensions. Check the backlash between the drive gear of the balance weights and the driven gear on the balance weight. The correct backlash is given in the data and dimensions.

8 Fit the oil transfer plate to the rear of the rear cover and tighten the setscrews to 30 Nm (22 lbf ft) 3,1 kgf m. Ensure that the plate is fitted correctly for the oil filter position. The direction arrow (C or D) indicates the direction of lubricating oil flow for left side (C) and right side (D) oil filter positions.

The symbols and arrows (C or D) indicate the position of the plugs in the balancer frame and the shape of their socket heads. Ensure that the plug on the bottom face of the frame is just below the face. If a new frame and plugs are used, ensure that the plugs are fitted correctly for the oil filter position and the symbols on the oil transfer plate.

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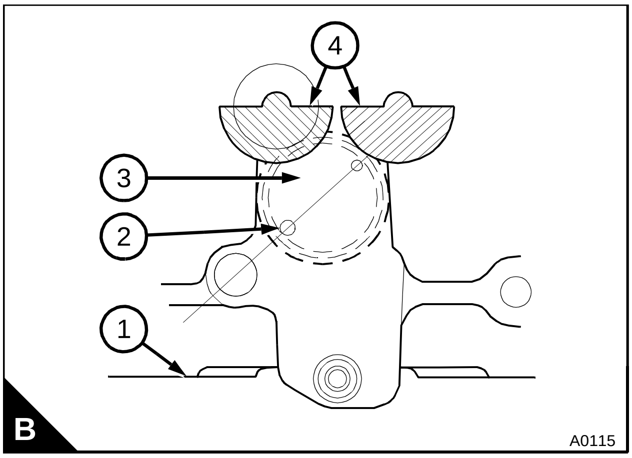
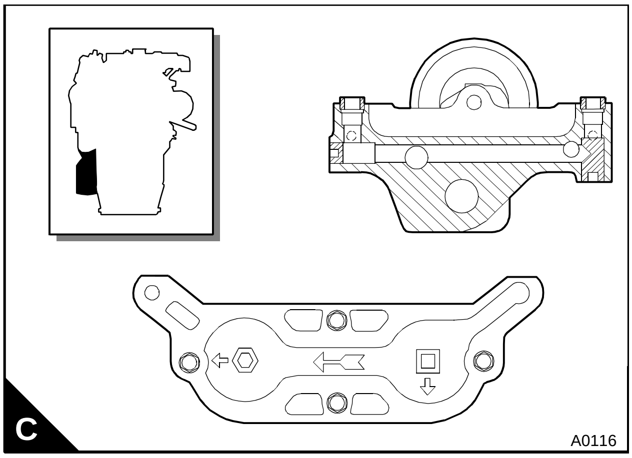
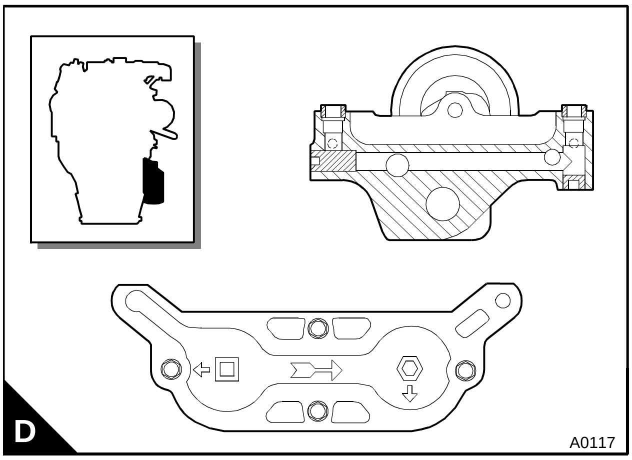


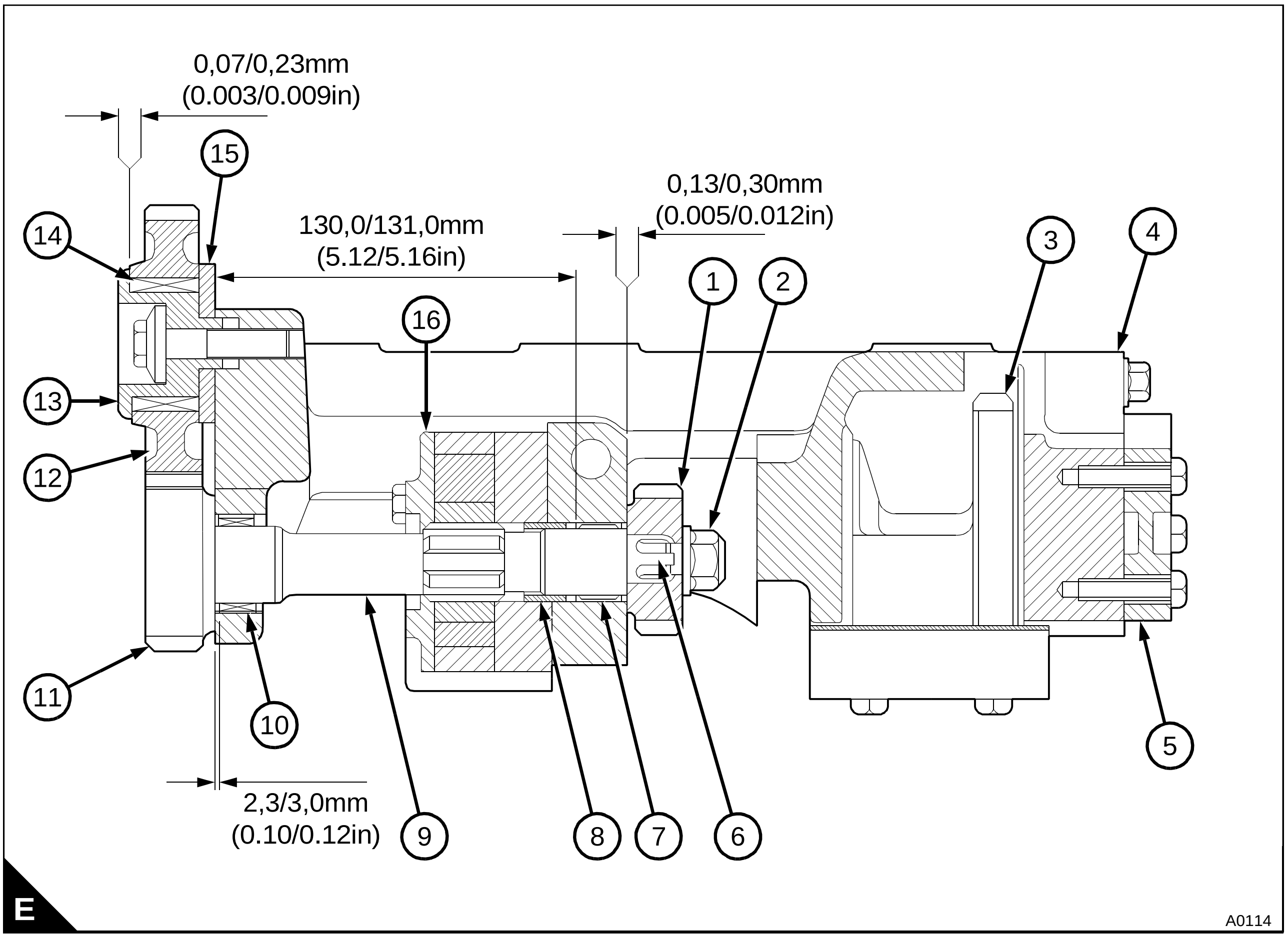




9 If necessary, press a new bearing (E14) into the idler gear (E12). Lubricate the bearing with clean engine lubricating oil. Fit the hub (E13) into the bearing and fit the thrust washer (E15) onto the rear of the hub. Ensure that the threads of the setscrew are clean and dry. Fit the setscrew through 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 with the idler gear in mesh with the gear of the drive shaft (E11). Tighten the setscrew to 93 Nm (68 lbf ft) 9,5 kgf m. 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 23 for the correct backlash.

10 Fit the balance weight cover and tighten the setscrews.

11 Fit the suction tube and the joint and tighten the setscrews.



To inspect **Operation 5-21**

1 Clean all the components before inspection.

2 Check the gear teeth and the splines of the drive shaft for wear or other damage. Renew the drive shaft if necessary.

3 Check the idler gear, needle roller bearing, hub and thrust washer for wear or other damage. Renew the components if necessary.

4 Check the drive gear for the balance weights for wear or other damage. Renew the gear if necessary.

5 Check the balance weights for wear or other damage. If either balance weight is worn or damaged, both balance weights must be renewed.

6 Check the needle roller bearings for the drive shaft for wear or other damage. Renew the bearings, see Operation 5-22, if necessary.

7 Check the bushes for the balance weights for wear or other damage. Renew the bushes, see Operation 5-23, if necessary.

8 To inspect the lubricating oil pump, see Operation 10-8.

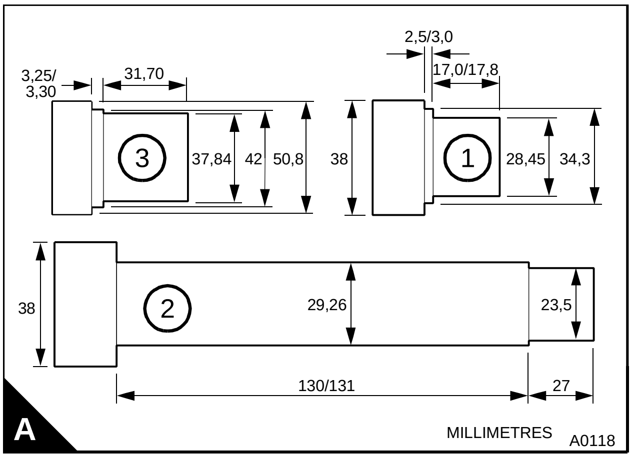
To remove and to fit the needle roller bearings for the drive shaft **Operation 5-22**

1 Press out the bearings with a suitable adaptor.

2 Clean the parent bores and lubricate them with clean engine lubricating oil.

3 Make a suitable adaptor to the dimensions given in (A2). Fit the rear bearing, see Operation 5-20, onto the adaptor with the stamped face of the bearing towards the shoulder of the adaptor. Press the bearing into the parent bore in a continuous movement until the shoulder of the adaptor is against the front face of the balancer frame. In this position the front face of the bearing should be 130,0/131,0 mm (5.12/5.16 in) from the front face of the balancer frame (refer to Operation 5-20 illustration A).

4 Make a suitable adaptor to the dimensions given in (A1). Fit the front bearing, see Operation 5-20, onto the adaptor with the stamped face of the bearing toward the shoulder. Press the bearing into the parent bore in a continuous movement until the shoulder of the adaptor is against the front face of the balancer frame. In this position the front face of the bearing should be 2,5/3,0 mm (0.01/0.12 in) from the front face of the balancer frame (refer to Operation 5-20 illustration A).



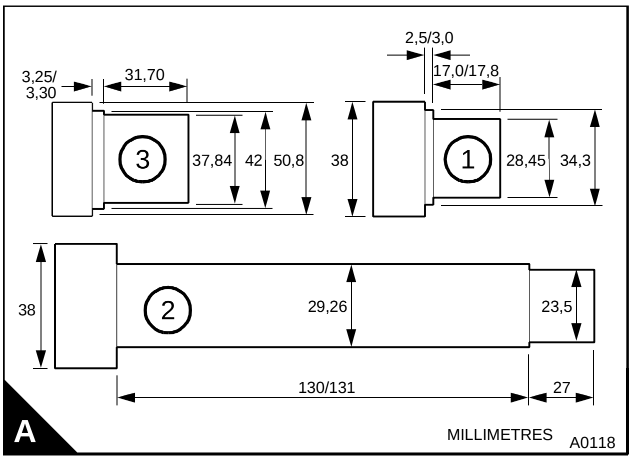
To remove and to fit the bushes for the balance weights **Operation 5-23**

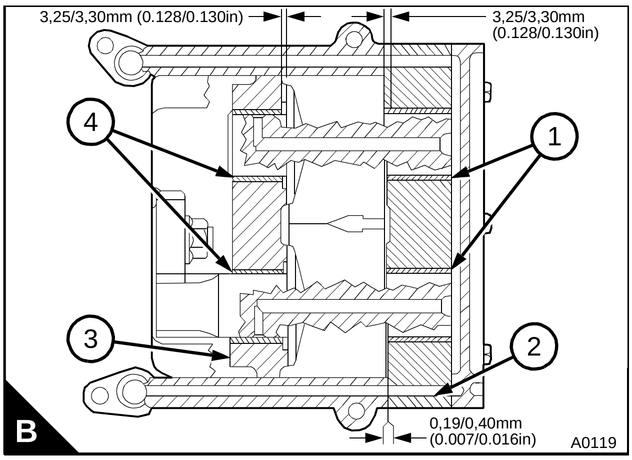
1 Press the bushes out of the balancer frame and the rear cover with a suitable adaptor.

2 Clean the parent bores and lubricate them with clean engine lubricating oil.

3 Make a suitable adaptor to the dimensions given in (A3). Fit a bush onto the adaptor. Press the bush (B4) into the parent bore in the rear of the balancer frame (B3), in a continuous movement, until the shoulder of the adaptor is against the rear face of the balancer frame. In this position the rear face of the bush should be 3,25/3,30 mm (0.128/0.130 in) from the rear face of the balancer frame (B). Repeat this operation for the other bush.

4 Fit a bush (B1) onto the adaptor and put it into position at the front end of one of the parent bores in the rear cover (B2). Press in the bush, in a continuous movement, until the shoulder of the adaptor is against the front face of the rear cover. In this position the front face of the bush should be 3,25/3,30 mm (0.128/0.130 in) from the front face of the rear cover (B). Repeat this operation for the other bush.





6

Timing case and drive assembly

General description

The timing case (A) is for engines fitted with a gear driven coolant pump. The timing case (B) is for engines fitted with a belt driven coolant pump. The timing case is made of either aluminium or cast iron.

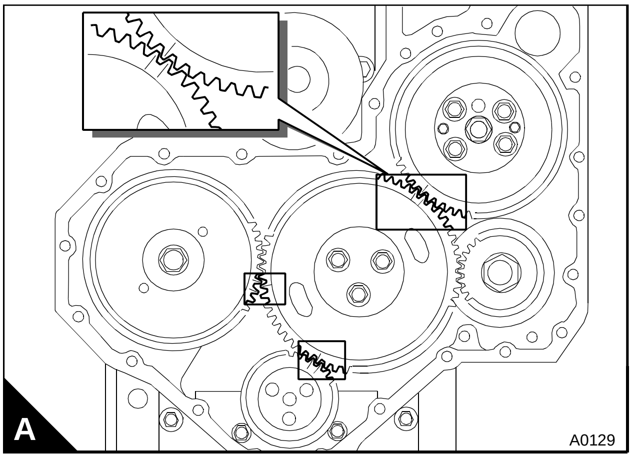
The timing gears on most engines are made of steel, but cast iron gears are used on certain low rated engines. A power take-off is available on the left side of the aluminium timing case or from both sides of the timing case made of cast iron. Some applications that need a power take-off from both sides of the timing case can have an idler gear assembly that uses needle roller bearings.

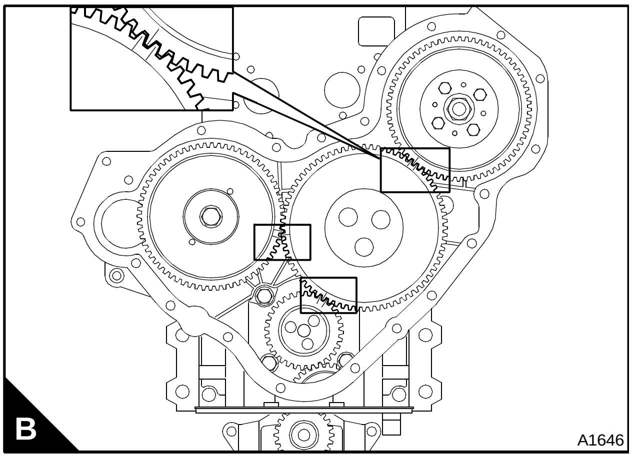
The drive from the crankshaft gear passes through an idler gear to the camshaft gear and to the gear of the fuel injection pump. The drive from the crankshaft gear also passes through a lower idler gear to the gear of the lubricating oil pump or, on some four cylinder engines, to the gear of the balancer unit. The gear driven 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.

The aluminium cover of the timing case contains the front oil seal; this is made of Viton and has a dust lip in front of the main lip. On some engines the cover has a noise shield fitted to its front face.

Warning! *Read the safety precautions for "Viton seals" on page 6.*

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





Timing case cover

To remove **Operation 6-1**

1 Remove the fan, see Operation 12-19.

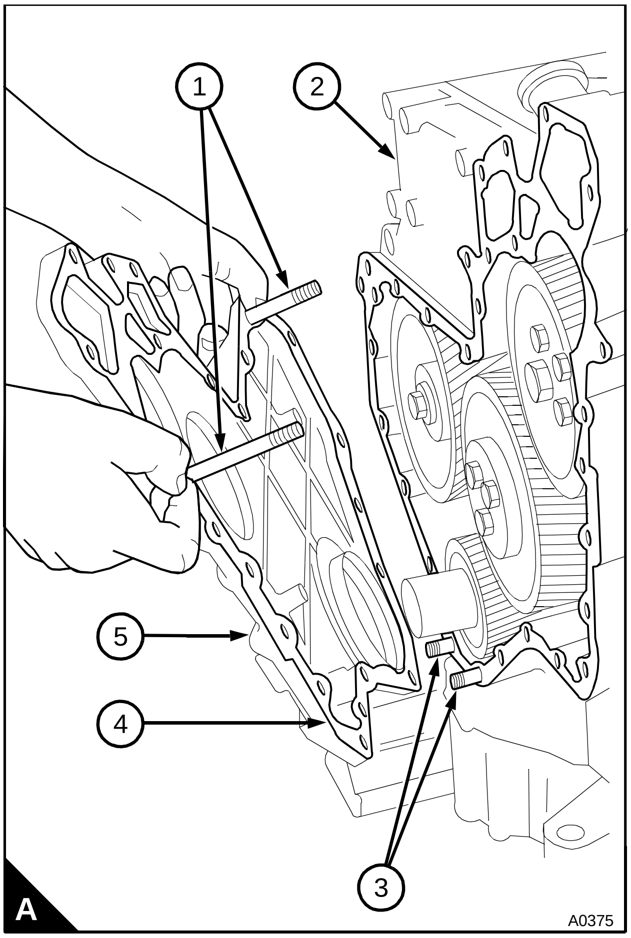
2 Remove the alternator, see Operation 14-4.

3 Remove the crankshaft pulley, see Operation 5-1 or Operation 5-2.

4 Drain the coolant and remove the coolant pump. Gear driven pumps only, see Operation 12-4 or Operation 12-9.

5 Release the setscrews and nuts of the cover (A5) and remove the cover, from the timing case assembly (A2).

6 Discard the joint (A4).



To fit **Operation 6-2**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Centralising tool, (6 cylinder engines)	21825574	Centralising tool, (4 cylinder engines)	21825936

Notes:
- When the timing case cover is removed from the engine it is recommended that the oil seal is renewed.
- If the oil seal is to be renewed, renew the oil seal before the timing case cover is fitted, see Operation 6-3.
- The timing case cover should not be fitted to the engine without a correctly fitted oil seal in place.
- A new timing case cover is supplied with a new oil seal fitted.

1 Clean the joint faces of the timing case and the cover.

2 Put the cover (A5) and a new joint (A4) in position on the timing case (A2). Ensure that the two studs (A3) are tightened correctly. Loosely fit two setscrews (A1) which are in opposite locations to hold the cover in position. Fit the centralising tool in the oil seal housing (B) and use the special washer and the crankshaft pulley setscrews to put the cover in its correct position. Do not overtighten the setscrews. Fit the remainder of the setscrews and nuts and tighten all of the cover fasteners to 22 Nm (16 lbf ft) 2,2 kgf m. Remove the centralising tool.

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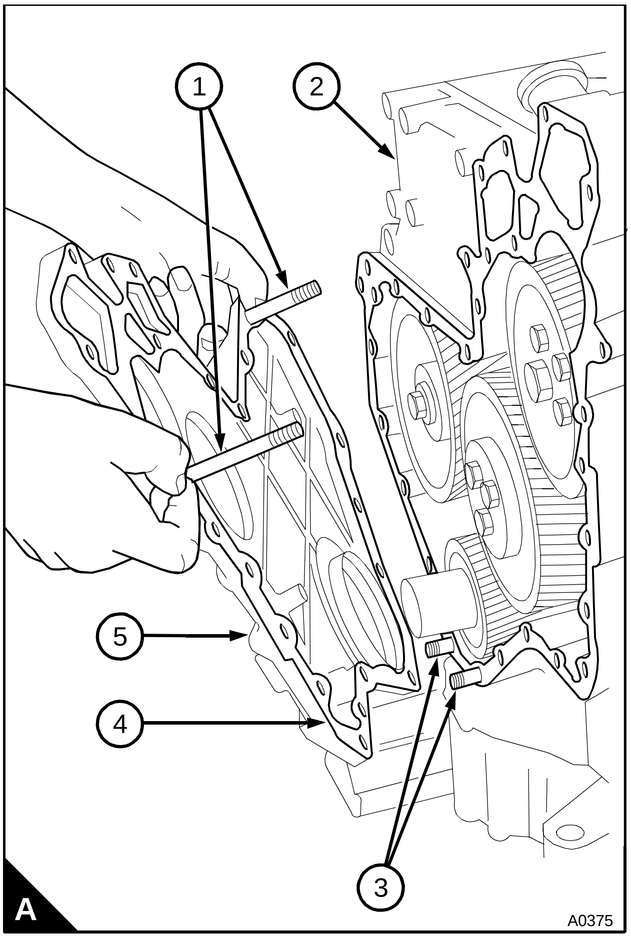
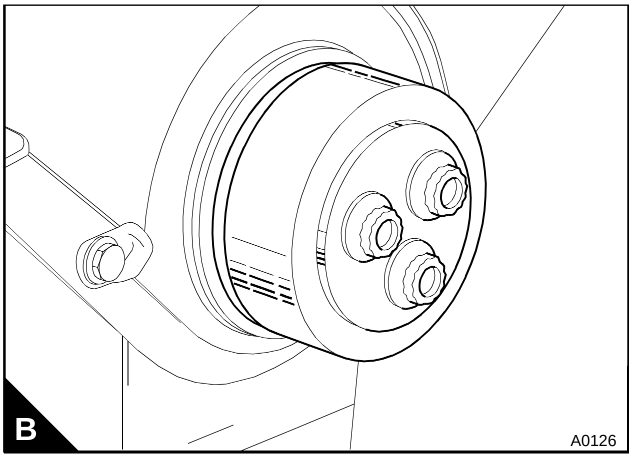




Caution: *For engines with gear driven coolant pumps, It is important that the cover of the timing case is centred correctly. If the cover is not centred, the backlash between the fuel pump gear and coolant pump gear could be affected. This could cause the seizure of the fuel injection pump.*

3 Fit the coolant pump. Gear driven pumps only, see Operation 12-5 or Operation 12-10.

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

5 Fit the alternator, see Operation 14-4.

6 Fit the drive belts, see Operation 14-3 and adjust the belt tension, see Operation 14-2.

7 Fit the fan, see Operation 12-19.

8 Fill the cooling system.

Front oil seal

To remove **Operation 6-3**

To remove an oil seal from a timing case cover that is removed from the engine

To remove the oil seal from a timing case cover that has been removed from the engine: Use a suitable adaptor or spacer to press the old seal out of the cover. ensure that the timing case cover is supported correctly, and that excessive pressure is not used to remove the seal, this can damage or distort the cover.

To remove an oil seal from a timing case cover that is fitted to the engine

1 Remove the fan, see Operation 12-19. and the drive belts, see Operation 14-3.

2 Remove the crankshaft pulley, see Operation 5-1 or Operation 5-2.

3 Remove the oil seal with a suitable lever behind the main lip of the oil seal. Do not damage the edge of the oil seal housing.

To fit **Operation 6-4**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Crankshaft front oil seal replacer	21825577	Pressure plate for use with 21825577	21825578
Anchor plate for use with 21825577	21825580	Sleeve for use with 21825577	21825579
Adaptor for use with 21825577 (refer to your nearest Perkins distributor)			

Note: The seal is fitted to a depth of 10,20/10,70 mm (0.402/0.421 in) from the front face of the oil seal housing to the flat front face of the oil seal. If, in service, there is wear in the seal location area of the crankshaft pulley, oil will continue to leak after a new oil seal is fitted. To repair a worn crankshaft pulley, see Operation 6-5.

To fit an oil seal to a timing case cover that is removed from the engine

1 Clean the oil seal housing. Inspect the new seal for damage. If a scratch can be seen across the lip of the seal, do not fit the seal.

2 Lubricate the outer circumference of the oil seal with clean engine lubricating oil and enter the seal into the housing. Ensure that the spring loaded lip of the oil seal is towards the inside of the timing case cover and that the oil seal is square to the bore of the seal housing.

3 Use a press and the correct adaptor to press the seal into the housing to a depth of 10,20/10,70 mm (0.402/0.421 in) from the front face of the oil seal housing to the flat front face of the oil seal. Ensure that the timing case cover is supported correctly, and that excessive pressure is not used to fit the seal, this can damage or distort the cover.

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

Continued

To fit an oil seal to a timing case cover that is fitted to the engine

1 Clean the oil seal housing. Inspect the new seal for damage. If a scratch can be seen across the lip of the seal, do not fit the seal.

2 Lubricate the outer circumference of the oil seal with clean engine lubricating oil and enter the seal into the housing. Ensure that the spring loaded lip of the oil seal is towards the inside of the timing case cover and that the oil seal is square to the bore of the seal housing.

3 Assemble the oil seal replacer tool (A). Fit the anchor plate, (A3) to the front of the crankshaft. Put the adaptor, (A5) on the nose of the crankshaft and against the seal. Ensure that the adaptor has the side stamped 10,5 mm towards the seal.

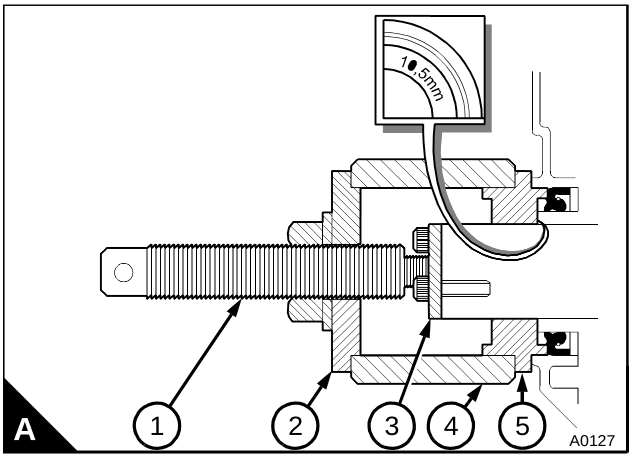
Assemble the pressure plate, (A2) together with the sleeve, (A4) onto the threaded bar, (A1). Put the tool assembly in position on the adaptor, and tighten the threaded bar onto the stud of the anchor plate (A3).

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 to push the seal into the housing to the correct depth.

4 Remove the replacer tool and lightly lubricate the seal location area of the crankshaft pulley with clean engine lubricating oil. Fit the crankshaft pulley, see Operation 5-1 or Operation 5-3.

5 Fit the drive belts, see Operation 14-3 and adjust the belt tension, see Operation 14-2.

6 Fit the fan, see Operation 12-19.



To remove and to fit a wear sleeve **Operation 6-5**

To repair a worn crankshaft pulley, a wear sleeve (B) is fitted over the spigot (A1).

To remove

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

To fit

1 Ensure that the pulley spigot is dry and free from oil, dirt and sealant.

2 Remove any rough spots from the pulley spigot surface.

3 Apply a small continuous bead of sealant (B2) 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 (B1).

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

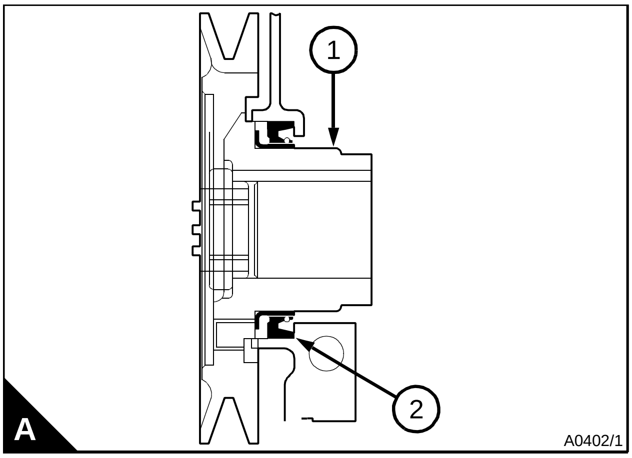
4 Place the wear sleeve on to the pulley spigot, use the tool that is supplied with the new wear sleeve and a suitable hammer, to force the wear sleeve (B) over the pulley spigot.

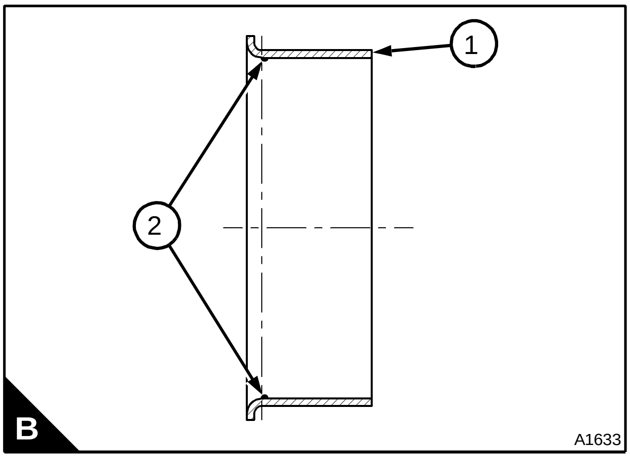
5 It is not necessary to remove the flange of the wear sleeve after it is fitted.

A new front oil seal (A2) must be used when a wear sleeve is fitted.

The dimension, to press the new oil seal into the timing case, with a wear sleeve fitted, is 10,20/10,70 mm (0.402/0.421 in), from the front face of the timing case.

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





Idler gear and hub

To remove **Operation 6-6**

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

2 Rotate the crankshaft until the marked teeth of the crankshaft gear and the camshaft gear and the fuel pump gear are all aligned with the marked teeth of the idler gear (A).

Note: The marked teeth of the idler gear will not necessarily be in mesh with the marked teeth of the other gears because of the different speed of rotation of the idler gear.

3 Release the three setscrews (B8), remove the plate (B1) of the idler gear and remove the gear (B3) from the idler gear hub (B5). The drive gear of the fuel injection pump may rotate counter clockwise when the idler gear is removed.

4 Remove the idler gear hub, note the position of the oil hole (B6).

Caution: *The valve timing and fuel injection pump timing will be lost if the crankshaft is rotated when the idler gear is removed.*

5 Inspect the gear and the bushes (B2) and (B7) for wear and other damage and renew if necessary. The gear and bushes are available as an assembly or as separate parts.

6 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, machine the bores to get the correct clearance on the hub and machine the faces to get the correct end clearance, refer to the Data and dimensions for "Idler gear and hub" on page 25.

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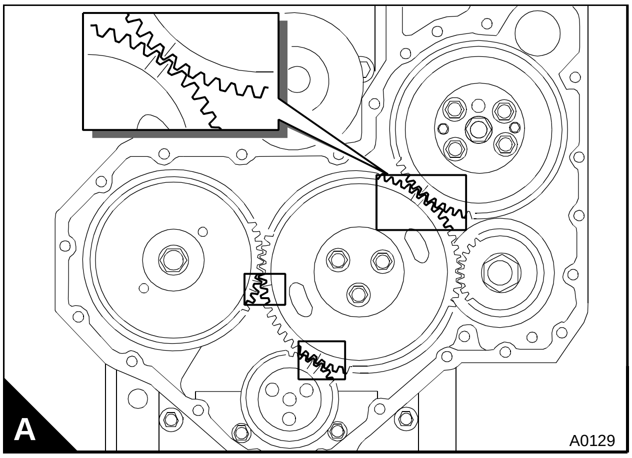
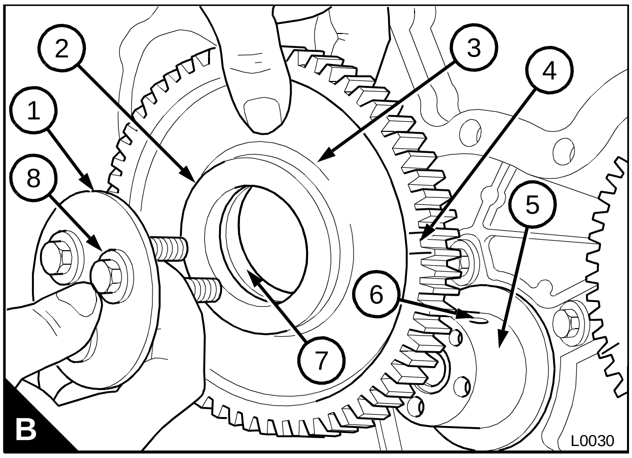
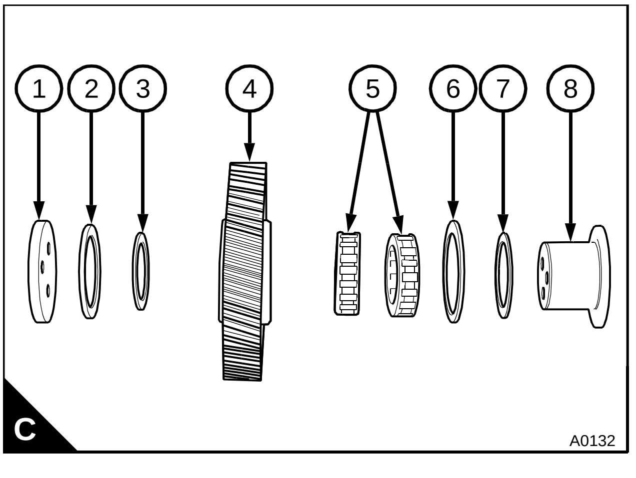




7 For engines that use the idler gear assembly with needle roller bearings; Release the three setscrews, remove the plate of the idler gear (C1). Remove the front thrust washer (C2), the front spacer (C3) and the gear (C4). Remove the two needle roller bearings (C5), if these are to be used again, they should be fitted in their original positions. Remove the rear thrust washer (C6) and the rear spacer (C7). Remove the hub (C8).



To fit **Operation 6-7**

1 Use the three idler gear setscrews to ensure the correct position of the idler gear hub (A2) with the lubrication hole (A1) at the top. Push the hub into position and remove the setscrews.

2 Lubricate the idler gear bushes with clean engine lubricating oil. Align the timing marks on the idler gear with the marks on the crankshaft and camshaft gears. If necessary, rotate the gear of the fuel injection pump clockwise to align the relevant timing mark with the marks on the idler gear and slide the idler gear into position. Check that all the timing marks are in correct mesh (B), or (C) for engines fitted with a belt driven coolant pump. Fit the plate and the setscrews to the idler gear hub and tighten the setscrews to 44 Nm (33 lbf ft) 4,5 kgf m.

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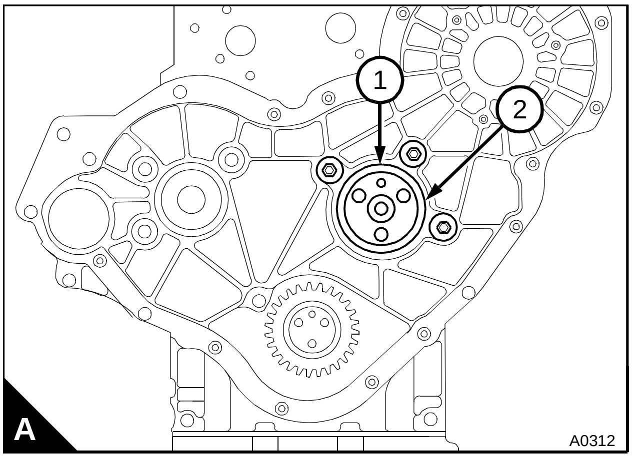
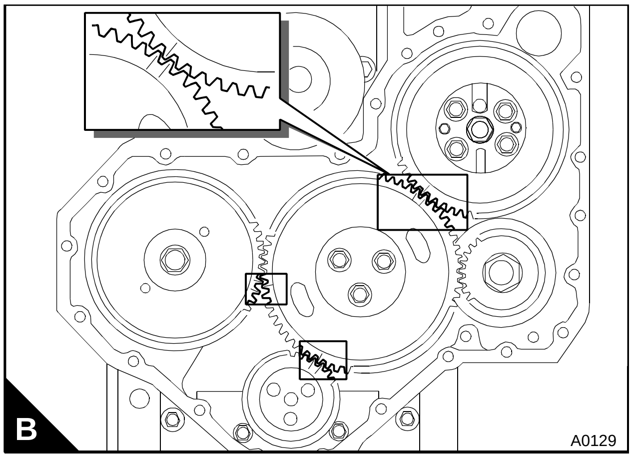
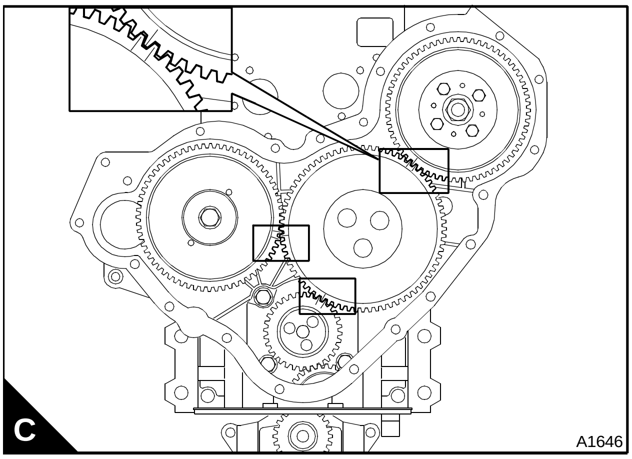


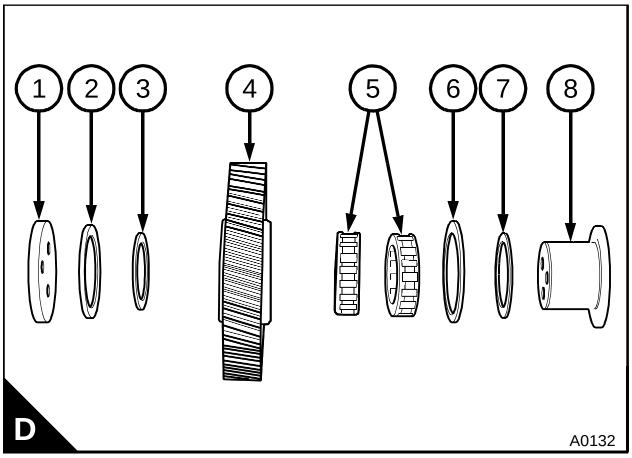


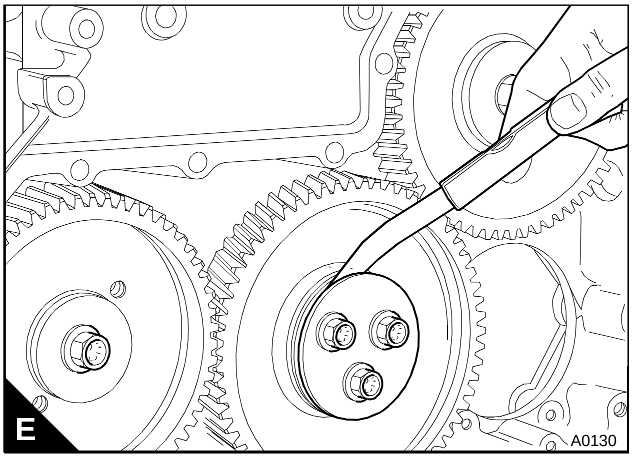


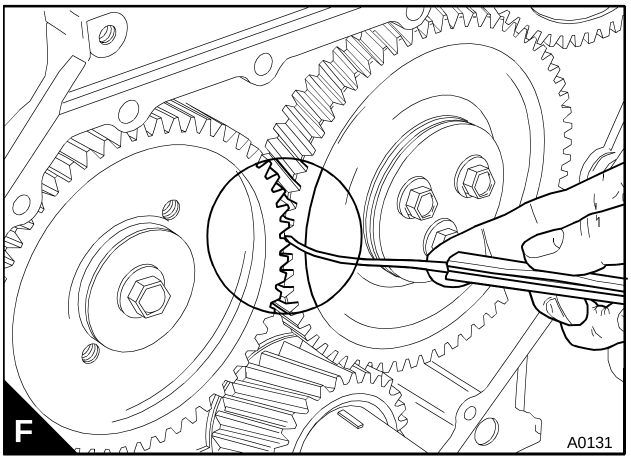
3 For engines that use the idler gear assembly with needle roller bearings - Inspect the components for wear and other damage and renew them if necessary. Lightly lubricate the components with clean lubricating oil before assembly onto the hub. Fit the hub (D8) as described in step 1. Put the rear spacer (D7) in position on the hub. Put the rear thrust washer (D6) in position on the rear spacer. Put the bearings (D5) in position on the hub in the same position as they were before they were removed. Lightly lubricate the bore and thrust washer faces of the gear (D4) with clean lubricating oil and put the gear in position on the bearings. Put the front spacer (D3) in position on the hub then put the front thrust washer (D2) in position on the spacer. Put the plate (D1) in position. The plate has TOP stamped on the front face as the holes in the plate are not equally spaced. Fit the setscrews and tighten them to 44 Nm (33 lbf ft) 4,5 kgf m).

4 Check the idler gear end-float (E) and the timing gear backlash (F). Refer to the Data and dimensions for "Idler gear and hub" on page 25.

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







Idler gear and hub for the compressor

To remove

Operation 6-8

The compressor is driven directly from the engine timing case and does not have an auxiliary drive assembly. The engine idler gear (A12) drives the compressor gear (A4) through a separate idler gear (A11/B4) fitted onto a hub (A9). The hub is fastened to the back of the timing case (A5) by a bracket (A3).

The idler gear is fitted on a needle roller bearing (A7) which is fitted onto the hub. The hub has an "O" ring (A1) to prevent oil leakage from the rear of the timing case. The roller bearing and the idler gear are retained on the hub by a plate (A10) which is fastened to the idler hub.

1 Set the piston of number 1 cylinder to TDC, see Operation 8-1 or Operation 8-2.

2 Remove the timing case cover (A6), see Operation 6-1.

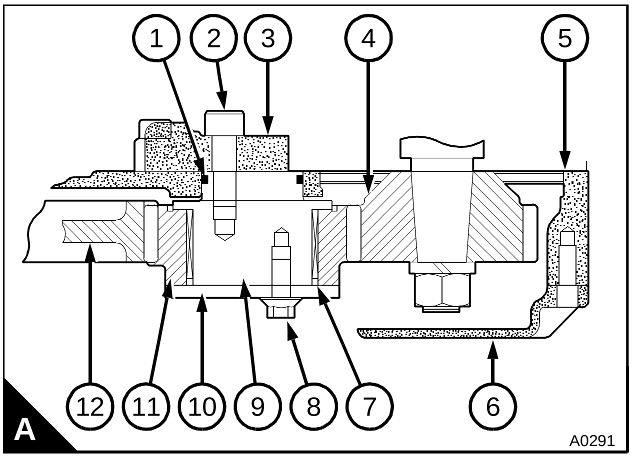
Caution: *Do not rotate the engine crankshaft or the compressor crankshaft if the idler gear is removed. If either of the crankshafts are moved, the compressor must be timed to the engine.*

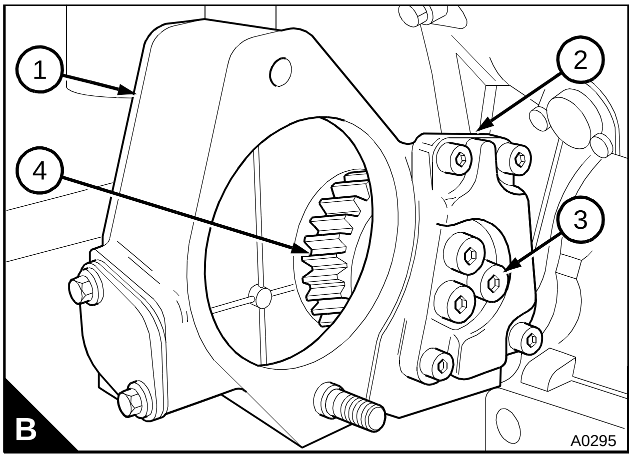
3 Release the three setscrews (A8). Remove the plate (A10) which retains the idler gear (A11). Remove the gear and the needle roller bearing (A7) from the idler hub (A9).

4 Remove the three cap screws (B3) which fasten the idler hub to the bracket (B2) at the rear of the timing case (B1). Remove the idler gear hub.

5 Remove and discard the "O" ring (A1).

6 Inspect the idler gear, needle roller bearing and idler gear hub for wear and other damage and, if necessary, renew them.





To fit **Operation 6-9**

1 Renew the "O" ring (A1). Lightly lubricate the components with clean lubricating oil before they are assembled onto the hub.

Check that the four cap screws which secure the idler hub bracket (B2) to the timing case are tightened to the correct torque 35 Nm (26 lbf ft) 3,5 kgf m.

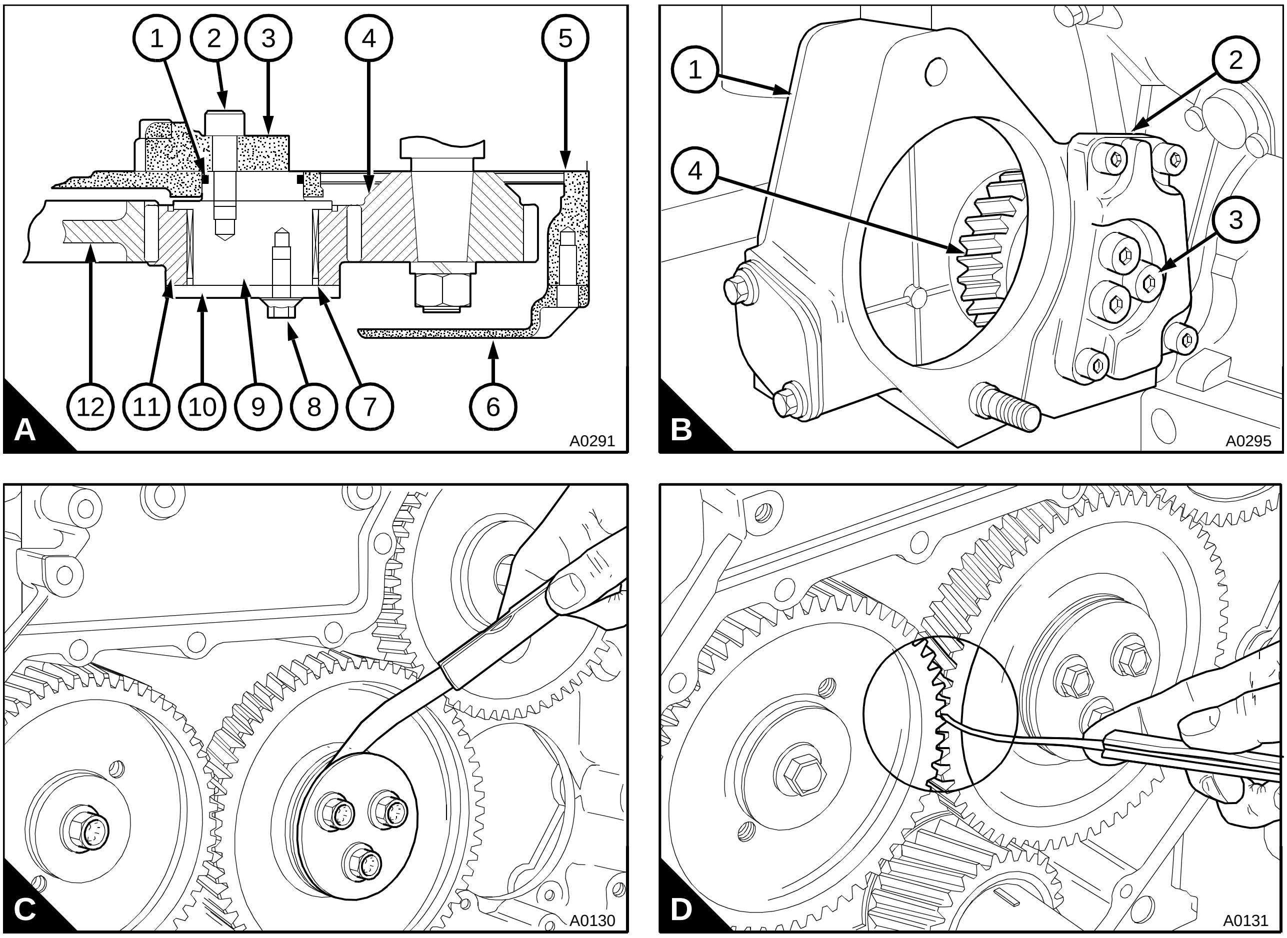
Fit the hub (A9) with the "O" ring towards the timing case. Fit the three M10 cap screws (B3) and tighten them to 60 Nm (44 lbf ft) 6 kgf m). Put the needle roller bearing (A7) into position on the hub.

Caution: *Do not rotate the engine crankshaft or the compressor crankshaft if the idler gear (B4) is removed. If either of the crankshafts are moved, the compressor must be timed to the engine.*

2 Lightly lubricate the bore of the gear (A11) with clean lubricating oil and put the gear in position on the bearing. Put the plate (A10) in position. Fit the setscrews (A8) and tighten them to 22 Nm (16 lbf ft) 2,2 kgf m.

3 Use the method shown (C) to check the compressor idler gear end-float and (D) for the timing gear backlash. Refer to the Data and dimensions for "Idler gear and hub for the compressor" on page 25 for the correct idler gear end-float and backlash dimensions.

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



Fuel pump gear

The fuel injection timing is set with specialist tools in the factory after the engine has been accurately set to TDC, number 1 cylinder on the compression stroke. The fuel pump gear has timing marks (A) which can be used to find the approximate position of TDC on number 1 cylinder compression stroke. The marked teeth of the crankshaft, the camshaft and the fuel pump gears will be in mesh with the idler gear when number 1 piston is close to top dead centre (TDC) on the compression stroke. The marked teeth of the idler gear may not necessarily be in mesh in this position, because of the different speeds at which the gears rotate.

The fuel injection pump is timed at TDC on the compression stroke of number 1 cylinder. It is important that fuel injection timing is accurate to conform to emissions legislation. Always use the methods in Operation 8-1 or Operation 8-2 to obtain TDC on the compression stroke of number 1 cylinder accurately.

To remove **Operation 6-10**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Bosch fuel injection pump timing pin	27610032	Stanadyne and Lucas/Delphi fuel injection pump timing pin	27610033
Socket Torx drive	27610122		

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

Caution: *Do not lock the shaft of the fuel injection pump, for Bosch pumps see Operation 11-10 or for Lucas/ Delphi DP 200 Series pumps Operation 11-13.*

2 Set the number one piston to TDC on the compression stroke, see Operation 8-1 or Operation 8-2.

Fit the timing pin (B3) until the small end of the pin (B2) is pushed fully into the hole in the fuel pump body (B4). The pin can only be fitted when the number one piston is correctly in position at TDC on the compression stroke. If the timing pin cannot be pushed into the pump body, check the timing of the fuel injection pump, see Operation 8-4.

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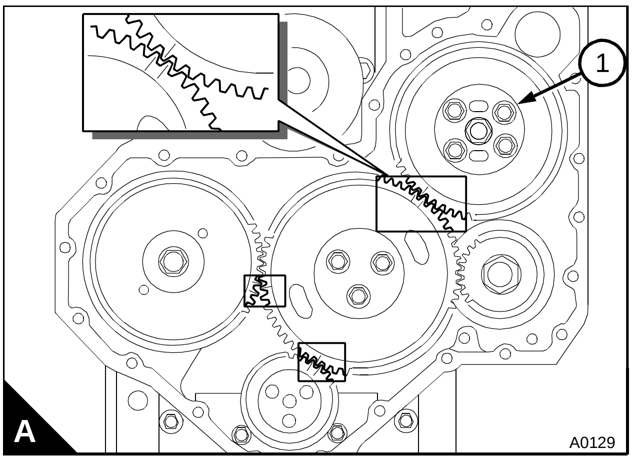
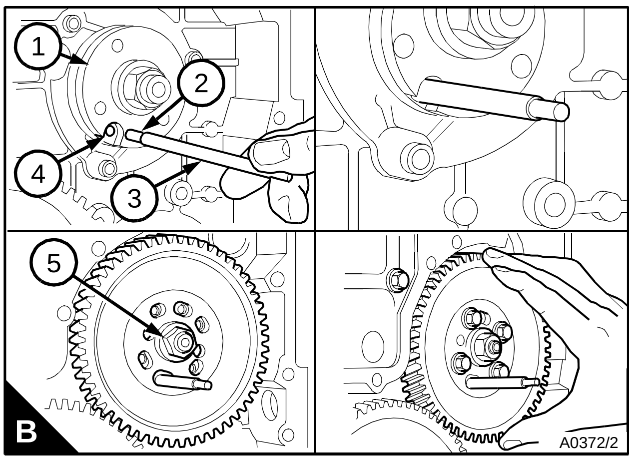


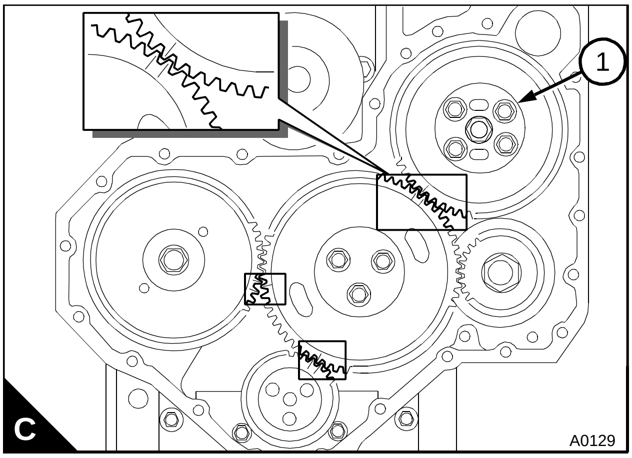


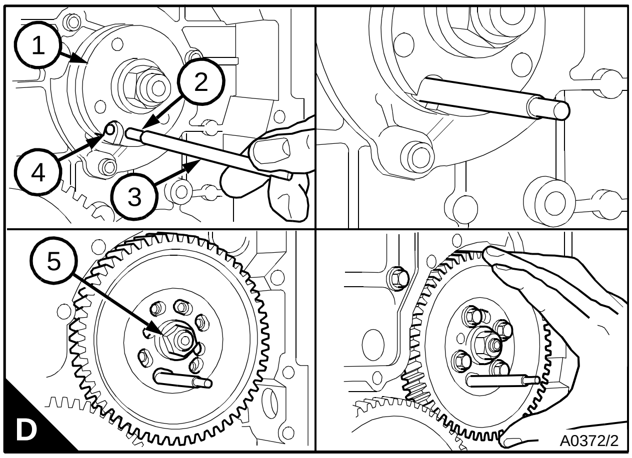
Caution: *Do not remove the nut (D5) which retains the hub (D1) to the shaft of the fuel injection pump. The hub is fitted permanently to the shaft. If the hub is moved, it will be necessary for a fuel injection pump specialist to correctly position the hub on the shaft with special test equipment.*

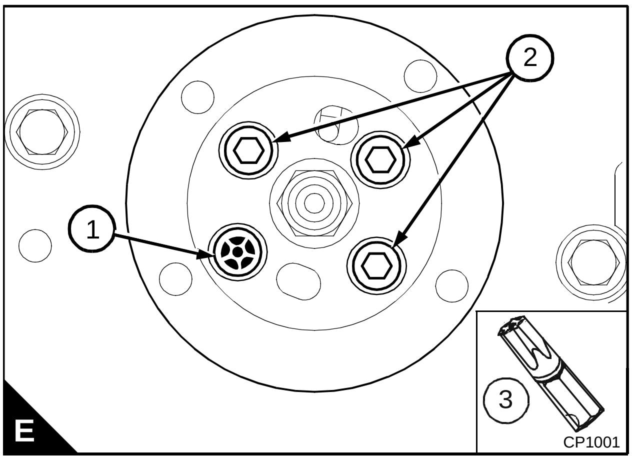
3 Remove the four fasteners (E or F) from the fuel pump gear and remove the gear from the hub of the fuel pump.

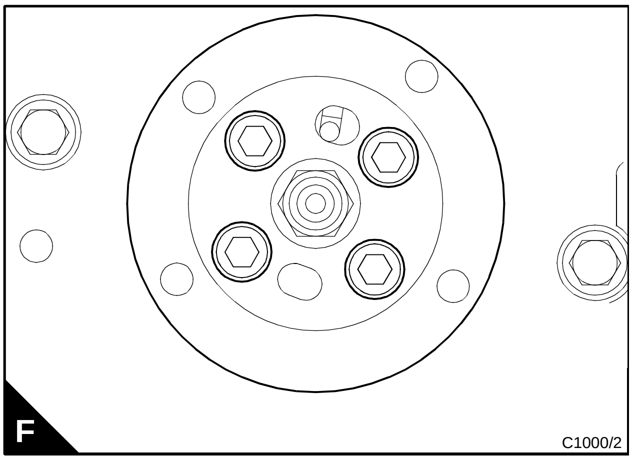
Note: For engine models AP, AQ and AS with belt driven coolant pumps, either four tamper proof fasteners or one tamper proof fastener and three flanged setscrews are used to retain the fuel pump gear. All Torx screws are fitted with a special hardened flat washer. A special Torx socket (E3) part number 27610122 is needed to remove and to fit these tamper proof fasteners, refer to your Perkins distributor. All other engine models have four flanged setscrews to secure the gear.

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









To fit **Operation 6-11**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Bosch fuel injection pump timing pin	27610032	Stanadyne and Lucas/Delphi fuel injection pump timing pin	27610033
Socket Torx drive	27610122		

The fuel pump gear will only fit in one position. The gear is fitted with the letters C and M at the front.

Caution: *Check that the shaft of the fuel injection pump is released, see Operation 11-10 for Bosch pumps or Operation 11-13 for Lucas/Delphi DP 200 Series pumps.*

1 Ensure that the engine is set to TDC with the number one piston on the compression stroke, see Operation 8-1 or Operation 8-2.

2 If the pin (A3) has been removed before the gear is fitted rotate the hub (A1) until the hole (A4) can be seen in the slot. Fit the small end of the pin (A2) fully into the hole in the pump body. Leave the pin (A3) in position.

3 Fit the fuel pump gear (B1), over the pin (B3) and into mesh with the idler gear (B2).

4 Loosely fit the four fasteners in the centre of the slots (B1) in the gear.

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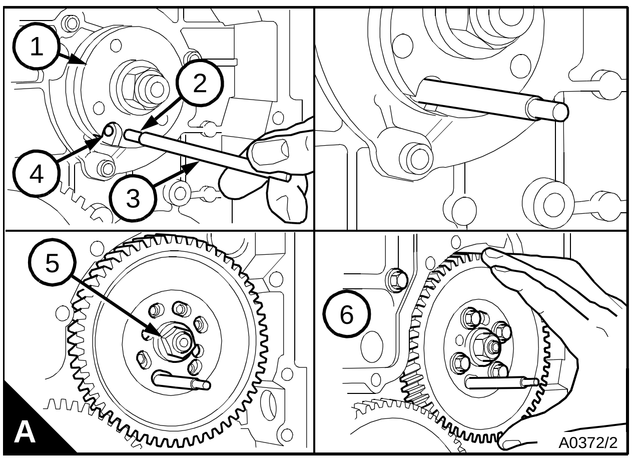
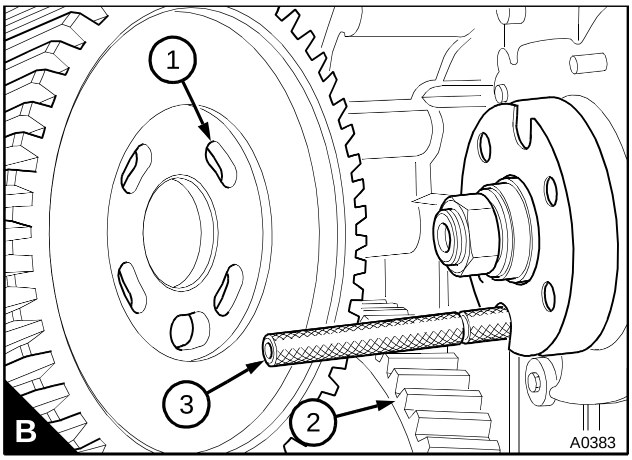




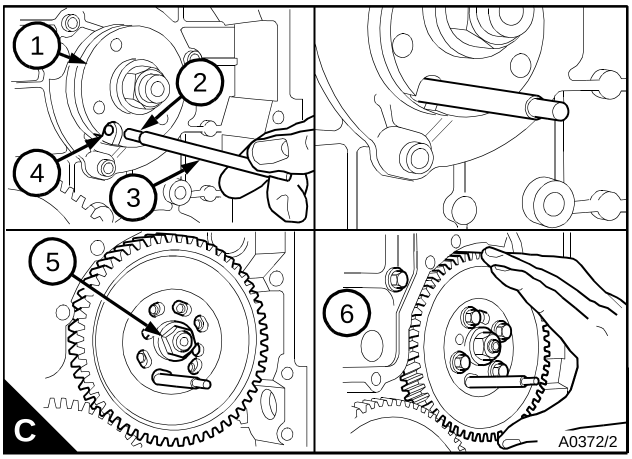
5 Carefully rotate the gear (C6) counter-clockwise until the backlash between the idler gear and the fuel pump gear has been removed. Do not rotate the crankshaft or it will be necessary to set TDC again.

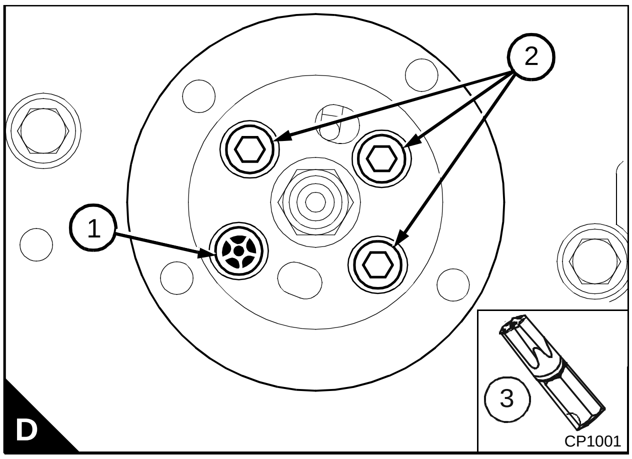
6 Tighten the four fasteners (D or E) that retain the gear to 28 Nm (20 lbf ft) 2,8 kgf m. Remove the timing pin.

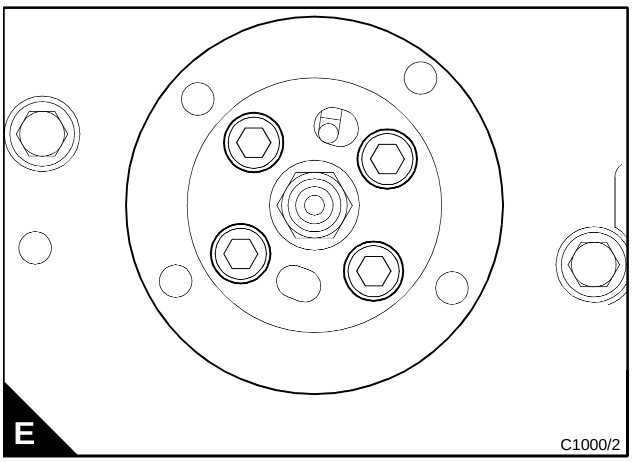
Note: For engine models AP, AQ and AS with belt driven coolant pumps, either four tamper proof fasteners or one tamper proof fastener and three flanged setscrews are used to retain the fuel pump gear. All Torx screws are fitted with a special hardened flat washer. A special Torx socket (D3) part number 27610122 is needed to remove and to fit these tamper proof fasteners, refer to your Perkins distributor. All other engine models have four flanged setscrews to secure the gear.

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

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







Camshaft gear

To remove and to fit — Operation 6-12

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Gear puller	21825565	Adaptors for use with 21825565	21825930

To remove

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

2 Rotate the crankshaft until the marked teeth of the crankshaft gear and the camshaft gear are in mesh with the idler gear. The marked teeth of the idler gear will not necessarily be in mesh with the marked teeth of the other gears because of the different speed of rotation of the idler gear.

3 Remove the setscrew and washer of the camshaft gear. Put a suitable adaptor onto the end of the camshaft and remove the gear with the puller and adaptor (A). Ensure that the key in the camshaft is not lost.

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

To fit

1 Ensure that the key in the camshaft is fitted correctly.

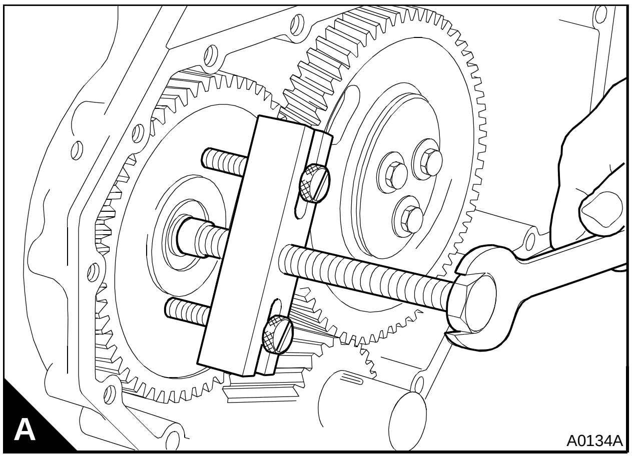
2 Remove the idler gear, see Operation 6-6.

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.

4 Fit the idler gear with the marked teeth in correct mesh, see Operation 6-7. If the camshaft has to be turned and a valve hits a piston, disengage the rocker assembly.

5 Fit the washer and the setscrew for the camshaft gear and tighten the setscrew to press the camshaft gear into position. Tighten the setscrew to 78 Nm (58 lbf ft) 8,0 kgf m. If a new camshaft gear has been fitted, check the backlash.

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



Crankshaft gear

To remove and to fit **Operation 6-13**

To remove

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

2 Rotate the crankshaft until the marked teeth of the crankshaft gear and the camshaft gear are in mesh with the idler gear. The marked teeth of the idler gear will not necessarily be in mesh with the marked teeth of the other gears because of the different speed of rotation of the idler gear.

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

4 The crankshaft gear is a transition fit on the crankshaft. It may slide off easily or, if it is a tight fit and the gear is to be renewed, it may be necessary to remove the crankshaft, see Operation 5-15, to remove the gear safely.

To fit

1 The gear can fit easily, or it may be necessary to heat the gear before it will fit onto the crankshaft. If the gear is to be heated, heat it in an oven to not more than 180 °C (226 °F). If an oven is not available, heat it in coolant which is at its boiling point. Do not use a flame as this can cause local damage. Fit the gear with the timing marks to the front.

2 Fit the idler gear, see Operation 6-7 and ensure that all the timing marks are correctly aligned.

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

Timing case

To remove **Operation 6-14**

1 Remove the fan, see Operation 12-19.

2 Remove the drive belts, see Operation 14-3.

3 Remove the crankshaft pulley, see Operation 5-1 or Operation 5-2.

4 If necessary, remove the fan drive assembly, see Operation 12-20.

5 Drain the coolant and remove the coolant pump. Gear driven pumps only, see Operation 12-4 or Operation 12-9.

6 Remove the alternator together with its mounting bracket and front support plate.

7 Remove the compressor and drive assembly, see Operation 15-1, and the exhauster, if fitted, see Operation 15-15.

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

9 Rotate the crankshaft until the marked teeth of the crankshaft gear and the camshaft gear are in mesh with the idler gear. The marked teeth of the idler gear will not necessarily be in mesh with the marked teeth of the other gears because of the different speed of rotation of the idler gear.

10 Remove the fuel injection pump:

- For Bosch fuel injection pumps, see Operation 11-10
- For Lucas/Delphi DP200 Series fuel injection pumps, see Operation 11-13
- For Stanadyne fuel injection pumps, see Operation 11-17.

11 Remove the idler gear, see Operation 6-6 and the camshaft gear, see Operation 6-12.

12 Remove the setscrews which hold the timing case to the cylinder block and the setscrews which hold the sump to the bottom of the timing case.

13 Remove the timing case and the joint, do not allow the idler gear hub to fall. Ensure that the camshaft thrust washer is not lost.

To fit **Operation 6-15**

Special requirements

Consumable products			
Description	**Part number**	**Description**	**Part number**
POWERPART Jointing compound	1861117	POWERPART Threadlock and nutlock	21820117

1 Ensure that the sump joint is not damaged. If the joint is damaged, remove the sump and fit it with a new joint after the timing case has been fitted. The front section of the joint can be cut away and the front section of a new joint fitted, without the removal of the sump, but extreme care must be used to prevent possible leaks.

2 If the sump has been removed, fit the idler gear hub (A2) or (B2) to the front of the cylinder block; use the three setscrews of the idler gear to hold the hub in position. Ensure that the oil hole is at the top.

3 Ensure that the thrust washer for the camshaft is in position.

4 Fit a new joint for the timing case to the cylinder block. Cut the bottom ends of the joint to fit correctly. Apply POWERPART Jointing compound to the bottom ends of the joint.

5 Put the timing case in position. If the sump has not been removed, fit the idler gear hub, refer to step 2. Fit the four setscrews (A1), or three setscrews (B1) for engines fitted with a belt driven coolant pump, around the idler gear hub.

Note: Ensure that the bottom of the timing case is correctly aligned with the bottom of the cylinder block before the setscrews are tightened.

6 Put the fan drive assembly and/or the alternator and its front support plate in position and fit and tighten the remainder of the setscrews of the timing case. If the front support plate has been separated from the alternator bracket, ensure that the right side of the plate is level with the machined face on the cylinder block where the alternator bracket is fitted. If a new timing case is fitted, remove the two studs from the timing case and clean the threads which fit into the timing case. Seal the threads with POWERPART Threadlock and nutlock and fit the studs into the new timing case. Remove the setscrews from the idler gear hub.

7 If necessary, fit the lubricating oil sump, see Operation 10-3, and fill it to the correct level with an approved oil.

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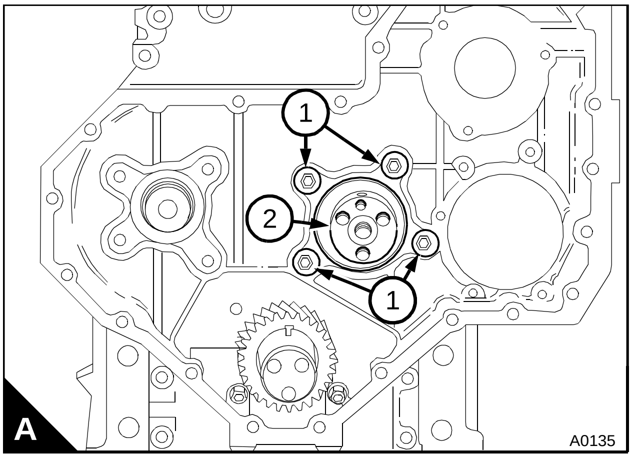
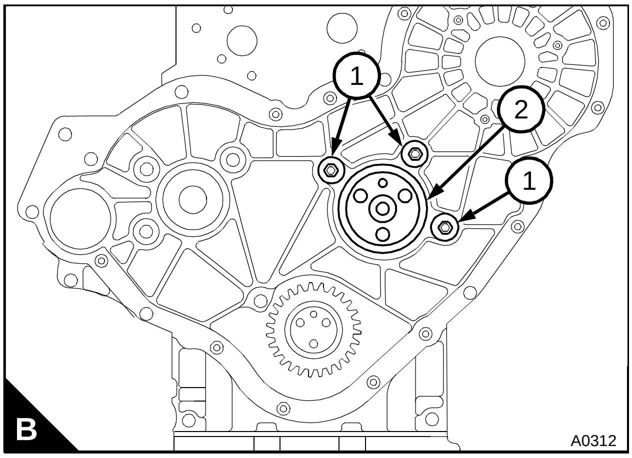




8 Fit the camshaft gear, see Operation 6-12 and the idler gear, see Operation 6-7. Ensure that all the timing marks are correctly aligned.

9 Fit the fuel injection pump and the drive gear:

- For Bosch fuel injection pumps, see Operation 11-11
- For Lucas/Delphi DP200 Series fuel injection pumps, see Operation 11-14
- For Stanadyne fuel injection pumps, see Operation 11-18.

10 Eliminate air from the fuel system, see Operation 11-20.

11 Fit the compressor, see Operation 15-2, and its drive assembly, if fitted, see Operation 15-15.

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

13 Fit the coolant pump. Gear driven pumps only, see Operation 12-4 or Operation 12-10.

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

15 If necessary, fit the fan drive pulley, see Operation 12-20.

16 Fit the alternator, see Operation 14-4 and the alternator front bracket.

17 Fit the drive belts, see Operation 14-3 and adjust the belt tension, see Operation 14-2.

18 Fit the fan, see Operation 10-12.

19 Fill the cooling system.

Camshaft and tappets

To remove

Operation 6-16

1 Drain the lubricating oil and the coolant.

2 Remove the timing case, see Operation 6-14.

3 Remove the rocker cover, see Operation 3-1.

4 Remove the rocker assembly and the push rods, see Operation 3-3.

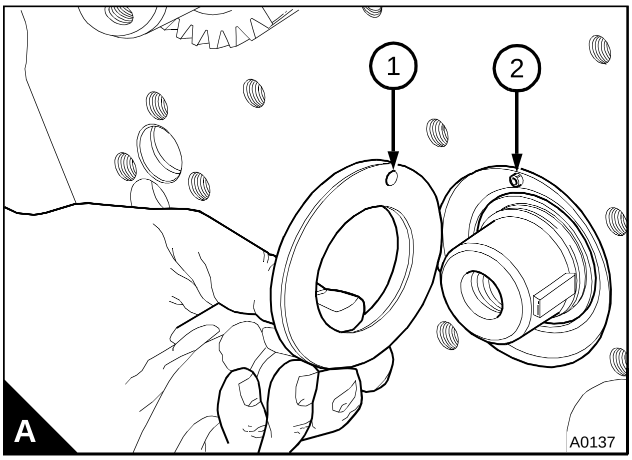
5 Remove the fuel lift pump, see Operation 11-6.

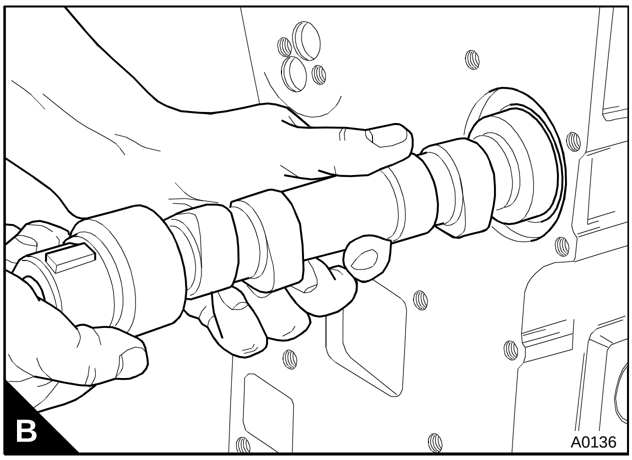
6 Turn the engine upside down and remove the lubricating oil sump, see Operation 10-3.

7 Remove the camshaft thrust washer (A1) and carefully remove the camshaft (B).

8 Remove the tappets.

9 Inspect the camshaft and the tappets for wear and other damage, also inspect the camshaft bush. Renew the components as necessary.





To fit

Operation 6-17

1 Ensure that all components are clean and are lubricated with clean engine lubricating oil.

2 With the engine upside down, fit the tappets in position.

3 Carefully fit the camshaft.

4 Fit the camshaft thrust washer. Ensure that it is fitted correctly on the hollow dowel (A2).

5 Rotate the camshaft until the cam for the fuel lift pump is at the minimum lift position and fit the fuel lift pump, see Operation 11-6.

6 Fit the timing case with a new joint, see Operation 6-15.

7 Fit the lubricating oil sump, see Operation 10-3.

8 Turn the engine the right way up.

9 Check that the camshaft end-float is within limits, refer to the Data and dimensions for "Camshaft" on page 24.

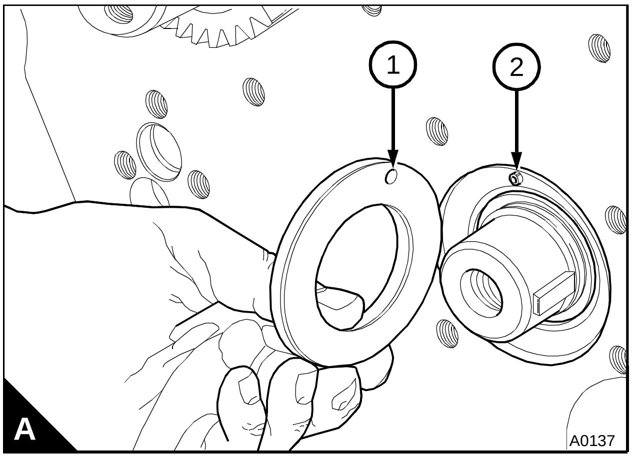
10 Fit the push rods and the rocker assembly, see Chapter 3, Cylinder head assembly.

11 Set the valve tip clearances, see Operation 3-6 for four cylinder engines or Operation 3-7 for six cylinder engines.

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

13 After the engine has been installed: Fill the cooling system. Fill the lubricating oil sump to the correct level with an approved lubricating oil.

14 Eliminate air from the fuel system, see Operation 11-20.



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7

Cylinder block assembly

General description

The cylinder block is made of cast iron and provides a full length support for the dry liners which are also made of cast iron. Production liners are a press fit in the block. In service two liners are available:

- A finished liner, which has a transition fit in the parent bore.
- A partially finished liner, which is an interference fit in the parent bore and must be machine finished after it has been installed.

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

Engine types AR and AS do not have cylinder liners fitted and the cylinder bores must be machined oversize to correct a worn cylinder bore, refer to the Data and dimensions for "Cylinder bore specifications (engine types AR and AS)" on page 27.

Note: Short engines are also available.

Your Perkins distributor has specialist equipment and personnel with the correct training to repair worn cylinder bores.

Cylinder block

To dismantle **Operation 7-1**

Note: If 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 block face cannot be maintained with the original piston and connecting rod assemblies, see Operation 4-6.

1 Drain the cooling system and the lubricating oil.

2 Remove the engine from the vehicle or machine.

3 Remove the alternator drive belts, see Operation 14-3, and the alternator and its mounting brackets, see Operation 14-4.

4 Remove the fan, the fan drive and the coolant pump, see Chapter 12, Cooling system on page 257.

5 Remove the compressor, see Operation 15-1, or the exhauster, where fitted, see Operation 15-15.

6 Remove the fuel filter assembly and the atomisers, see Operation 11-4.

7 Remove the fuel injection pump:

- For Bosch fuel injection pumps, see Operation 11-10
- For Lucas/Delphi DP200 Series fuel injection pumps, see Operation 11-13
- For Stanadyne fuel injection pumps, see Operation 11-17.

8 Remove the lubricating oil cooler, where fitted:

- For 4 cylinder engines, see Operation 12-21
- For 6 cylinder engines, see Operation 12-24 or Operation 12-25.

9 Remove the lubricating oil filter assembly, Operation 10-2, and the lubricating oil sump, see Operation 10-3.

10 If necessary, remove the turbocharger, see Operation 9-1.

11 Remove the fuel lift pump, see Operation 11-6.

12 Remove the starter motor, see Operation 14-7.

13 Remove the cylinder head assembly, see Operation 3-12.

14 Remove the timing case and the timing gears, see Chapter 6, Timing case and drive assembly.

15 Remove the lubricating oil pump, see Operation 10-6, and the pressure relief valve, see Operation 10-12, or remove the balancer unit, see Operation 5-18.

16 Remove the piston and connecting rod assemblies, see Operation 4-4.

17 Remove the camshaft and the tappets, see Operation 6-16.

18 Remove the flywheel, see Operation 13-1, and the flywheel housing, see Operation 13-3.

19 Remove the rear oil seal assembly, see Operation 5-5 or Operation 5-6, and the crankshaft, see Operation 5-15.

20 Remove the piston cooling jets, see Operation 4-15.

21 Inspect the cylinder block, see Operation 7-3.

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, or a similar sealant, 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 5-16, and the rear oil seal assembly, see Operation 5-5 or Operation 5-6.

5 Fit the piston and connecting rod assembly, see Operation 4-5.

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

7 Fit the tappets and the camshaft, see Operation 6-17.

8 Fit the lubricating oil pump, see Operation 10-7, and the pressure relief valve, see Operation 10-12, or fit the balancer unit, see Operation 5-18.

9 Fit the timing case and the timing gears, see Chapter 6, Timing case and drive assembly.

10 Fit the cylinder head assembly, see Operation 3-13 or Operation 3-14.

11 Fit the starter motor, see Operation 14-7.

12 Fit the fuel lift pump, see Operation 11-6.

13 If necessary, fit the turbocharger, see Operation 9-2.

14 Fit the lubricating oil filter assembly, see Operation 10-2, and the lubricating oil sump, see Operation 10-3.

15 If necessary, fit the lubricating oil cooler:

- For 4 cylinder engines, see Operation 12-22
- For 6 cylinder engines, see Operation 12-25.

16 Fit the fuel filter and the atomisers, see Operation 11-5.

17 Fit the fuel injection pump:

- For Bosch fuel injection pumps, see Operation 11-11
- For Lucas/Delphi DP200 Series fuel injection pumps, see Operation 11-14
- For Stanadyne fuel injection pumps, see Operation 11-18.

18 If necessary, fit the compressor, see Operation 15-2, or the exhauster, see Operation 15-15.

19 Fit the fan, the fan drive and the coolant pump, see Chapter 12, Cooling system, on page 257.

20 Fit the alternator and its mounting brackets, see Operation 14-4, and the alternator drive belts, see Operation 14-3.

21 Install the engine into the vehicle or machine.

22 Fill the cooling system.

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

24 Eliminate air from the fuel system, see Operation 11-20.

To inspect **Operation 7-3**

1 Clean the passages for the coolant and for the oil.

2 Check the cylinder block for cracks and for other damage.

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

4 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 will be towards the front of the engine, when fitted. Press in the 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.

To remove and to fit a new type ‘D’ plug to the tappet chamber **Operation 7-4**

Special requirements

Consumable products	
Description	**Part number**
POWERPART Pipe sealant	21820122

The new ‘D’ plug (A) has baffle plates (A1) attached to the rear of the ‘D’ plug. When fitted to the engine the push rods fit inside the baffle plates.

To identify if the engine has the new ‘D’ plug, the part number 3774A004 has been stamped on its outer face.

Paint, dirt and debris may have to be removed from the ‘D’ plug to enable it to be identified.

***Cautions*:**

- *Care must be taken when a new type ‘D’ plug is removed. Damage may occur to the push rods or the ‘D’ plug bore if it is not removed correctly.*
- *The new type ‘D’ plug must be fitted to a depth of 3,0 mm (0.12 in), this will provide clearance for the push rods.*

To remove a new type ‘D’ plug

1 Remove the rocker cover, see Operation 3-1.

2 Loosen only the tappet adjustment screws for the ‘D’ plug that is to be removed and remove the push rods.

3 Use a suitable tool to remove the ‘D’ plug and remove any remaining sealant.

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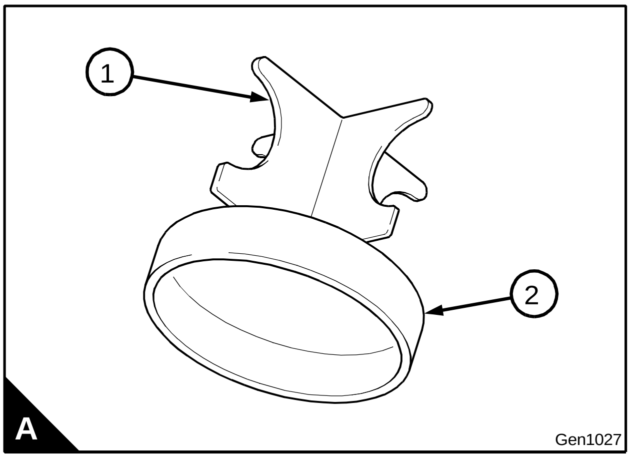


To fit a new type 'D' plug

Caution: *The baffle plates on the new type 'D' plug must be fitted horizontally and vertically to within ± 5°. This will ensure the maximum performance of the baffle plates.*

1 Ensure that the recess in the cylinder block is clean and free from damage.

2 Apply POWERPART Pipe sealant to the outer edge of the 'D' plug (B2).

3 Place the 'D' plug into its recess. The 'D' plug must be fitted with the baffle plates within ± 5° of the horizontal and vertical lines (C).

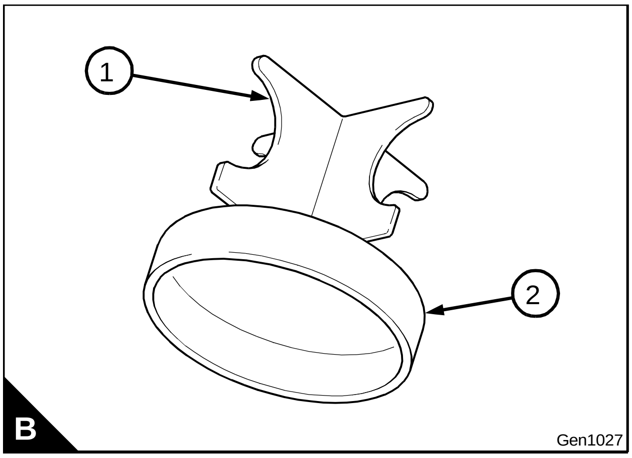
4 Use the tool (D) to fit the 'D' plug into the recess in the cylinder block until it is recessed (D1) to a depth of 3,0 mm (0.12 in). All measurements for the tool are in millimetres.

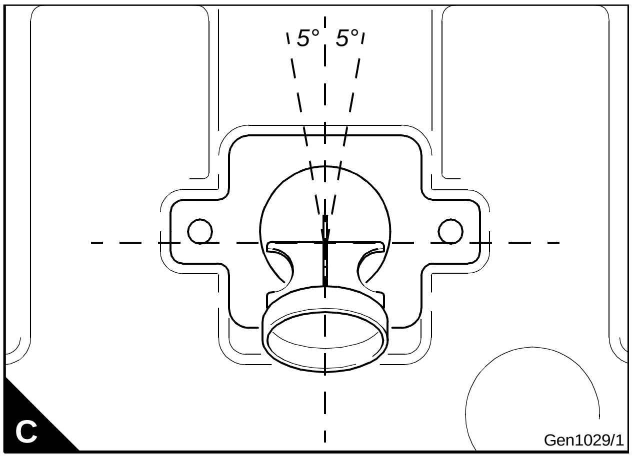
5 Remove any excess sealant.

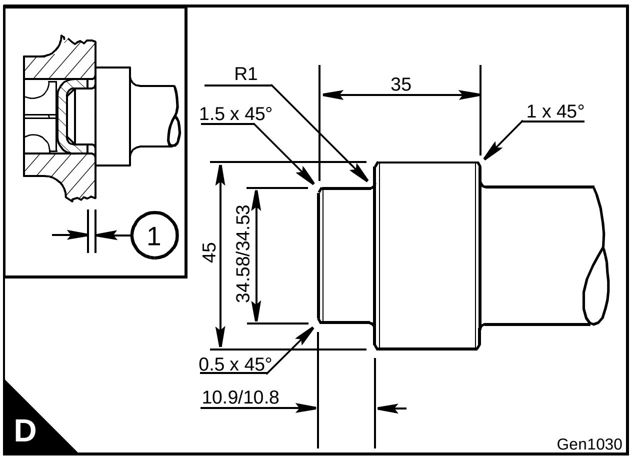
6 Fit the push rods and locate under the adjustment screws. From the top of the engine look down into the tappet chamber to ensure that there is clearance between the push rods and the baffle plates on the 'D' plug.

7 Adjust the tappets, see Operation 3-6 or Operation 3-7.

8 Fit the rocker cover, see Operation 3-2.







Cylinder liner

To inspect **Operation 7-5**

To ensure the best performance during the life of the engine it is important that worn or damaged cylinder liners are renewed. If a change of liner becomes necessary in service, transition fit liners and partially finished liners are available.

The condition of a cylinder liner is decided by:

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

Note: It will not be necessary to renew the liners if:

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

To check the condition of a cylinder liner

1 Inspect the liner surface for cracks and deep scratches.

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

***Cautions*:**

- *Do not use "Flex-hone" to repair cylinder liners.*
- *Damaged or worn liners must be discarded.*
- *New piston rings must be fitted when the cylinder liner is renewed.*
- *An engine can have high oil consumption with very little wear of the liner bores, if the surfaces of the liners are glazed.*
- *Specialist training and equipment is needed to machine the finish of a partially finished liner.*

Partially finished cylinder liners must be bored and then diamond honed, silicon carbide base honed and silicon carbide plateau honed to the finished size. Refer to the Data and dimensions for a "Partially finished liner" on page 26. Specialist training and equipment is needed to machine a partially finished liner. For further information contact your nearest Perkins Distributor.

To remove

Operation 7-6

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Remover/replacer for cylinder liner (main tool)	21825543	Adaptors for use with 21825543	21825563

Where several liners are to be removed or a very tight production liner is fitted, a press should be used. Where a single liner is to be removed or the crankshaft is to remain in position, a tool for hand operation is available.

1 Drain the lubricating oil and remove the lubricating oil sump, see Operation 10-3.

2 Remove the cylinder head assembly, see Operation 3-12.

3 Remove the piston and connecting rod assembly, see Operation 4-4.

4 Carefully remove the piston cooling jet, where fitted, see Operation 4-15.

5 Rotate the crankshaft to give access to the cylinder liner. Protect the crank pin.

6 Put the tool (A4) on the top face of the cylinder block and over the centre of the liner (A5). Ensure that the base of the tool is not on top of the liner flange of the next cylinder.

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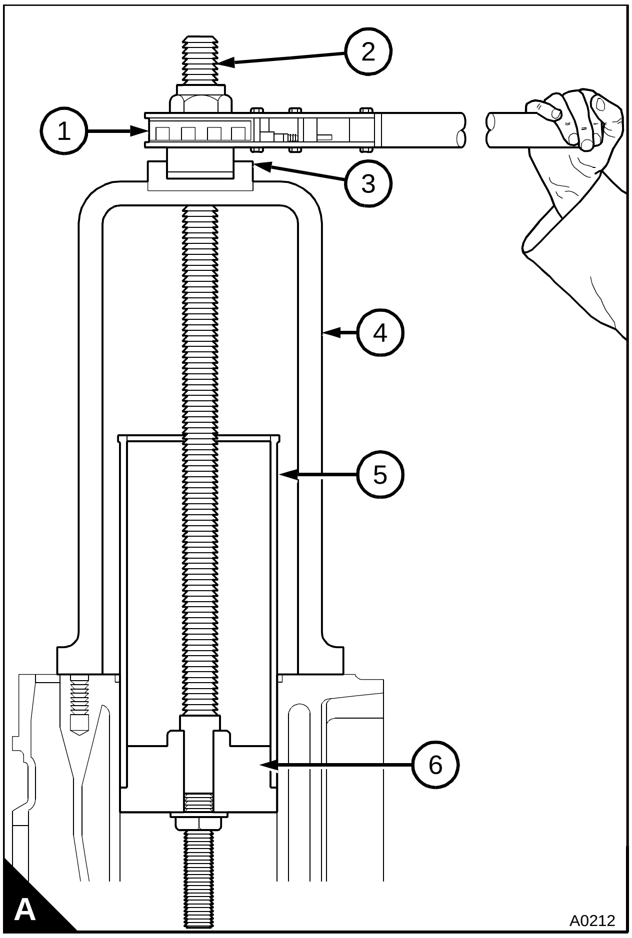
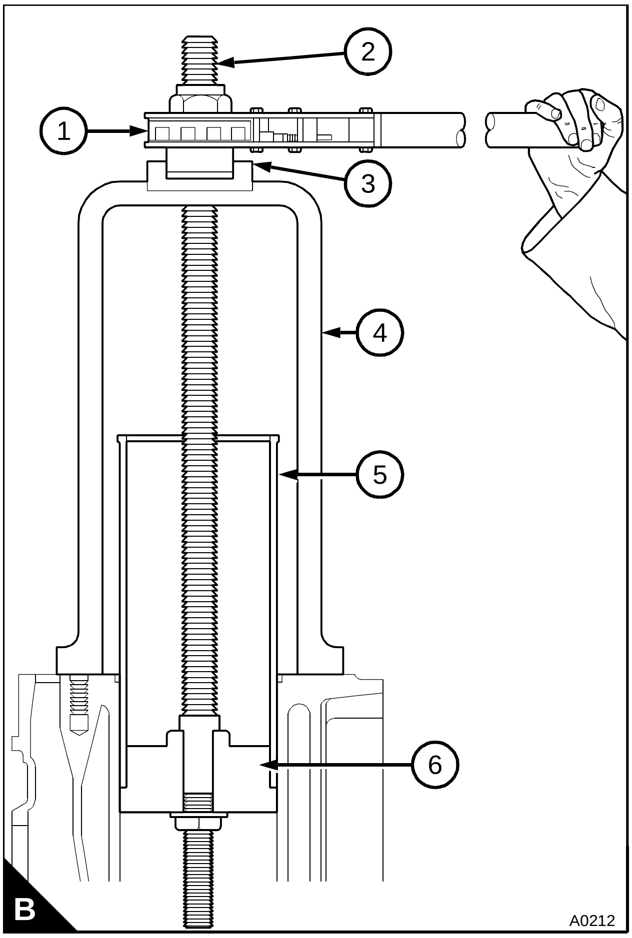


7 Put the bearing (B3) in the recess in the top of the tool with the flat face of the bearing to the bottom of the recess.

8 Fit the threaded rod (B2) through the bearing and the top of the tool until the handle (B1) is in the recess in the top of the bearing. In this position adjust the threaded rod until the end is below the bottom of the cylinder liner. Fit the adaptor (B6) onto the threaded rod and against the bottom of the cylinder liner. Ensure that the two lugs on the top of the adaptor engage with the flats on the threaded rod. Fit the washer and nut and tighten the nut onto the adaptor.

9 Lubricate the ratchet of the handle and the threaded rod with a suitable lubricating oil. Operate the handle and pull the cylinder liner out of the top of the cylinder block.



To fit a service liner **Operation 7-7**

Special requirements

Special tools		Consumable products:	
Description	**Part number**	**Description**	**Part number**
Remover/replacer for cylinder liner (main tool)	21825543	POWERPART Retainer (oil tolerant)	21820603
Adaptors for use with 21825543	21825563	POWERPART Safety cleaner	21820128
Gauge for cylinder liner flange	21825496		
Dial gauge for use with 21825496	21825617		

A service liner is a transition fit of +/- 0,03 mm (+/- 0.001 in) in the parent bore. A special tool will not be necessary to fit some liners, but where a liner is a tight fit, tool 21825543 can be used.

Caution: *Do not hit a liner with a hammer.*

1 Clean thoroughly the parent bore. Clean the top 50 mm (2.0 in) and the recess for the liner flange with POWERPART Safety cleaner; use it in accordance with the manufacturer's instructions.

2 Clean thoroughly the outer surface of the liner with POWERPART Safety cleaner.

3 Lubricate lightly the parent bore with clean engine lubricating oil, except for the top 50 mm (2.0 in).

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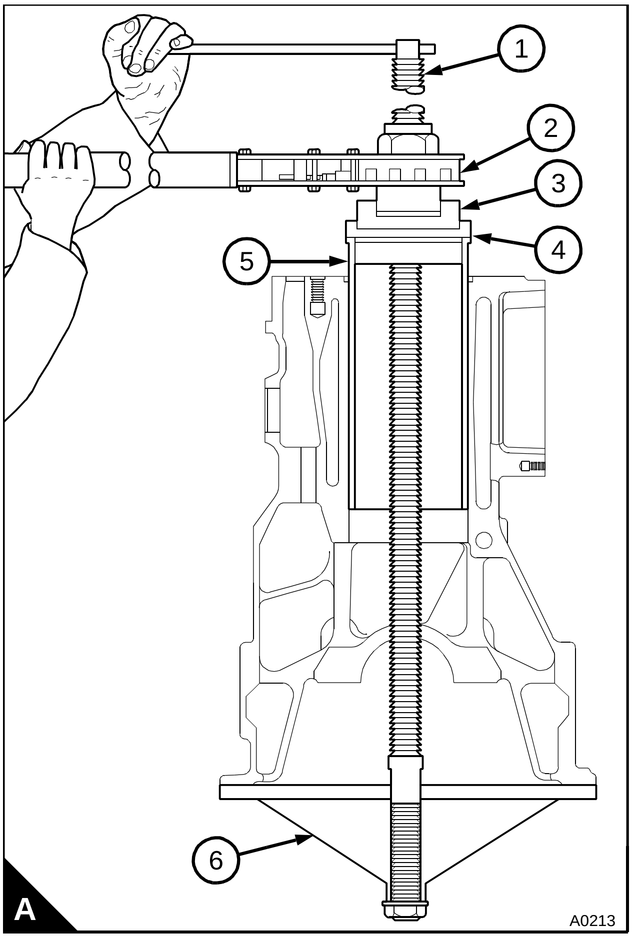

4 Engage the cylinder liner (B5) into the parent bore; ensure that the liner is vertical. Put the adaptor (B4) onto the top of the liner with the shoulder of the adaptor on the liner flange. Put the bearing (B3) into position in the recess in the top of the adaptor with the flat face of the bearing to the bottom of the recess.

5 Fit the threaded rod (B1) through the bearing, the adaptor and the liner until the handle (B2) is against the recess in the bearing. In this position adjust the threaded rod until the end is below the bottom face of the cylinder block.

6 Fit the adaptor (B6) onto the threaded rod; ensure that the flat face of the adaptor is against the bottom face of the cylinder block. Fit the washer and the nut; ensure that the threaded rod is in the centre of the liner and tighten the nut onto the adaptor.

7 Lubricate the ratchet of the handle and the threaded rod with a suitable lubricating oil. Operate the handle and press the liner into the parent bore to within 50 mm (2.0 in) of the fitted position. Clean the area below the flange of the liner with POWERPART Safety cleaner. Apply POWERPART Retainer (oil tolerant) to the top 25 mm (1.0 in) of the outer surface of the liner and under the flange; also apply POWERPART Retainer (oil tolerant) to the bottom of the flange recess in the parent bore.

8 Press the liner in to the fully fitted position. Remove the tool and clean the retainer from the top of the cylinder block.

9 Allow 15 minutes to elapse before the liner bore dimension is checked. The retainer will reach full strength after 6 hours. The inside diameter of a service liner, when fitted, should be 100,00/100,06 mm (3.937/3.939 in).

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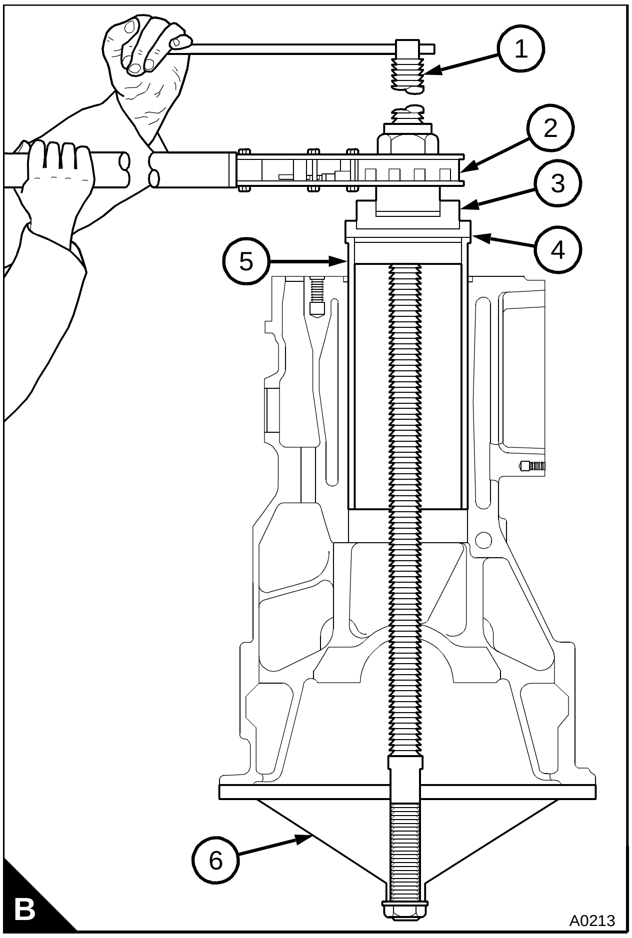


10 Use tool 21825496 to check that the liner flange is between 0,10 mm (0.004 in) above to 0,10 mm (0.004 in) below the top face of the cylinder block (C).

This measurement must be from the flange (C2) of the cylinder liner, not the top of the flame ring (C1).

11 Fit new piston rings, see Operation 4-8.

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

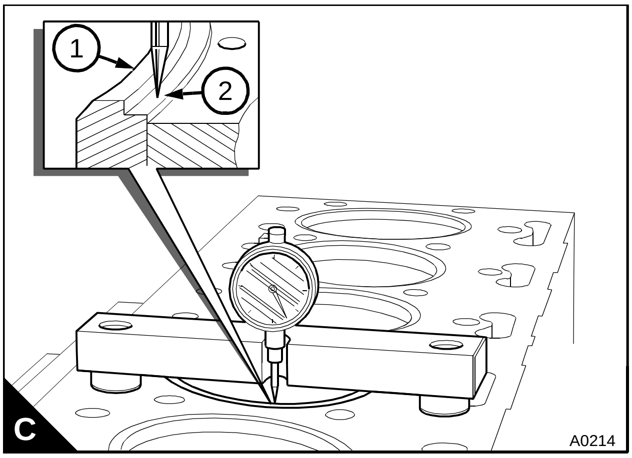
13 If necessary, fit the piston cooling jet, see Operation 4-15.

14 Fit the cylinder head assembly, see Operation 3-13 or Operation 3-14.

15 Fit the lubricating oil sump, see Operation 10-3, and fill it to the correct level with an approved lubricating oil.

Caution: *After a new service liner has been fitted, these recommendations are advised for the first 240 km (150 miles) or 5 hours of operation*

- Do not operate the engine at full load
- Do not operate the engine at high speed
- Do not allow the engine to run at low idle speed for long periods.



To fit a partially finished liner **Operation 7-8**

Special requirements

Special tools		Consumable products:	
Description	**Part number**	**Description**	**Part number**
Remover/replacer for cylinder liner (main tool)	21825543	POWERPART Safety cleaner	21820128
Adaptors for use with 21825543	21825563		
Gauge for cylinder liner flange	21825496		
Dial gauge for use with 21825496	21825617		

The liner is an interference fit in the parent bore. A special tool will be necessary to fit the liners, tool 21825543 can be used. If a liner is a very tight fit it may be necessary to use a hydraulic press.

***Cautions*:**

- *A partially finished liner, fitted to an emissions compliant engine must be finished to the specifications given in this manual. Failure to do so may mean that the engine is not emissions compliant.*
- *Do not hit a liner with a hammer.*

1 Clean thoroughly the parent bore of the cylinder block with an approved degreasing fluid.

2 Inspect the parent bore for damage and corrosion. Damaged cylinder blocks should be discarded.

3 Clean thoroughly the outer surface of the liner with POWERPART Safety cleaner.

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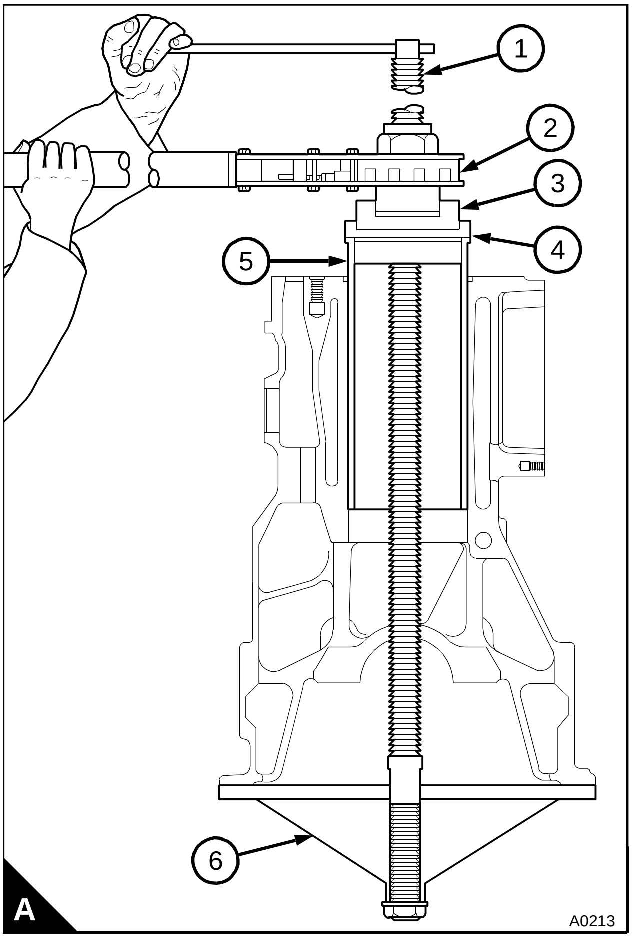

4 Apply a small amount of engine oil around the top of the parent bore to assist the entry of the liner.

5 Engage the cylinder liner (B5) into the parent bore; ensure that the liner is vertical. Put the adaptor (B4) onto the top of the liner with the flame ring in the groove of the adaptor. Put the bearing (B3) into position in the recess in the top of the adaptor with the flat face of the bearing to the bottom of the recess.

6 Fit the threaded rod (B1) through the bearing, the adaptor and the liner until the handle (B2) is against the recess in the bearing. In this position adjust the threaded rod until the end is below the bottom face of the cylinder block.

7 Fit the adaptor (B6) onto the threaded rod; ensure that the flat face of the adaptor is against the bottom face of the cylinder block as shown (B). Fit the washer and the nut; ensure that the threaded rod is in the centre of the liner and tighten the nut onto the adaptor.

8 Lubricate the ratchet of the handle and the threaded rod with a suitable lubricating oil. Operate the handle and press the liner into the fully fitted position.

9 Remove the tool 21825543 and thoroughly clean the top of the cylinder block.

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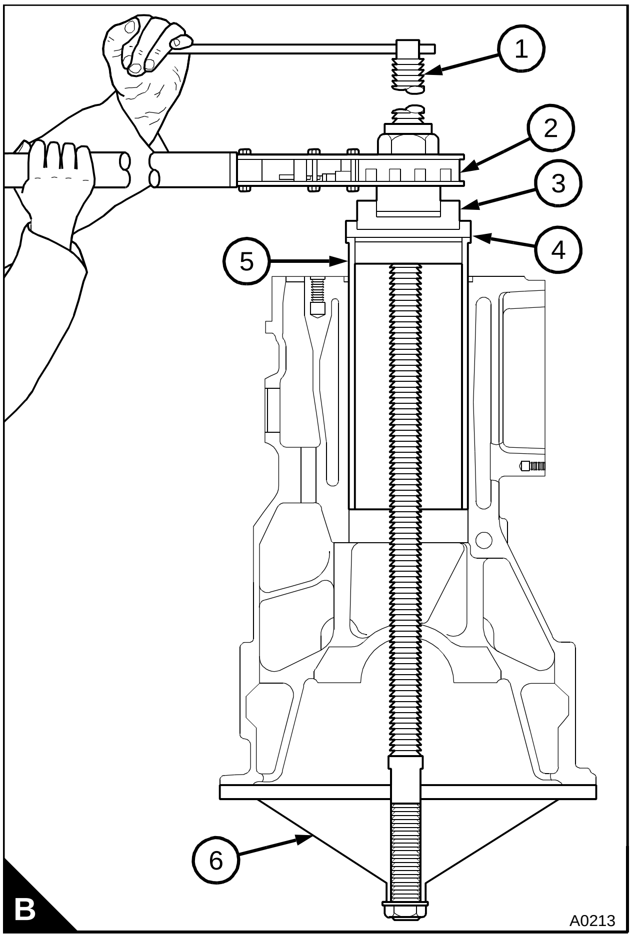


10 Use tool 21825496 to check that the flange of the cylinder liner is between 0,10 mm (0.004 in) above to 0,10 mm (0.004 in) below the top face of the cylinder block (C).

This measurement must be from the flange (C2) of the cylinder liner, not the top of the flame ring (C1).

Caution: *Specialist training and equipment is needed to machine the finish of a partially finished liner.*

Partially finished cylinder liners must be bored and then diamond honed, silicon carbide base honed and silicon carbide plateau honed to the finished size. Refer to the Data and dimensions for "Partially finished liner" on page 26. Specialist training and equipment is needed to machine a partially finished liner. For further information contact your nearest Perkins Distributor.

11 Fit new piston rings, see Operation 4-8.

12 Fit the piston and connecting rod assembly, Operation 4-5.

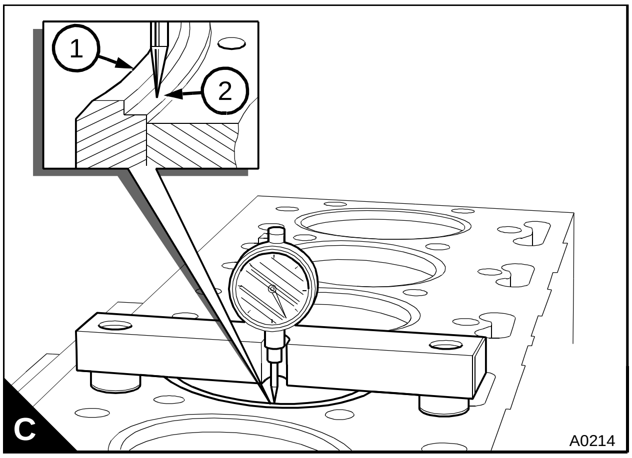
13 If necessary, fit the piston cooling jet, see Operation 4-15.

14 Fit the cylinder head assembly, see Operation 3-13 or Operation 3-14.

15 Fit the lubricating oil sump, see Operation 10-3 and fill it to the correct level with an approved lubricating oil.

Caution: *After a new cylinder liner has been fitted, these recommendations are advised for the first 240 km (150 miles) or 5 hours of operation:*

- Do not operate the engine at full load.
- Do not operate the engine at high speed.
- Do not allow the engine to run at low idle speed for long periods.



Cylinder bore, engine types AR and AS

To inspect **Operation 7-9**

To ensure the best performance during the life of the engine it is important that worn or damaged cylinder bores are corrected.

The condition of a cylinder bore is decided by:

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

Note: It will not be necessary to correct the bore if:

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

1 Inspect the surface of the cylinder bore 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 liner 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.*
- *An engine can have high oil consumption with very little wear of the cylinder bores, if the surfaces of the bores are glazed.*
- *Specialist training and equipment is needed to machine the finish of a cylinder bore.*

If necessary, the cylinder bores can be bored and honed 0,50 mm (0.0197 in) and 1,00 mm (0.0394 in) oversize in diameter and oversize pistons fitted.

To obtain oversize cylinder bores they must be bored and then diamond honed, silicon carbide base honed and silicon carbide plateau honed to the finished size. Refer to the Data and dimensions for "Cylinder bore specifications (engine types AR and AS)" on page 27. Specialist training and equipment is needed to machine a cylinder bore. For further information contact your nearest Perkins distributor.

8

Engine timing

General description

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

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

The fuel injection pump is timed at TDC on the compression stroke of number 1 cylinder. It is important that fuel injection timing is accurate to conform to emissions legislation. Always use Operation 8-1 or Operation 8-2 to obtain TDC on the compression stroke of number 1 cylinder accurately.

Caution: *The fuel injection pump has a lock screw (B1) which locks the shaft. It is important that the lock screw is released and the pump shaft is free to turn. The drive shaft of the pump must not be rotated without the spacer (B2) in position under the locking screw. If the drive shaft is rotated with the locking screw tightened on to the shaft, the drive shaft will be damaged.*

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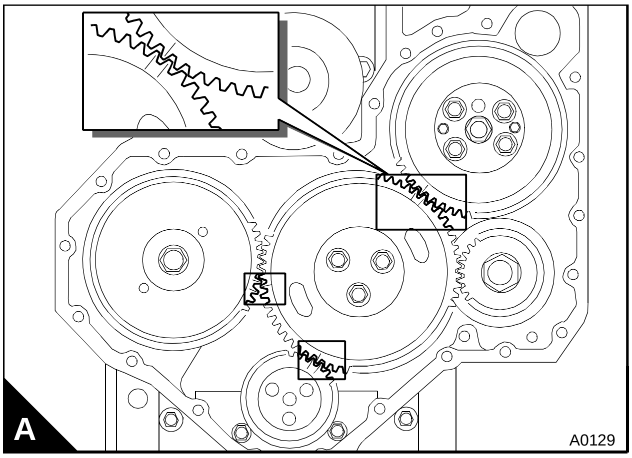
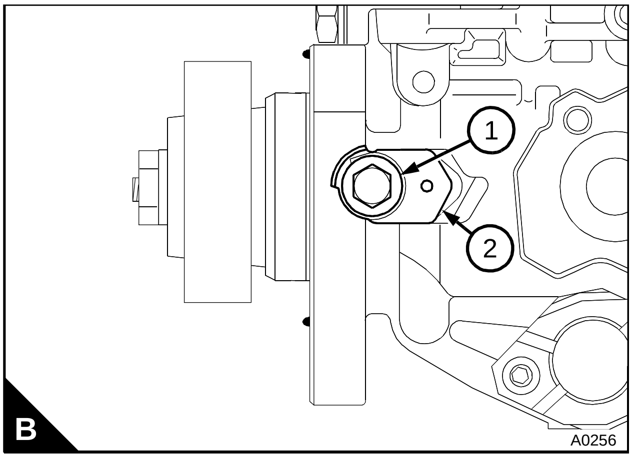




The latest fuel injection pumps have a hub (C2) which is mounted permanently onto the drive shaft.

The manufacturer fits the hub to the pump to ensure very accurate timing. Engines that have this arrangement have the drive gear fastened to the hub instead of to the shaft of the pump. A pin (C1) is used to accurately time these pumps in service.

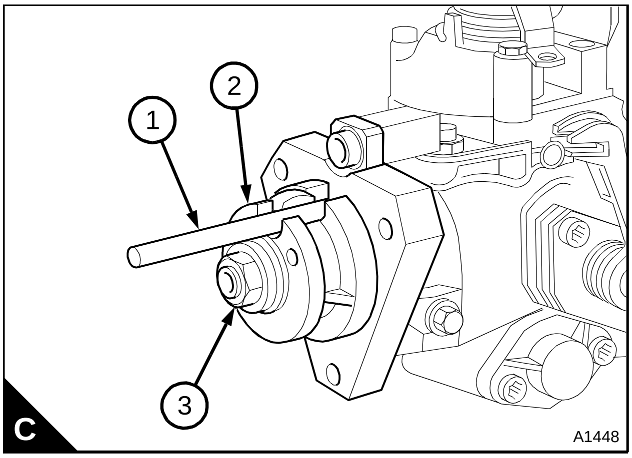
Caution: *Do not release the nut (C3) from the fuel injection pump. Illustration (D) shows the nut (D2) in position when the fuel pump is fitted to the engine. The fuel pump hub is fitted to the shaft in the factory to ensure that the fuel pump is in the correct position for timing. If the nut is removed and the hub moves, the hub will need to be accurately fitted to the pump by use of specialist equipment before the pump can be fitted to the engine.*

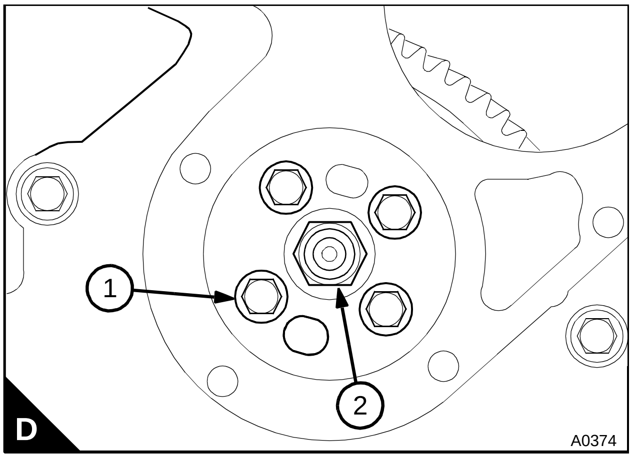
The fuel pump gear is fastened to the hub of the fuel pump by four setscrews. The setscrews pass through slots in the gear which allow removal of the backlash.

Note: On the latest engines with belt driven coolant pumps, four tamper proof fasteners retain the fuel pump gear. Special tools are needed to remove these fasteners, refer to your Perkins distributor.

To remove the fuel injection pump from the engine it is only necessary to remove the four setscrews (D1) which secure the fuel pump gear to the hub:

- For Bosch fuel injection pumps, see Operation 11-10
- For Lucas/Delphi DP200 Series fuel injection pumps, see Operation 11-13
- For Stanadyne fuel injection pumps, see Operation 11-17.





To set number 1 piston to TDC on the compression stroke — Operation 8-1

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Valve spring compressor	21825666	Setscrew adaptor for use with 21825666	21825932
Stud adaptor for use with 21825666	21825931		

1 Fasten a temporary pointer to the timing case cover with its tip near to the outer edge of the crankshaft pulley or damper (A1).

2 Loosen the gland nuts that retain the atomisers, see Operation 11-4.

3 Remove the rocker cover, see Operation 3-1.

4 Rotate the crankshaft, clockwise from the front, until the push rod for the inlet valve of the rear cylinder just tightens.

5 Remove the spring clip and the spacer from the front of the rocker shaft. Release the fasteners of the front two pedestals of the rocker shaft and remove the front rocker lever; tighten the fasteners of the rocker shaft pedestals.

6 Remove the valve spring from the front valve with the valve spring compressor and the adaptor for pedestal studs, or the adaptor for pedestal setscrews.

Caution: *Fit a suitable collar near the top of the valve to hold the valve if the crankshaft is rotated too far.*

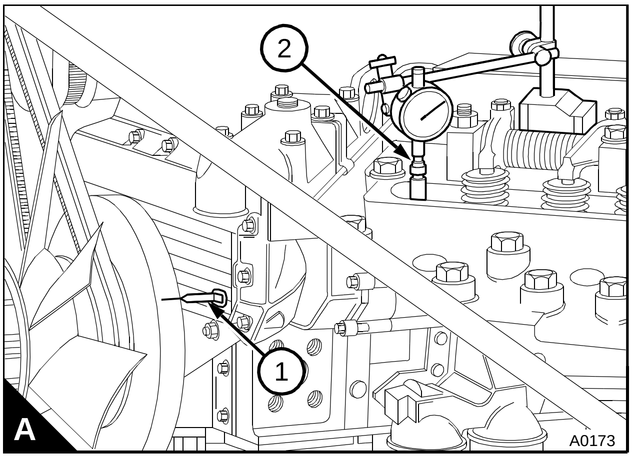
7 Allow the valve to be held by the top of the piston.

8 Fasten a dial test indicator with its plunger in contact with the top of the valve stem (A2) and with a reading shown on the gauge. Rotate slowly the crankshaft, clockwise from the front, until the clockwise movement of the dial gauge pointer just stops. Make a suitable mark on the crankshaft pulley or damper to align with the temporary pointer. Continue to rotate the crankshaft, in the same direction, until the gauge pointer just begins to move in a counter-clockwise direction. Make another mark on the pulley or damper to align with the pointer. Mark the centre point between the two marks on the pulley or damper and remove the other two marks.

9 Remove the dial test indicator from number 1 inlet valve and fit the spring, the rocker lever and the circlip to the rocker shaft. Ensure that the rocker shaft pedestals are tightened to the correct torque.

10 Adjust the valve tip clearance, see Operation 3-6 or Operation 3-7.

11 Rotate the crankshaft approximately 45° counter clockwise from the front and then clockwise until the mark on the pulley or damper is aligned with the pointer. Number 1 piston is now at TDC on the compression stroke.



Another method to set number 1 piston to TDC on the compression stroke **Operation 8-2**

1 Fasten a temporary pointer to the timing case cover (or other suitable position) with its tip near to the outer edge of the crankshaft damper or pulley.

2 Loosen the gland nuts that retain the atomisers, see Operation 11-4.

3 Remove the rocker cover, see Operation 3-1.

4 Rotate the crankshaft clockwise, from the front, until the push rod for the inlet valve of the rear cylinder just tightens.

5 Rotate the crankshaft a further 1/8 of a turn clockwise. Insert a suitable lever between the rocker lever and the valve spring cap of number 1 inlet valve. Open the inlet valve and put a spacer approximately 5,0 mm (0.2 in) thick between the valve tip and the rocker lever.

6 Slowly rotate the crankshaft counter-clockwise until the piston makes contact with the open valve. Make a temporary mark on the damper or pulley to align accurately with the tip of the pointer.

7 Rotate the crankshaft clockwise one or two degrees and remove the spacer between the valve and the rocker lever. Rotate the crankshaft 1/4 of a turn counter-clockwise. Put the spacer between the valve tip and the rocker lever.

8 Slowly rotate the crankshaft clockwise until the piston makes contact with the open valve. Make another temporary mark on the damper or pulley to align accurately with the tip of the pointer.

9 Make a temporary mark at the centre point between the two marks on the damper or pulley and remove the other two marks. Rotate the crankshaft counter-clockwise 1/8 of a turn and remove the spacer between the valve and the rocker lever. Slowly rotate the crankshaft clockwise until the mark on the damper or pulley aligns accurately with the tip of the pointer. Number 1 piston is now at TDC on the compression stroke.

To check the valve timing **Operation 8-3**

1 Set the piston of number 1 cylinder to TDC on the compression stroke, see Operation 8-1 or Operation 8-2.

2 Rotate the crankshaft, clockwise from the front, until the inlet valve of the rear cylinder is fully open.

3 Set the valve tip clearance of number 1 cylinder inlet valve to 1,5 mm (0.059 in).

4 Rotate the crankshaft, clockwise from the front, until the push rod of number 1 cylinder inlet valve just tightens. 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.

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

C = circumference of pulley or damper

P = 2.5 degrees

5 If the timing is more than 2.5° out of position, the timing gears are probably not in correct mesh.

Note: One tooth on the camshaft gear is equivalent to 23 mm (0.9 in) at the circumference of a pulley of 203 mm (8 in) diameter. If a large damper is fitted, one tooth on the camshaft gear is equivalent to 35 mm (1.4 in) at the circumference of a damper of 310 mm (12.2 in) diameter, or 37 mm (1.5 in) at the circumference of a damper of 327 mm (12.8 in) diameter.

6 Rotate the crankshaft, clockwise from the front, until the inlet valve of the rear cylinder is fully open. Set the valve tip clearance of the inlet valve of number 1 cylinder to 0,20 mm (0.008 in).

7 Fit the rocker cover, see Operation 3-2.

8 Remove the temporary pointer from the timing case and the timing mark from the pulley or damper.

To check the timing of the fuel injection pump **Operation 8-4**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Timing pin Bosch fuel injection pumps	27610032	Timing pin Lucas/Delphi and Stanadyne fuel injection pumps	27610033

Caution: *Do not remove the nut (A2) which retains the hub (A4) to the shaft of the fuel injection pump. The hub is fitted permanently to the shaft. If the hub is moved, it will be necessary for a fuel injection pump specialist to correctly position the hub on the shaft with special test equipment available to Perkins distributors.*

1 Set the piston of number 1 cylinder to TDC on the compression stroke, see Operation 8-1 or Operation 8-2.

2 Remove the gear cover from the cover of the timing case.

3 For gear driven coolant pumps: Remove the coolant pump, see Operation 12-4 or Operation 12-9.

Note: On the latest engines with belt driven coolant pumps, four tamper proof fasteners retain the fuel pump gear. Special tools and personnel with the correct training are necessary to remove these fasteners, refer to your nearest Perkins distributor.

4 Insert the timing pin (A1) through the hole (A5) in the fuel pump gear and the slot of the hub (A4). Push the pin fully into the hole (A3) 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.

Note: The position for the timing pin for Lucas/Delphi and Stanadyne fuel injection pumps is (A1). The position for the timing pin for Bosch EPVE fuel injection pumps is (B1).

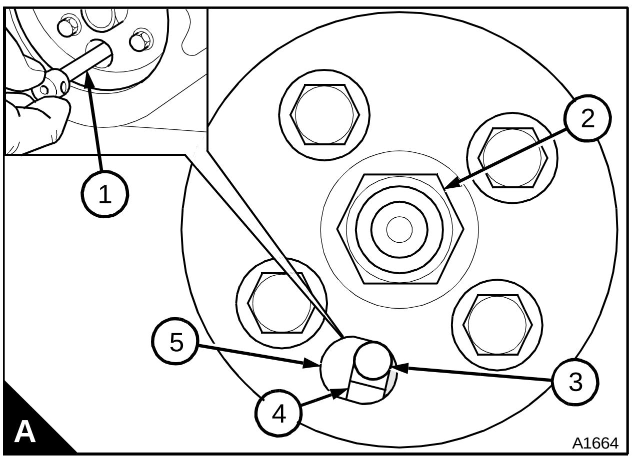
5 Remove the timing pin.

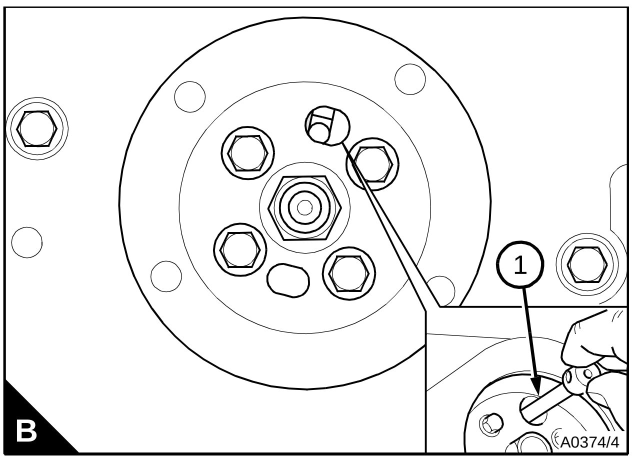
6 If the timing pin cannot be pushed into the pump body, check that the engine is correctly set at TDC on the number 1 cylinder compression stroke, see Operation 8-1 or Operation 8-2.

If the engine is set correctly at TDC on the number 1 cylinder compression stroke, but the pin does not fit into the hole, the fuel pump must be removed and set by a specialist.

7 Fit the gear cover to the cover of the timing case.

8 For gear driven coolant pumps. Fit the coolant pump, see Operation 12-5 or Operation 12-10.





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.*

A turbocharger (A), is fitted between the exhaust and intake manifolds. The turbocharger is driven by exhaust gases and passes air to the engine at more than atmospheric pressure. It is lubricated by oil from the main gallery. The oil passes through the bearing housing of the turbocharger and returns to the lubricating oil sump; arrows are included on the illustration to indicate the typical oil flow.

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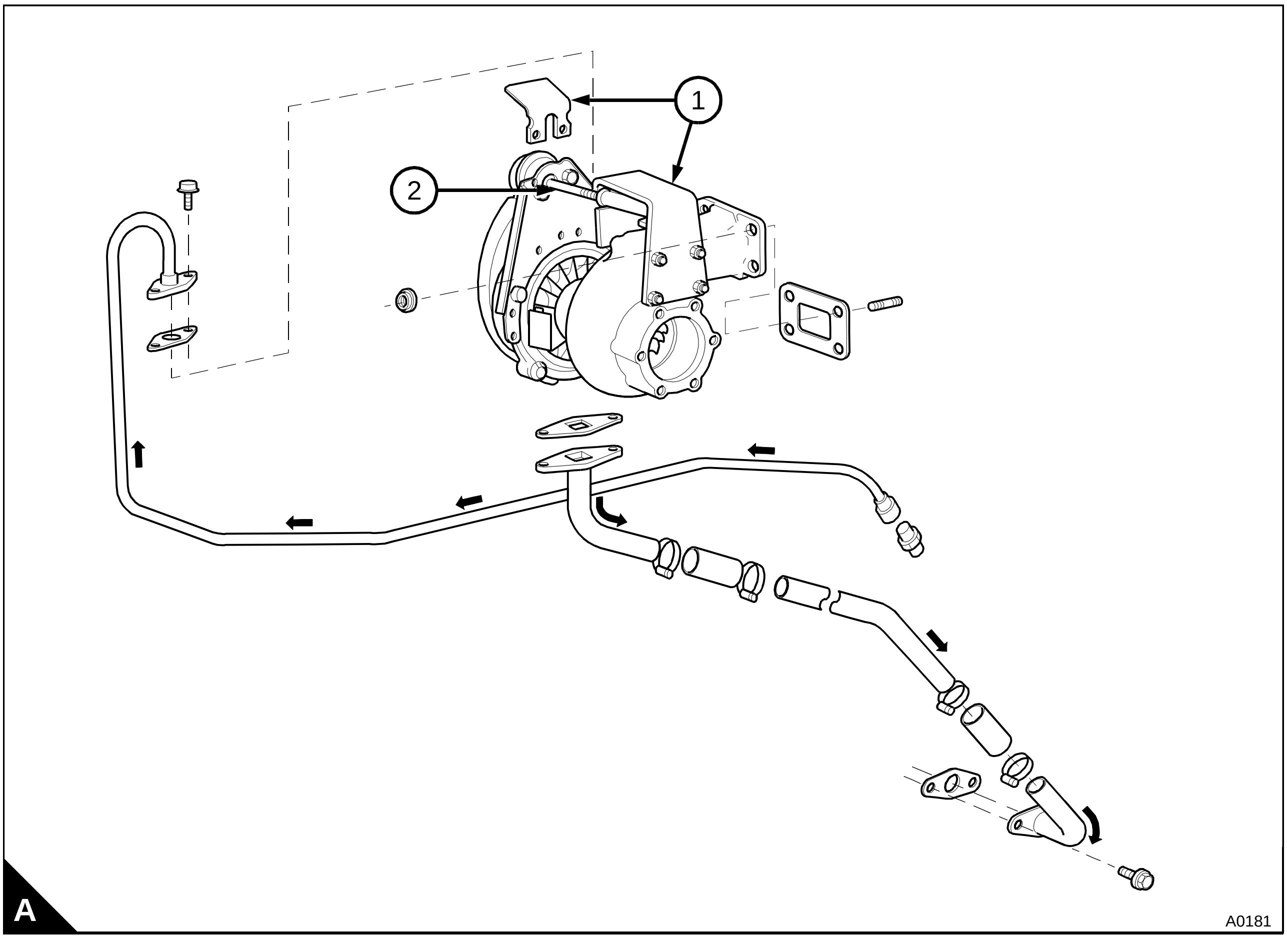
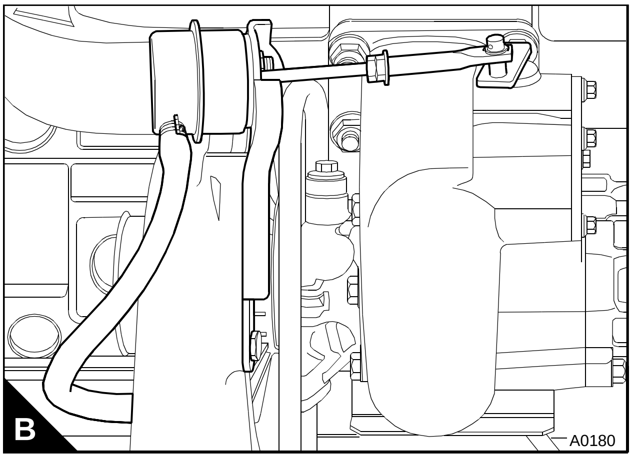


Some turbochargers are fitted with a waste-gate unit (B). This unit, which is controlled by boost pressure, allows some of the exhaust gases to bypass the turbine rotor at higher engine speeds. With this arrangement, the turbocharger can be designed to be more effective at lower engine speeds. A waste-gate guard, page 171 (A1) is fitted to protect the actuator rod, page 171 (A2) of some engines.

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



Turbocharger

To remove — Operation 9-1

1 Thoroughly clean the turbocharger.

2 Remove the air cleaner hose at the compressor inlet.

3 Remove or disconnect the support bracket for the turbocharger. If necessary, remove the heat shield for the fuel lift pump. Disconnect the exhaust pipe for the application and remove the exhaust elbow from the turbocharger. Where the elbow has a joint, release the nuts and remove the elbow and the joint. Where the elbow has a sleeve, pull the elbow together with the sleeve away from the turbocharger.

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

5 Release the setscrews from the flange of the oil supply pipe at the top of the bearing housing and the union nut/connection at the other end of the pipe. If the lower section of the oil supply pipe is flexible, use a spanner to hold the flats on the pipe while the union connection is removed from the oil filter head/adaptor plate. This will prevent damage to the flexible section of the pipe. If an adaptor is used in the oil filter head/adaptor plate, use a spanner to hold the adaptor when the union nut is released. Remove the pipe and the flange joint.

6 Release the setscrews from the flange of the oil drain pipe at the bottom of the bearing housing. If necessary, release the hose clip(s) from the oil drain pipe and push the hose down. Remove the oil drain pipe and the joint from the flange.

Caution: *If the turbocharger has a waste-gate, ensure that the actuator rod of the waste-gate is not used to lift or move the turbocharger. This could damage the waste-gate and affect the calibration.*

7 Release the nuts at the turbocharger to exhaust manifold flange and remove the turbocharger and the joint. Cover the open ports in the manifolds, the turbocharger and the pipes to ensure that dirt, etc. will not enter.

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

To fit **Operation 9-2**

Special requirements

Consumable products	
Description	**Part number**
POWERPART Pipe sealant	21820122

Note: Reflective heat shields 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, manifolds and the turbocharger.

2 Check that the turbocharger inlets and outlets are clean and free from restriction and that the turbocharger shaft rotates freely. Also check that the open ports in the manifolds and the exhaust pipe are clean and free from restriction.

3 Fit a new joint to the exhaust manifold to turbocharger flange (A1). If the original nuts are to be used, ensure that the threads of the studs are clean and apply a suitable compound to the studs to prevent seizure. The threads of new nuts are phosphated to prevent seizure. Fit the turbocharger. Fit the nuts and tighten them to 44 Nm (33 lbf ft) 4,5 kgf m.

4 Lubricate the bearing housing of the turbocharger with clean engine lubricating oil. Fit the oil supply pipe together with a new joint and tighten the flange setscrews. If the lower section of the pipe is flexible, clean the thread of the union connection and apply POWERPART Pipe sealant. Ensure that dirt does not enter the oil filter head/adaptor plate. Use a spanner to hold the flats on the pipe while the union connection is fitted to the oil filter head/adaptor plate. If an adaptor is used in the oil filter head/adaptor plate, use a spanner to hold the adaptor when the union nut is tightened.

5 Fit the oil drain pipe together with a new joint and tighten the flange setscrews, but do not connect the hose.

6 Where the exhaust elbow has a flange, clean the threads of the studs in the flange of the turbocharger. Apply a suitable compound to the studs to prevent seizure of the nuts. Put a new joint in position on the flange and fit the elbow. Tighten the nuts to 22 Nm (16 lbf ft) 2,2 kgf m (plated) or 25 Nm (18 lbf ft) 2,5 kgf m (non-plated). Fit or connect the support bracket between the elbow and the cylinder block. Ensure that there is no stress on the exhaust elbow. If necessary fit the heat shield for the fuel lift pump.

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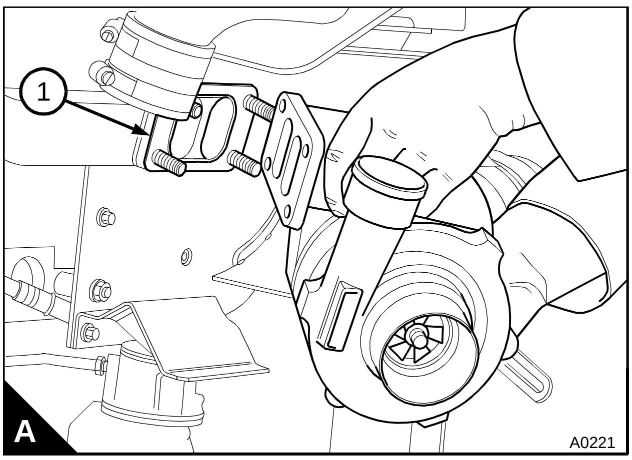


7 Where the exhaust elbow (B2) has a sleeve (B1), check that the sleeve protrusion from the end of the elbow is 23 mm (0.90in) (A9).

8 Fit the elbow in the correct position to the support bracket (B5) and tighten the setscrews (B4) finger tight. Some engines have an aluminium heat shield (B3) between the elbow and the bracket.

9 Fit the sleeve together with the elbow and bracket into the turbocharger outlet. Fit the setscrews (B6 and B7) which hold the bracket to the cylinder block, finger tight. Ensure that the setscrew (B6) has a thick washer fitted between the setscrew and the bracket.

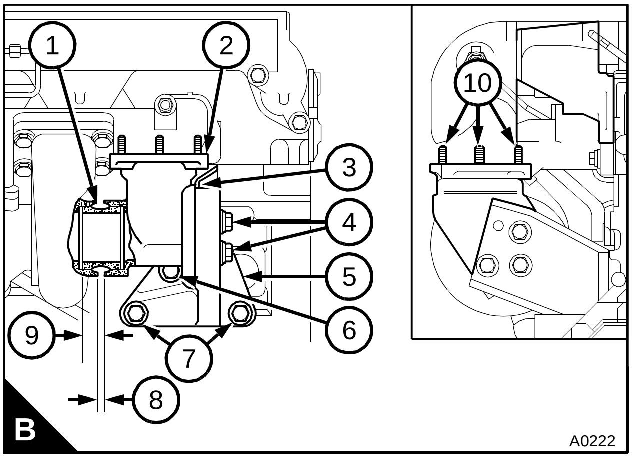
10 Fit the joint and connect the exhaust pipe for the application to the exhaust elbow. Tighten the studs (B10) to the recommended torque.

11 Fully tighten the setscrews that hold the bracket to the elbow. Check that there is a gap of 6,5 mm (0.25 in) (B8) between the turbocharger outlet and the end of the elbow. This gap should be equal all around the elbow. Fully tighten the setscrews that hold the bracket to the cylinder block.

12 Slide the hose on the intake manifold elbow onto the compressor outlet and tighten the hose clips.

13 Check that there is no restriction in the air filter to turbocharger hose. Fit the hose and tighten the clip.

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



To clean the impeller and the compressor casing **Operation 9-3**

Generally, it is not necessary to remove the turbocharger to remove the compressor casing, except on some engines where the compressor casing is held by a circlip and access to the circlip is not always possible. This type of turbocharger is usually fitted to engines used in vehicle applications.

1 Release the clip and remove the hose from the compressor inlet. Release the clips and push the hose on the compressor outlet up the elbow of the intake manifold.

2 Make a reference mark on the compressor casing (A1) and on the bearing housing to ensure correct assembly later.

3 Release the setscrews and remove the lock plates. If the compressor casing is retained by a circlip, remove the circlip. It may be necessary to remove the turbocharger if access to the circlip is not possible. If the turbocharger has a waste-gate unit, remove the actuator and bracket assembly, see Operation 9-4.

Caution: *Be careful not to damage the impeller blades. If the impeller is damaged, the turbocharger must be renewed.*

4 Remove carefully the compressor casing from the turbocharger (A). If the casing is tight, lightly hit it with a soft faced hammer.

5 Put the compressor casing in a suitable container that contains a non-caustic solution. Allow the dirt to become soft and then clean the casing with a hard brush and/or a soft scraper. Dry the casing with clean, compressed air at low pressure.

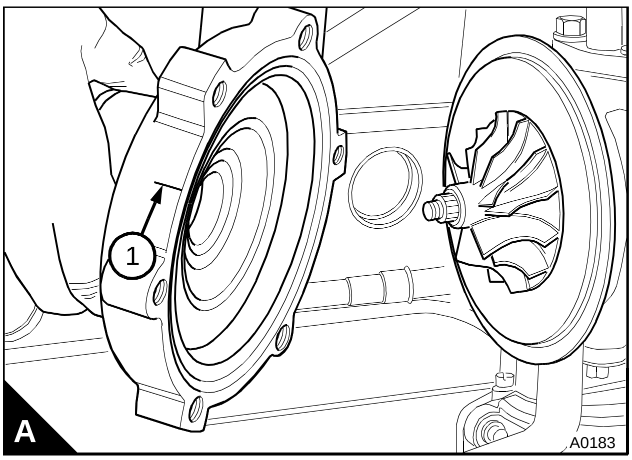
6 Clean the impeller with a soft brush.

7 Push carefully the compressor impeller towards the bearing housing and turn the impeller by hand. Check that there is no restriction of movement and that there is no noise which can indicate a fault. If there is a fault, remove the turbocharger for inspection by a specialist.

8 Fit the casing to the turbocharger and align the mark on the casing with the mark on the bearing housing. Fit the lock plates and the setscrews and tighten the setscrews.If the compressor casing of the turbocharger is retained by a circlip, fit the circlip loosely to the bearing housing. Ensure that the flat face of the circlip is toward the compressor casing. Fit the casing to the turbocharger and align the marks on the casing and on the bearing housing. Fit the circlip in its groove. If the turbocharger has a waste-gate unit, fit the actuator and bracket assembly, see Operation 9-4.

9 Fit the hoses to the compressor inlet and outlet and tighten the clips.

10 If necessary, fit the turbocharger to the engine, see Operation 9-2.



To remove and to fit the actuator assembly of the waste-gate unit **Operation 9-4**

It is important that the waste-gate actuator setting is not altered. Do not remove the actuator or mounting bracket unless it is necessary to renew the actuator assembly.

If a waste-gate actuator or mounting bracket assembly is removed from a turbine or compressor housing it is important that the bracket is fitted into the correct position on the housing.

To remove

1 Disconnect the boost sensor pipe (A1) at the actuator (A2).

2 Remove the clip (A4) which retains the actuator rod (A3) and lift the end of the actuator rod off the pin (A5) of the waste-gate valve.

3 Release the setscrews which retain the actuator bracket to the turbocharger and remove the actuator and bracket assembly.

To fit

1 Put the actuator and bracket assembly in position on the turbocharger and tighten the setscrews.

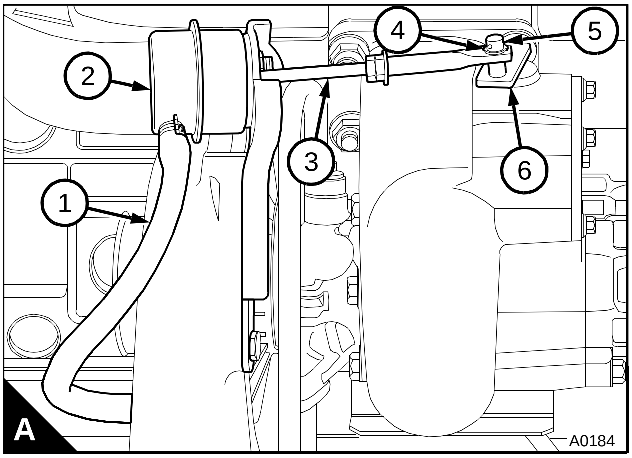
2 Connect to the actuator (A2) an air supply which can be adjusted accurately and is fitted with an accurate gauge.

3 Operate the arm (A6) of the waste-gate valve by hand to check that the valve is free to move.

4 Push the arm of the waste-gate valve as far as possible toward the actuator and hold the arm in this position. Slowly apply air pressure to the actuator until the end of the actuator rod (A3) will fit easily onto the pin (A5) of the waste-gate valve. Fit the clip (A4). Release the air pressure.

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

5 Check the operation of the waste-gate unit, see Operation 9-5.



To check and adjust the operation of the waste-gate **Operation 9-5**

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.

Caution: *A high pressure setting can cause high cylinder pressures. This can cause failure of the cylinder head joint and damage to the bearings and pistons.*

1 Disconnect the boost sensor pipe (A6) 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 (A4) to measure the axial movement of the rod.

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 28. 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 If the operation of the waste-gate is not correct, the actuator rod can be adjusted.

5 Remove the dial gauge from the end of the actuator rod.

6 With the air pressure still applied, release the lock nut (A5) on the actuator arm. Remove the clip (A2) and remove the actuator rod from the pin (A3) on the arm of the waste-gate valve.

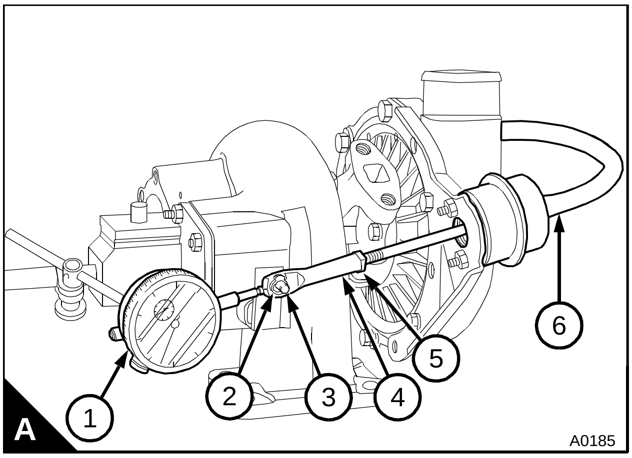
7 If the air pressure is too low, rotate the end of the actuator rod to reduce the length of the actuator rod. If the air pressure is too high, rotate the end of the actuator rod to increase the length of the actuator rod. Rotate the end of the actuator rod in half-turn increments.

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

8 Put the actuator rod in position on the pin of the waste-gate arm. Fit the clip. Tighten the lock nut. Release the air pressure.

9 Put the dial gauge in position on the end of the actuator rod. Apply air pressure to move the actuator rod 1,00 mm (0.039 in) and check if the air pressure is correct. If the air pressure is not correct, repeat from step 6 of this operation until the correct pressure is obtained.

10 If the air pressure is correct, release the air pressure, remove the test equipment and connect the boost sensor pipe.



Turbocharger faults

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

If the inside of the intake manifold is wet, check that there is not a fuel leak from the fuelled starting aid, if there is one fitted, see Operation 14-11.

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, 39, 40
Damaged compressor impeller	3, 4, 6, 8, 12, 15, 16, 20, 21, 23, 24, 29, 32, 33, 37, 38
Damaged turbine rotor	7, 8, 12, 13, 14, 15, 16, 18, 20, 22, 23, 24, 25, 27, 29, 32, 33, 37, 38
Rotating assembly does not turn freely	3, 6, 7, 8, 12, 13, 14, 15, 16, 18, 20, 21, 22, 23, 24, 29, 32, 33, 37, 38
Worn bearings, bearing bores, journals	6, 7, 8, 12, 13, 14, 15, 16, 23, 24, 29, 33, 37, 38
Noise from turbocharger	1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 20, 21, 22, 23, 24, 29, 32, 33, 34, 37, 38
Sludge or carbon deposit in bearing housing	2, 11, 13, 14, 15, 17, 18, 24, 29, 33, 37, 38

List of possible causes

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

Open engine breather

Introduction

Open breathers fitted to New 1000 Series engines have a hose connected to the rocker cover which will allow any crankcase pressure to pass directly from the engine. An oil separator is fitted to the rocker cover to remove any oil mist and return it to the engine.

Early engines were fitted with an oil separator (A) that could be serviced by removing the top cover to renew the steel gauze (A2).

Later engines are fitted with an oil separator that is not serviceable and must be renewed. The later oil separator has a part number marked on the top of the cover.

Note: New oil separators supplied will all be of the later type.

Caution: *Do not attempt to remove the cover of the later type of oil separator, this will damage the oil separator.*

To clean and to renew **Operation 9-6**

To clean (early type only)

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

1 Release the hose clip (B1) and remove the hose from the breather cover (A1). Release the breather cover from the body of the breather (A4). The cover is a press fit onto the body.

2 Remove and discard the steel gauze (A2).

3 Clean the body of the oil separator with clean kerosene. Ensure that all of the kerosene is removed from the oil separator after cleaning.

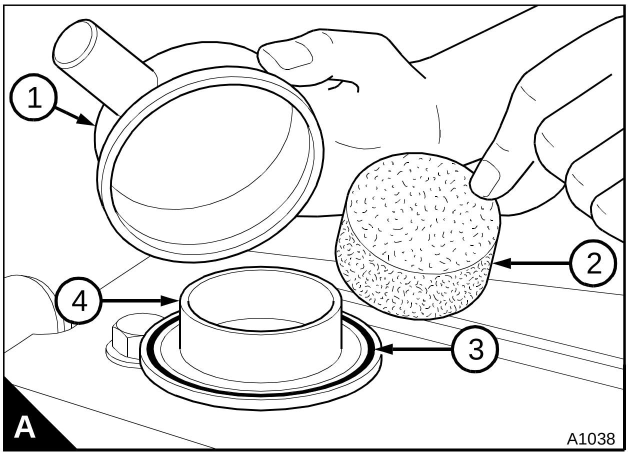
4 If necessary, renew the "O" ring seal (A3).

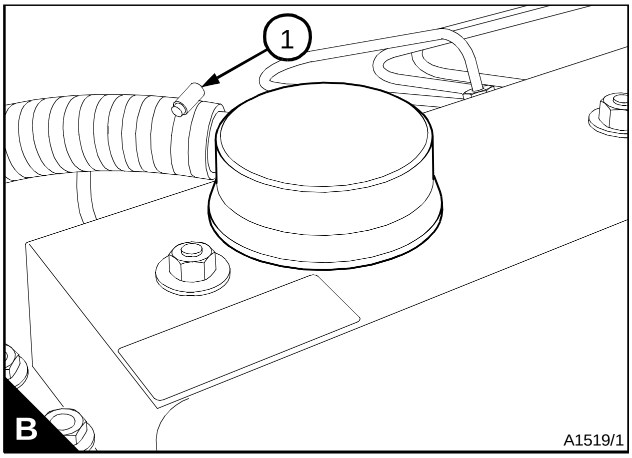
5 Check that the inside of the breather hose is clean. If the hose is not clean, release the hose clip and remove the hose. Wash the hose with kerosene and dry it with low-pressure air.

6 Fit a new steel gauze.

7 Fit the cover to the breather body, ensure that it is securely fitted.

8 Fit the hose and tighten the hose clip (B1).





To renew (early and later types)

Note: To remove the oil separator from the rocker cover, it will be necessary to make a tool (D) from 3,1 mm (0.125 in) mild steel plate, all dimensions are in millimetres.

1 Release the hose clip (C1) and remove the hose from the oil separator.

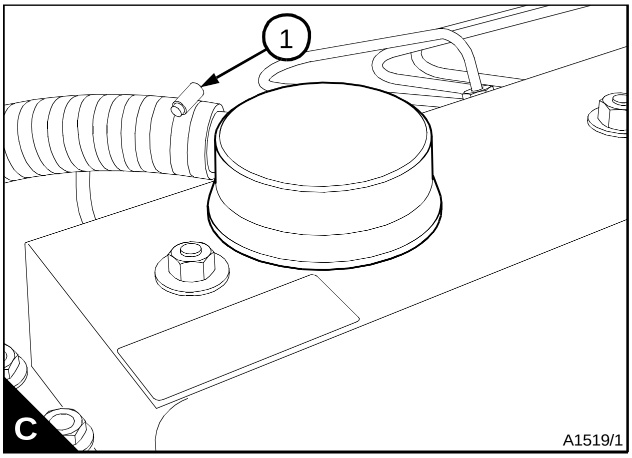
2 Use the pegs (E4) on the tool (E2) to contact the lugs (E5) of the oil separator. Rotate the tool counter-clockwise to release the oil separator.

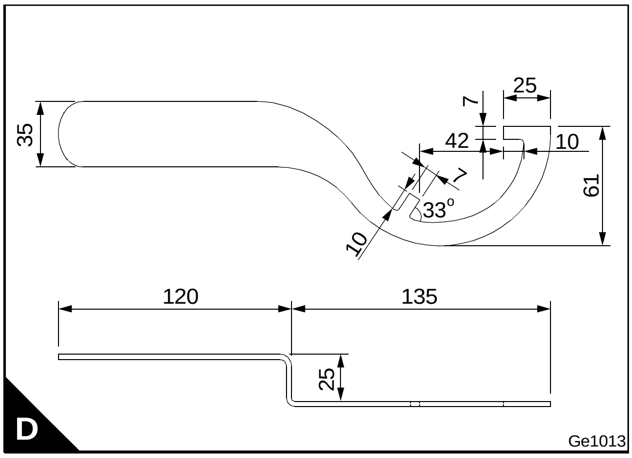
3 Ensure that the ‘O’ ring (E3), supplied with the new assembly, is fitted correctly to the new oil separator.

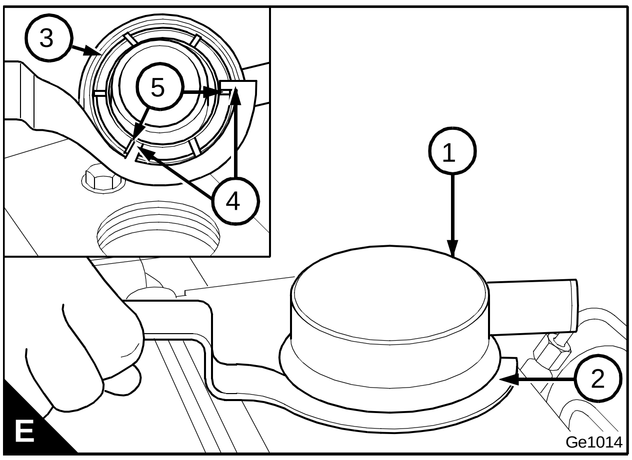
4 Lubricate the threads of the oil separator with clean engine lubricating oil.

5 Fit the new oil separator into the rocker cover until it is finger tight. Tighten the oil separator a further 90° with the tool.

6 Fit the hose and tighten the hose clip (C1).







To Inspect **Operation 9-7**

If excessive crankcase pressure is suspected, the following procedure must be used.

Note: This procedure only refers to engines fitted with plastic rocker covers.

1 Remove the rocker cover and check if the end of the shroud (A4) has a skin of plastic.

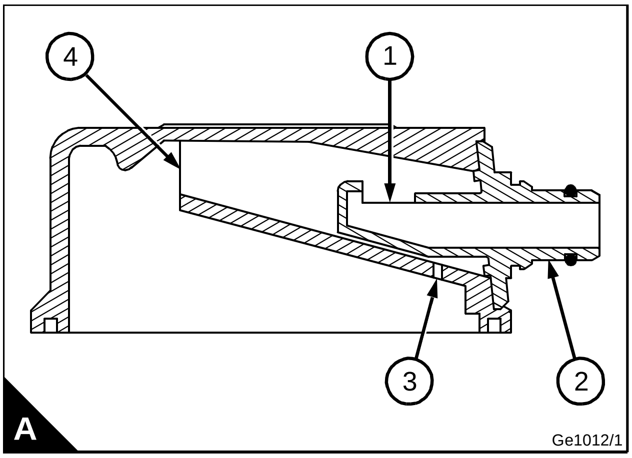
2 Remove the plastic skin and ensure all debris is removed.

3 Ensure hole (A3) in the shroud is not blocked, remove any blockage.

4 If breather connection (A2) is made of plastic, use low pressure compressed air in the end of the connection to check if there is any blockage, this can also have a plastic skin at the entry point (A1).

Notes:

- If the a plastic skin if found at (A1) the rocker cover assembly must be renewed.
- Do not try to remove the connector as this will result in a broken rocker cover.



Closed engine breather

Closed breather systems fitted to New 1000 Series engines have an oil separator assembly which is fastened to the crankcase and a breather valve is fitted between the oil separator and the intake manifold. Crankcase gases pass through the oil separator where oil from the gases is returned to the sump. The crankcase gases then pass through the breather valve to the intake manifold.

It is very important that closed engine breather systems are fitted correctly to the engine. Below is a list of safety precautions that must be applied at all times.

***Cautions*:**

- *Do not exceed the correct level of lubricating oil in the sump. If there is too much lubricating oil, the excess must be drained to the correct level. An excess of lubricating oil could enter the breather valve. This could cause the engine speed to increase rapidly without control.*
- *Do not operate the engine if any of the breather valve or the induction hoses are loose or disconnected as this could allow dirt into the engine and damage to the engine could occur.*
- *Do not operate the engine if there is a blockage in the air filter or the induction hose. This can cause lubricating oil to enter the cylinders through the breather valve.*
- *Do not operate the engine if any of the breather valve or the induction hoses are bent such as to cause a restriction to the gases that flow through them. This can cause lubricating oil to enter the cylinders through the breather valve.*
- *Do not operate the engine at an angle of tilt greater than the limit approved for the engine. If there is doubt, contact the Perkins Service Department. If the approved angle is exceeded, an excess of lubricating oil could enter the breather valve. This could cause the engine speed to increase rapidly without control.*
- *Ensure that the breather valve or the induction hoses are cleaned and maintained in accordance with the maintenance schedules in the User's Handbook or the handbook of the manufacturer of the machine.*
- *Ensure that the breather valve assembly is renewed in accordance with the maintenance schedules in the User's Handbook or the handbook of the manufacturer of the machine.*

To renew the breather valve assembly **Operation 9-8**

***Cautions*:**

- *It is important that the safety precautions are read and understood, see page 184.*
- *Ensure that the vent hole (A1) is not restricted during service.*

Note: The whole breather assembly must be renewed every complete overhaul of the engine or 8000 hours.

The closed breather system used on the New 1000 Series engine consists of a body (A4) and a valve assembly (A5).

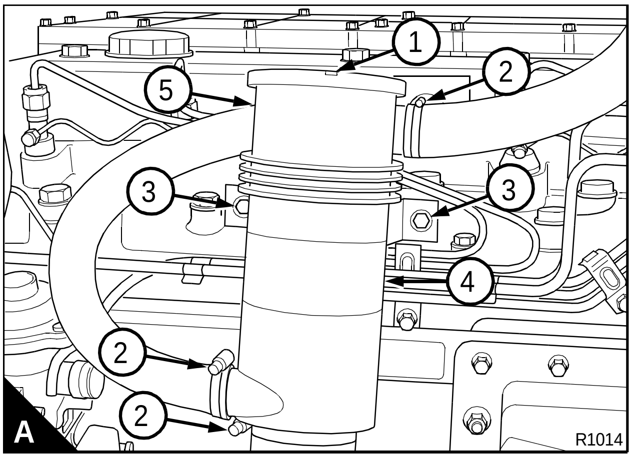
1 Release the three hose clips (A2) and remove the hoses.

2 Release the two setscrews (A3) and remove the breather assembly.

3 Clean the inside of the pipes with a proprietary cleaning fluid and dry them.

4 Fit a new breather assembly. Fit and tighten the two setscrews.

5 Fit the three hoses in their correct positions on the breather assembly and tighten the three hose clips (A2).



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10

Lubrication system

General description - four cylinder engine lubrication system

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-centre to each other. There is a key between the inner rotor and the drive shaft. The inner rotor has six lobes which mesh with the seven lobes of the outer rotor. When the pump rotates, the space between the lobes of the outer rotor which are in mesh increases to cause a suction or decreases to cause a pressure increase. If a balancer unit (page 190 illustration B) is fitted, the oil pump is fitted to the balancer frame and is driven by the balancer drive shaft.

Lubricating oil (page 189 illustration A1) from the sump passes through a strainer and pipe to the suction side of the pump.

The lubricating oil (page 189 illustration A2) passes from the outlet side of the pump through a pipe to a relief valve, which is fitted to the bottom of the left side of the cylinder block. If a balancer unit is fitted, the relief valve is fitted in the frame of the balancer. The relief valves opens if the oil pressure is too high and allows some of the lubricating oil to return to the sump.

From the relief valve, lubricating oil passes to a plate type oil cooler (some naturally aspirated engines do not have an oil cooler). The oil cooler is either fitted to the left side of the cylinder block and has seven plates, or it is fitted between the oil filter head and the filter canister and has ten plates. Some oil coolers are fitted with a by-pass valve. If cold oil increases the restriction in the cooler, the by-pass valve opens and the oil passes directly from the inlet side to the outlet side of the cooler.

Lubricating oil from the oil cooler, passes to an oil filter. The oil filter can be fitted to the left or right side of the engine. If the filter is fitted to the right side (page 190 illustration B) of the engine, the oil passes through a pipe connected between the relief valve and the right side of the cylinder block. The oil passes from the pipe through a passage in the right side of the cylinder block to an oil cooler and then to the oil filter. When the oil filter is on the right side of the engine, and an oil cooler is fitted, the oil cooler will be between the oil filter head and the oil filter canister.

The lubricating oil passes from the filter to the pressure rail which is drilled the complete length of the left side of the cylinder block. If the oil filter is on the right side of the engine, the oil passes through a passage drilled across the cylinder block to the pressure rail.

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 are lubricated by splash and oil mist.

Lubricating oil (page 189 illustration A3) passes from the main bearings through passages in the cylinder block to the journals of the camshaft. Lubricating oil passes from the centre journal of the camshaft through a passage in the cylinder block and cylinder head to a restriction in the pedestal of the rocker shaft, at a reduced pressure (page 189 illustration A4), to the rocker bushes. The oil passes through a passage in the rocker shaft to the bearings of the rocker levers. The valve stems, valve springs and the tappets are lubricated by splash and oil mist.

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

The turbocharger is lubricated by oil after the filter. Oil is supplied from a connection on the right side of the cylinder block through an external pipe to the turbocharger. The oil passes through the turbocharger and returns through a pipe to the sump.

Turbocharged engines have piston cooling jets fitted. These jets are connected to the oil pressure rail and spray lubricating oil inside the pistons to keep them cool. Naturally aspirated engine types AR and AS have one piston cooling jet fitted to the number one cylinder position.

General description - Six cylinder engine lubrication system

The oil pump is similar to that used on four cylinder engines and is also driven through an idler gear from the crankshaft gear. The inner rotor has four lobes and the outer rotor has five lobes.

Lubricating oil from the sump passes through a strainer and pipe to the suction side of the pump. The oil passes from the outlet side of the pump, through a pipe and a passage in the cylinder block to the oil filter head. The oil then passes through a passage in the filter head and a pipe to a plate type oil cooler, see the off set (page 189 illustration A), which is an integral part on the left of the cylinder block. On naturally aspirated engines the oil cooler has four plates and on turbocharged engines the cooler has eight plates. The oil cooler is fitted with a by-pass valve. If cold oil increases the restriction in the cooler, the by-pass valve opens and the oil passes directly from the inlet side to the outlet side of the cooler. If the engine is not fitted with an oil cooler, the oil passes from the oil pump to the relief valve.

From the oil cooler, the oil returns through a pipe to the filter head where the oil divides to the relief valve and to the oil filter. The oil filter can be fitted on the left or right side of the engine. If the filter is fitted on the right side of the engine, the oil passes through a pipe connected between the relief valve and the right side of the cylinder block to the oil filter.

The lubricating oil passes from the filter to the pressure rail which is drilled the full length of the left side of the cylinder block. If the oil filter is on the right side of the engine, the oil passes through a passage drilled across the cylinder block to the pressure rail.

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 are lubricated by splash and oil mist.

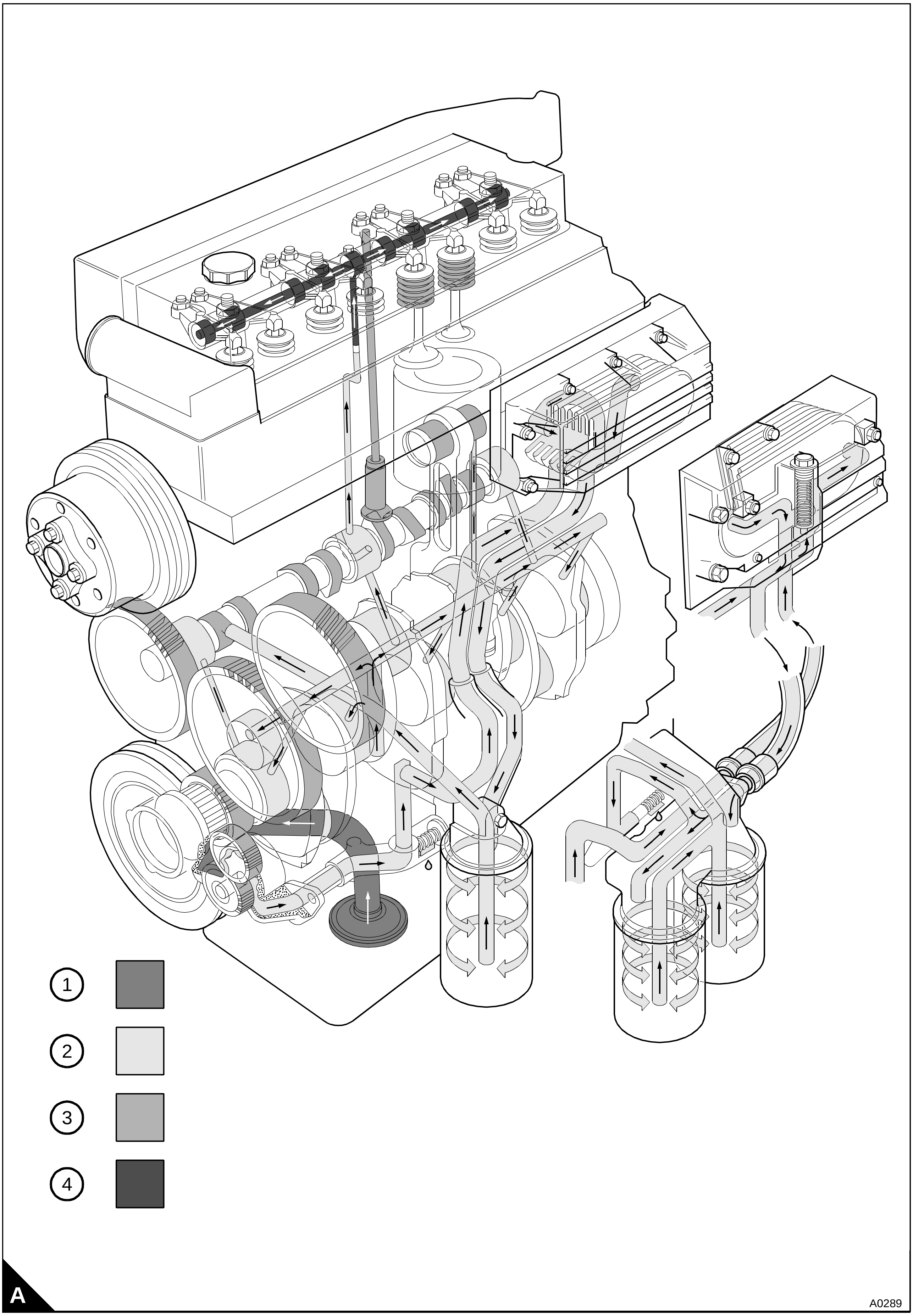
Lubricating oil passes from the main bearings through passages in the cylinder block to the journals of the camshaft. Lubricating oil passes, at a reduced pressure, from the second journal of the camshaft through a passage in the cylinder block and cylinder head to the rocker shaft. The oil passes through a passage in the rocker shaft to the bearings of the rocker levers. The valve stems, valve springs and the tappets are lubricated by splash and oil mist.

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

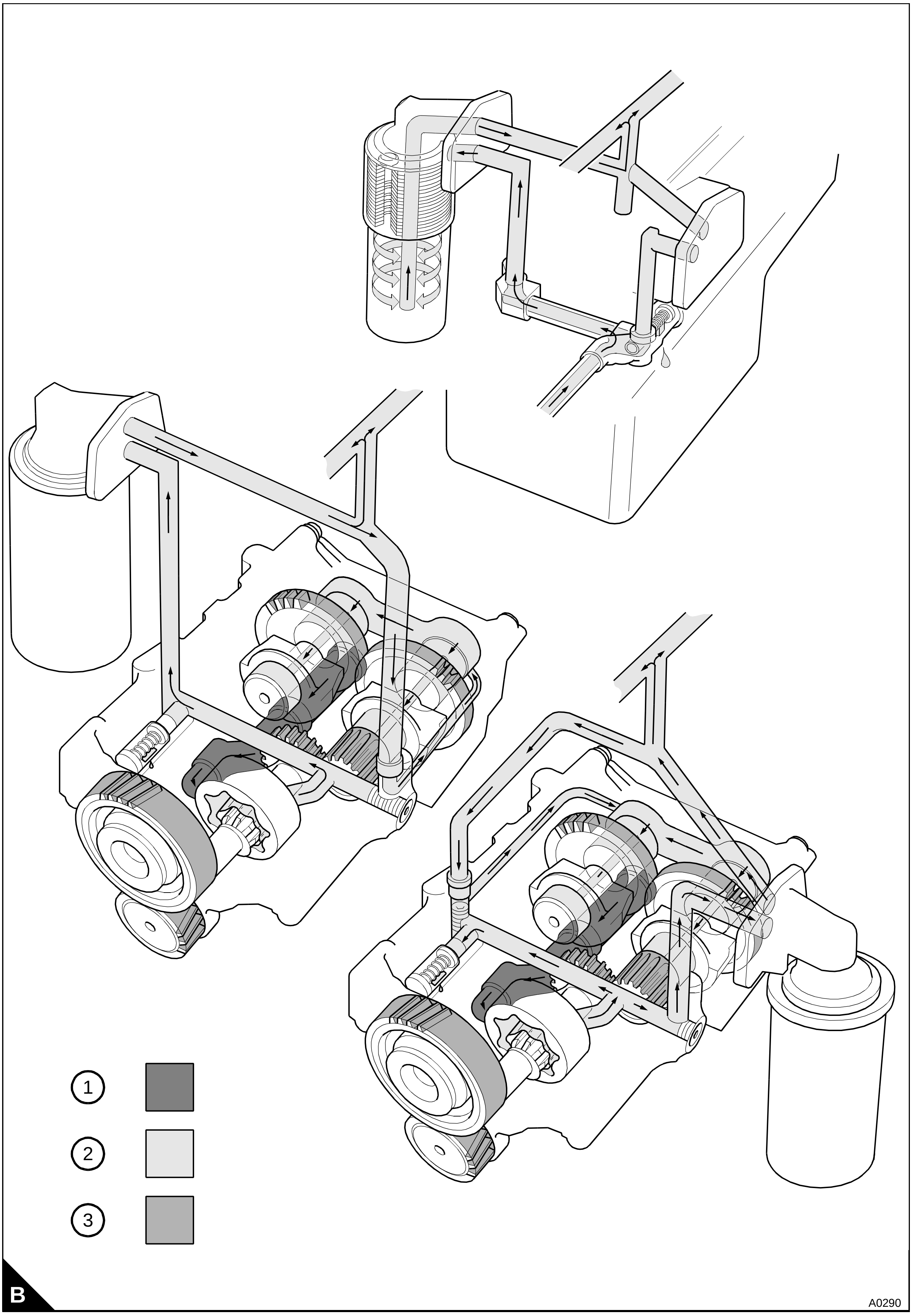
The turbocharger is lubricated by oil after the filter. Oil is supplied from a connection on the right side of the cylinder block through an external pipe to the turbocharger. The oil passes through the turbocharger and returns through a pipe to the sump.

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

Lubrication system flow diagram



Lubrication system flow diagram for the relief valve and balancer



Filter canister

To renew **Operation 10-1**

Warning! *Discard the used canister (B4) and lubricating oil in a safe place and in accordance with local regulations.*

Caution: *The canister contains a valve and special tube to ensure that lubricating oil does not drain from the filter. Therefore, ensure that the correct Perkins POWERPART canister is used.*

The filter can have one or two canisters (B4) or (A1) fitted. When two canisters are fitted, both must be renewed at the same time. On some engines an oil cooler (B2) is fitted to the filter head. This arrangement is fitted on the left side or the right side of the engine.

On some four and six cylinder engines the adaptor (A2) or (B1) is sealed into the filter head. A new filter head is supplied without the adaptor fitted; if either the adaptor or the filter head is to be renewed, both parts will be necessary.

1 Put a tray under the filter to contain spilt lubricating oil.

2 Remove the filter canister with a strap wrench or a similar tool and then discard the canister.

Note: If the adaptor is to be renewed, insert the end of the adaptor, which has the thread sealant applied during manufacture, into the filter head.

3 Clean the seal face of the filter head (A3).

Caution: *Ensure that the adaptor (A2) or (B1) is secure in the filter head.*

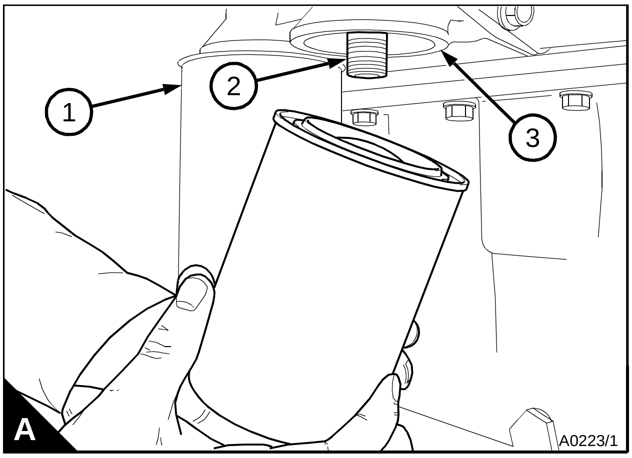
4 Add clean engine lubricating oil to the new canister. Give the oil time to fill the canister through the filter element.

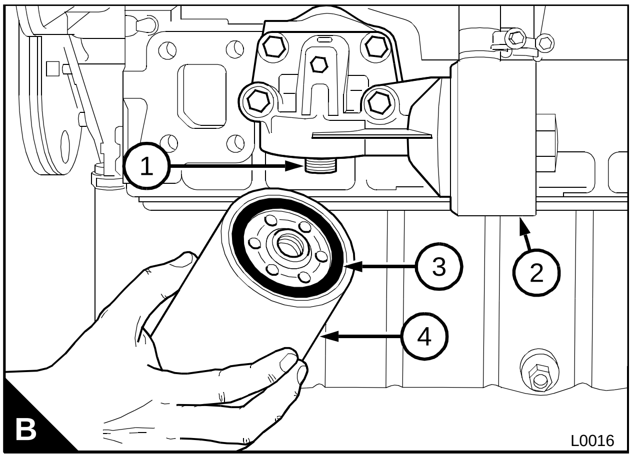
5 Lubricate the top of the canister seal (B3) with clean engine lubricating oil.

6 Install the new canister and tighten it by hand only. Do not use a strap wrench.

For turbocharged engines: Ensure that the engine will not start and operate the starter motor until oil pressure is obtained. To ensure that the engine will not start, either put the manual stop control in the "stop" position or disconnect the electrical stop control of the fuel injection pump. Oil pressure is indicated when the warning light is extinguished or by a reading on the gauge.

7 After the lubricating oil has been added to the sump, operate the engine and check for leakage from the filter. When the engine has cooled, check the oil level on the dipstick and add oil to the sump, as necessary.





Filter head

To remove and to fit **Operation 10-2**

Special requirements

Consumable products	
Description	**Part number**
POWERPART Threadlock and nutlock	21820117

To remove

1 Put a tray under the filter head to contain spilt lubricating oil.

2 Remove the filter canister(s), see Operation 10-1.

3 Remove the canister type oil cooler from the filter head, if one is fitted, see Operation 12-27.

4 Remove the flexible pipes from the filter head, if they are fitted, see Operation 10-15.

5 Release the setscrews and remove the filter head (A) from the cylinder block. Discard the joint (A3).

6 Clean the joint face of the filter head (A4) and the cylinder block.

To fit

1 Fit a new joint to the filter head, the joint is fitted dry.

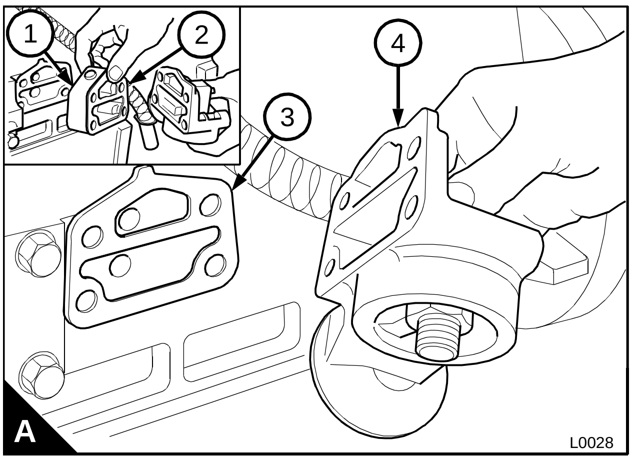
Notes:
- Some engines have an adaptor (A1) between the cylinder block and the filter head. If an adaptor is used, two joints are fitted (A2) and (A3).
- The setscrews for securing the filter head have a sealant (MEAS) applied by the manufacturer to the first 13,0 mm (0.50 in) of the threads. If the setscrews are used again, the sealant must be removed from the male and female threads and new sealant POWERPART Threadlock and nutlock applied to the first 13,0 mm (0.50 in) of the setscrew threads.

2 Fit the filter head to the cylinder block. Tighten the setscrews.

3 Fit the oil cooler to the filter head. If a canister type oil cooler is fitted, see Operation 12-27.

4 Fit the flexible pipes to the filter head, if they are fitted, see Operation 10-16.

5 Fit the new filter canister(s), see Operation 10-1.



Sump

To remove and to fit **Operation 10-3**

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

1 Operate the engine until it is warm.

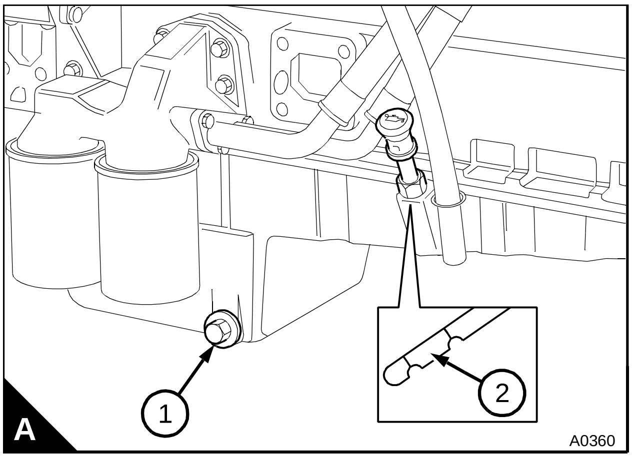
2 Stop the engine, remove the sump drain plug (A1) and its "O" ring and drain the oil. Where necessary, remove the dipstick and the dipstick tube.

3 Provide a support for the sump and remove the setscrews and the two nuts which fasten the sump to the cylinder block and to the timing case. Lower the sump and remove the joint.

4 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. If necessary, renew the felt dust seal which is fitted to the rear of the sump flange on some engines.

5 Fit the sump together with a new joint and ensure that the location is correct. Fit the remainder of the setscrews and the nuts and tighten all the fasteners to 22 Nm (16 lbf ft) 2,2 kgf m. Fit the drain plug together with a new "O" ring and tighten the plug to 34 Nm (25 lbf ft) 3,5 kgf m. Where necessary, fit the dipstick tube and the dipstick.

Fill the sump to the mark (A2) on the dipstick with new and clean lubricating oil of an approved grade.



Oil strainer and suction pipe

To remove and to fit **Operation 10-4**

The oil strainer is an integral part of the suction pipe. No regular service is necessary but wash the strainer when it is removed. On four cylinder engines which have a balancer fitted, the suction pipe is normally a short pipe which is fastened to the balancer frame and a pipe bracket is not fitted.

Some four cylinder engines have an oil strainer and suction pipe which are made of a composite material. This arrangement has an "O" ring seal on the flange face of the oil pump instead of a joint.

To remove 6 cylinder engines

1 Remove the sump, see Operation 10-3.

2 Release the setscrew which holds the bracket to the main bearing cap (A2).

3 Release the setscrews from the flange of the suction pipe (A1). Remove the suction pipe and strainer. Remove and the old joint. Clean the flange face of the oil pump and of the suction pipe.

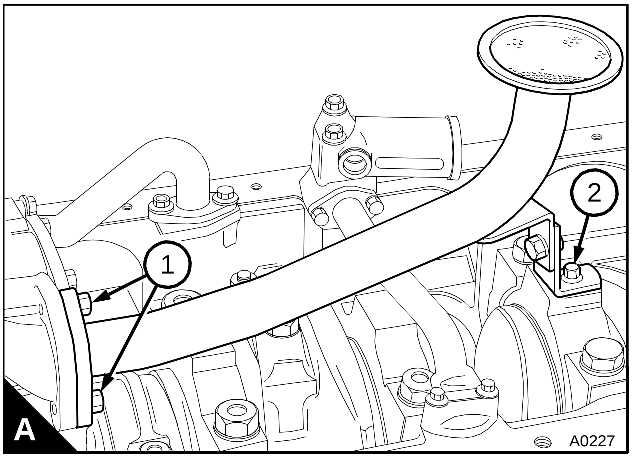
To fit 6 cylinder engines

1 Loosely assemble the bracket of the suction pipe to the correct main bearing cap (A2).

2 Fit the suction pipe to the oil pump together with a new joint (A1). Tighten the setscrews.

3 Tighten the setscrew of the suction pipe bracket. Ensure that there is no stress on the suction pipe.

4 Fit the sump, see Operation 10-3.



To remove 4 cylinder engines

1 Remove the sump, see Operation 10-3.

2 Release the setscrew which holds the bracket to the main bearing cap (B3).

3 Release the setscrews from the flange of the suction pipe (B1). Remove the suction pipe, strainer and bracket. Remove the old joint or “O” ring. Clean the flange face of the oil pump and of the suction pipe.

To fit 4 cylinder engines

1 Loosely fit the bracket (B3) of the suction pipe (if fitted) to the correct main bearing cap.

2 Fit the suction pipe to the oil pump together with a new joint or “O” ring. Tighten the setscrews (B1).

3 Tighten the setscrew of the suction pipe bracket (B3). Ensure that there is no stress on the suction pipe.

4 If the bolts and nuts (B2) for the clamp type bracket (B), used on some four cylinder engines, have been loosened or removed, assemble all parts loosely to the engine. Ensure that the clamp, the bracket and the pipe are correctly aligned before the bolts and nuts are tightened. Tighten the setscrews (B1) to the oil pump, then the setscrew (B3) and the bolts and nuts (B2) last. Ensure that there is no stress on the suction pipe.

5 Fit the sump, see Operation 10-3.

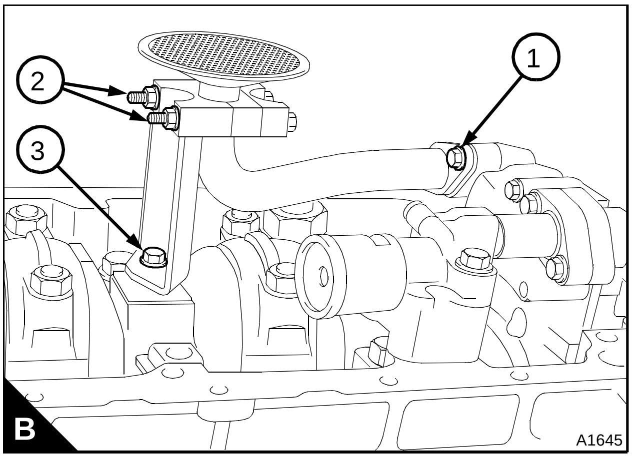
To inspect and to correct **Operation 10-5**

1 Wash the assembly in an approved cleaning fluid and dry it thoroughly.

2 Check the pipe, the strainer and the welded joints for cracks and other damage. Check that the mounting bracket is secure.

3 If the damaged component cannot be welded correctly, renew the assembly.

4 Composite material parts must be renewed if they have cracks or damage.



Lubricating oil pump

The lubricating oil pump has a channel (B1) in the body of the pump. Lubricating oil from the front main bearing passes down the channel in the body of the pump to an oil hole in the idler shaft. The lubricating oil then passes through the hole in the idler shaft to the bush in the idler gear.

To remove **Operation 10-6**

For four cylinder engines fitted with a balancer unit, the oil pump is integral with the balancer unit, see Operation 5-18 for removal instructions.

1 Drain the lubricating oil and remove the lubricating oil sump, see Operation 10-3.

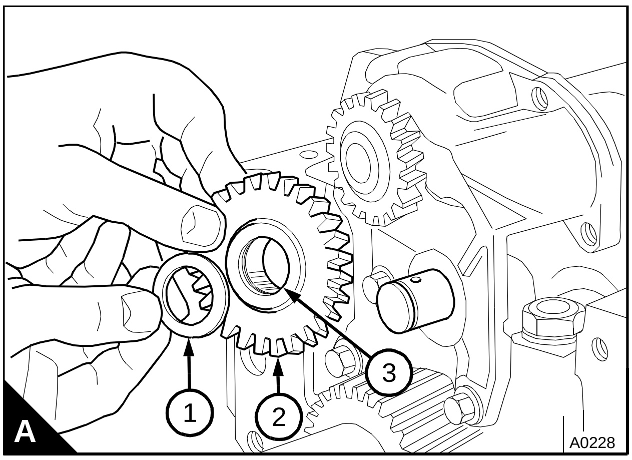
2 Remove the suction pipe and strainer, see Operation 10-4.

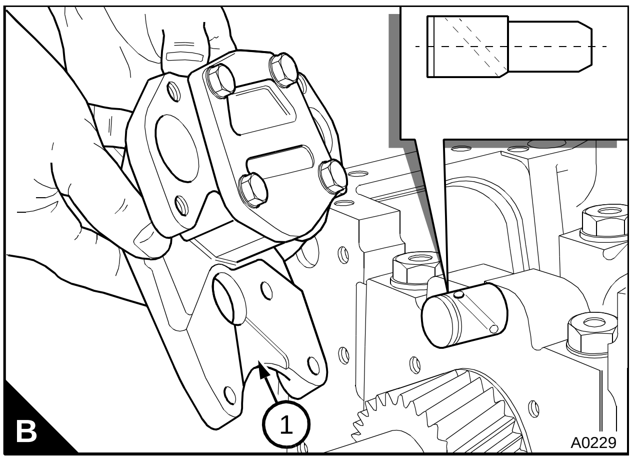
3 For four cylinder engines: Remove the oil pressure relief valve, see Operation 10-12, and the delivery pipe. For six cylinder engines: Remove the delivery pipe of the oil pump.

4 The oil pump is fitted to number 1 main bearing cap. The oil pump can be removed with the main bearing cap, if a suitable spanner is available that will enable the torque to be applied correctly to the setscrews of the main bearing cap when it is fitted. If a suitable spanner is not available, the timing case must be removed, see Operation 6-14.

5 Release the circlip which retains the idler gear of the oil pump and remove the washer (A1) and the idler gear (A2).

6 Release the setscrews and remove the oil pump (B).





To fit **Operation 10-7**

1 Fill the oil pump with clean engine lubricating oil. Fit the oil pump to the main bearing cap and tighten the setscrews to 22 Nm (16 lbf ft) 2,2 kgf m.

2 Check the idler gear and the bush for wear and other damage. If the gear and/or bush are damaged, they can be renewed as an assembly or the bush can be renewed as a single item. Check the shaft of the idler gear for wear or other damage. If the shaft is worn or damaged, renew the shaft, see Operation 10-9 and Operation 10-10 for six cylinder engines or Operation 10-11 for four cylinder engines. Lubricate the bush (A3) with clean engine lubricating oil and fit the idler gear (A2), the washer (A1) and the circlip. Check that there is a minimum of 0,076 mm (0.003 in) backlash between the oil pump gear and the idler gear (B).

3 If number 1 main bearing cap was removed, lubricate the bearing with clean engine lubricating oil and fit the bearing cap. Tighten the setscrews to 265 Nm (196 lbf ft) 27,0 kgf m. If the timing case was removed, fit the timing case, see Operation 6-15. Check that there is a minimum of 0,076 mm (0.003 in) backlash between the oil pump idler gear and the crankshaft gear.

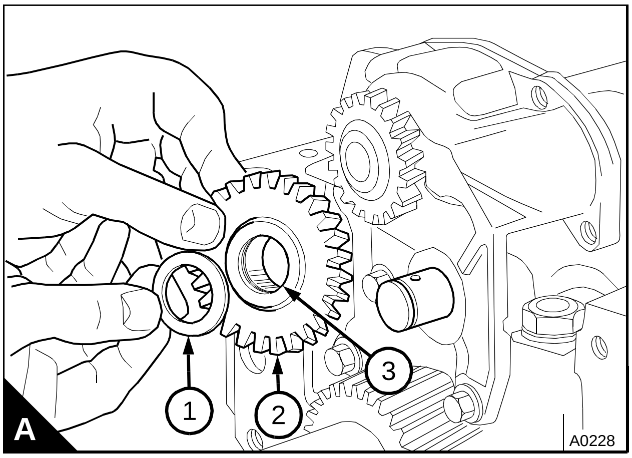
The end-float for the idler gear is as follows:

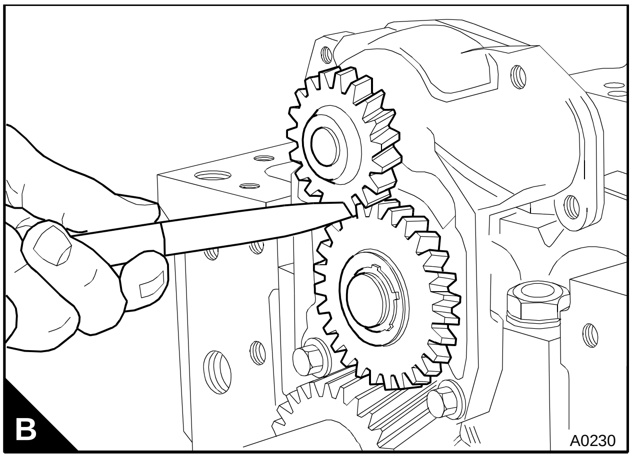
- Four cylinder engines 0,012/0,643 mm (0.0005/0.0253 in)
- Six cylinder engines 0,020/0,650 mm (0.0008/0.0256 in)

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

5 For four cylinder engines: Fit the delivery pipe and oil pressure relief valve, see Operation 10-12. For six cylinder engines: Fit the delivery pipe and tighten the setscrews. Use new joints.

6 Fit the lubricating oil sump, see Operation 10-3.





To inspect **Operation 10-8**

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 Release the setscrews and remove the cover of the oil pump. For pumps which are fitted to a balancer unit, remove the single setscrew and the cover.

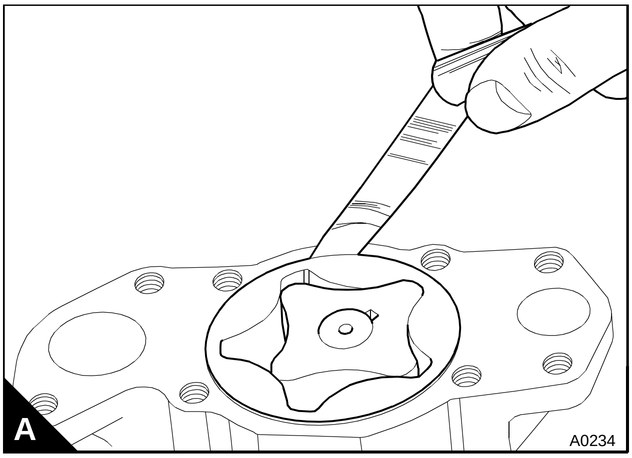
2 Remove the outer rotor and clean thoroughly all the parts. Check for cracks and any other damage.

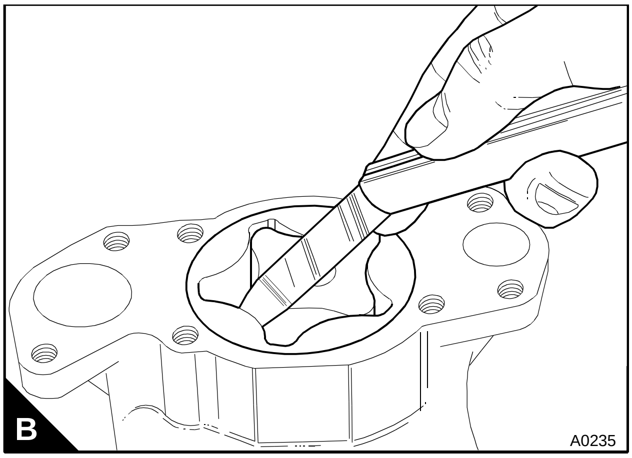
3 Fit the outer rotor and check the outer rotor to body clearance (A).

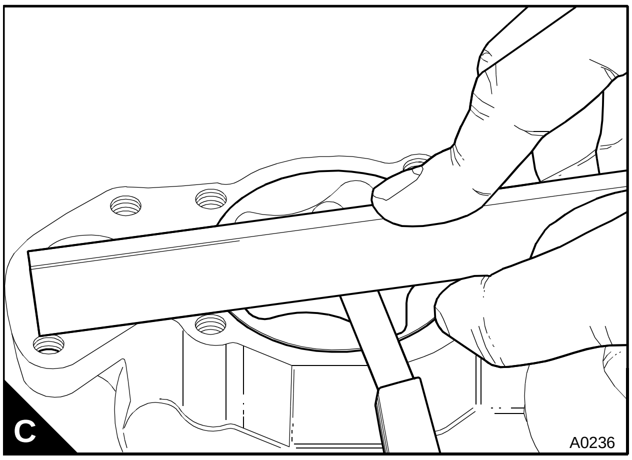
4 Check the inner rotor to outer rotor clearance (B).

5 Check the rotor end-float with a straight edge and a feeler gauge (C). For all the above clearances, refer to the Data and dimensions for "Lubrication system" on page 29.

6 Lubricate the inner and outer rotor with clean engine lubricating oil. Clean the top face of the oil pump and the bottom face of the cover and fit the cover. Tighten the setscrews to 28 Nm (21 lbf ft) 2,9 kgf m. For pumps which are fitted to a balancer unit, put the cover in position and tighten the single setscrew to 22 Nm (16 lbf ft) 2,2 kgf m.







Lubricating oil pump idler gear shaft

The idler shaft for the lubricating oil pump fitted in the front main bearing cap of six cylinder engines is retained by a pin and POWERPART Retainer (oil tolerant). If it is necessary to renew the idler shaft on these engines, follow the procedure given below.

The idler shaft (A3) has an oil hole (A2) to provide lubrication to the bush for the idler gear. The lubricating oil pump has a channel (A4) in the body of the pump. Lubricating oil from the front main bearing passes down the channel in the body of the pump to the oil hole in the idler shaft. The lubricating oil then passes through the hole in the idler shaft to the bush in the idler gear.

To remove (six cylinder engines) **Operation 10-9**

Caution: *The pin is very hard; if the tap is broken or the pin cannot be removed, then the other method must be used to remove the pin, see "Alternative method to remove the idler shaft" on page 200.*

1 Carefully use an M5 X 0,8 mm taper tap to put a chamfer in the end of the pin (B1). Remove the tap.

2 Carefully use an M5 X 0,8 mm plug tap to cut not less than three complete threads in the end of the pin. Remove the tap.

3 Obtain the parts listed below:

- An M5 X 0,8 mm setscrew, part number 2314E007 or a setscrew which has a thread which is at least 15 mm long.
- An M5 X 0,8 mm nut, part number 2318A601.
- A spacer with a 15,88 mm or 19,05 mm outside diameter and an internal diameter of 8,73 mm which is 9,53 mm long, part number(s), 0920481 or 0330819.

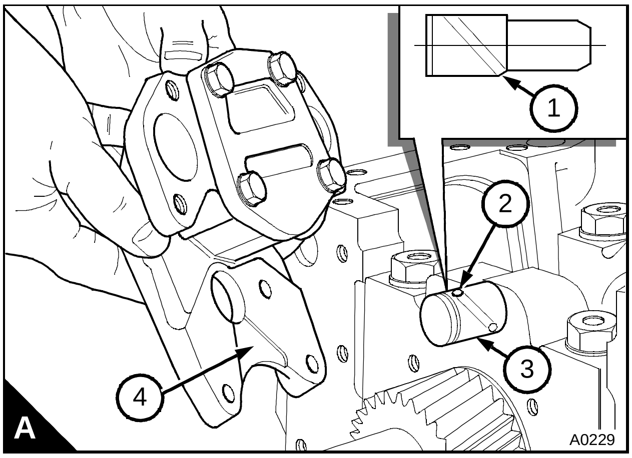
4 Fit the nut fully onto the threads of the setscrew and put the spacer onto the nut.

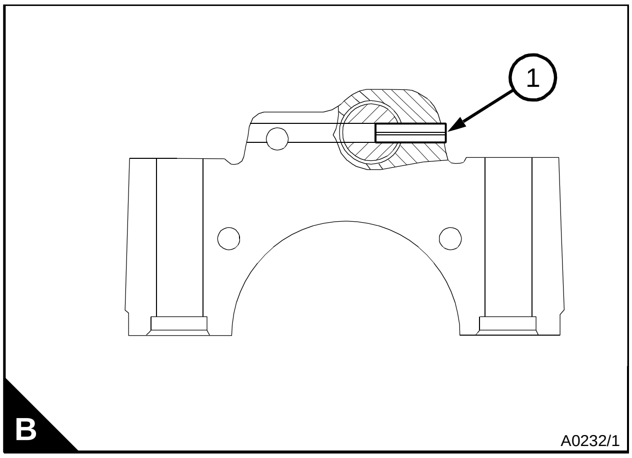
Caution: *Do not use excessive torque.*

5 Hold the spacer in position and engage the setscrew fully into the threads in the pin.

6 Put the spacer into position centrally over the pin and tighten the nut onto the spacer. Continue to tighten the nut and pull the pin through the spacer. Withdraw the pin enough to pull the pin out of the bearing cap with pliers.

7 Put a suitable adaptor on the small diameter of the idler shaft and press the idler shaft out of the bearing cap.





Alternative method to remove the idler shaft

Caution: *This method to remove the pin from the idler shaft must only be used if the pin cannot be removed by the earlier method.*

1 Make a drill guide (C) to the dimensions given in the table below.

2 Put the drill guide (D1) into position in the setscrew hole on the opposite side of the bearing cap to the pin (D2). Ensure that the countersink in the guide faces to the outside and that the edge of the guide is aligned with the front edge of the bearing cap. Use a 5/16 UNF setscrew (D3) and a plain washer (D4) to retain the guide in position.

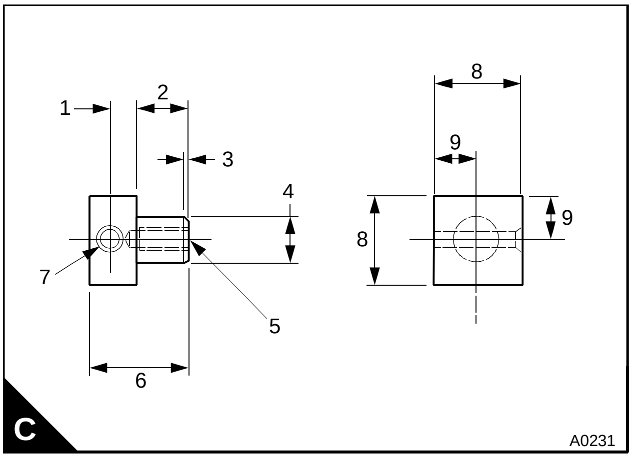
3 Drill a 6,35 mm (0.25 in) diameter hole in the bearing cap 47,0 mm (1.85 in) deep.

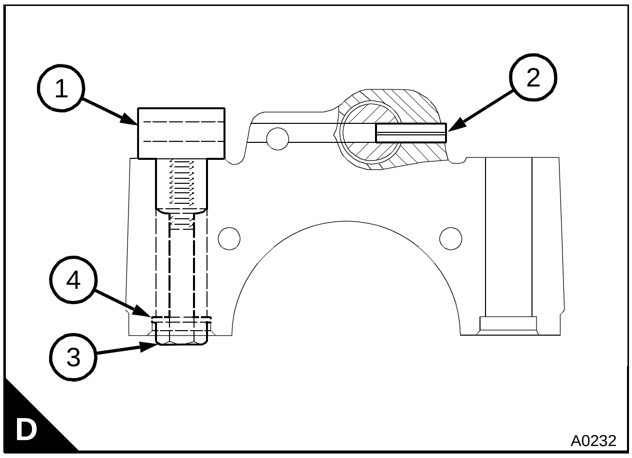
4 Remove the drill and the drill guide.

5 Insert a suitable drift into the hole in the bearing cap and drive out the pin.

6 Put a suitable adaptor on the small diameter of the idler shaft and press the idler shaft out of the bearing cap.

C1	8,3 mm (0.327 in)
C2	20,0 mm (0.984 in)
C3	1,0 mm (0.039 in)
C4	16,1/16,4 mm (0.633/0.646 in)
C5	6,9 x 22 mm (0.272 x 0.866 in) diameter hole for $^{5}/_{16\text{-}24}$ UNF x 18 mm thread
C6	36,0 mm (1.42 in)
C7	6,5/6,6 mm (0.256/0.260 in) diameter hole, countersink 9,0 mm x 900 included
C8	31,75 mm (1.250 in)
C9	15,9 mm (0.626 in)





To fit (six cylinder engines) **Operation 10-10**

Special requirements

Consumable products	
Description	**Part number**
POWERPART Retainer (oil tolerant)	21820603

1 Check that the new idler shaft and the hole for the idler shaft in the bearing cap are clean and free from oil or grease. Remove any rough edges from the hole of the bearing cap.

2 Support the rear of the bearing cap and ensure that the cap will not move when the idler shaft is pressed in. Apply only enough POWERPART Retainer (oil tolerant) around the chamfer of the shaft to fully cover the surface of the hole when the shaft is pressed into position. Enter the chamfer of the idler shaft into the hole.

If the idler shaft (A3) has an oil hole ensure that the hole (A2) in the idler shaft is at the top and that the flat (A1) is at the bottom before the shaft is pressed into the bearing cap.

Ensure that the idler shaft is square to the bearing cap and press the shaft in onto its shoulder. Remove the surplus POWERPART Retainer from the idler shaft, the oil hole and the bearing cap before the oil pump is fitted.

3 Use the original hole for the pin in the bearing cap as a guide and drill a 6,35 mm (0.25 in) diameter hole in the idler shaft 9,5 mm (0.37 in) deep.

4 Fit a new pin, part number 2116087, into the bearing cap and idler shaft.

To fit the idler shaft (where a pin was not fitted)

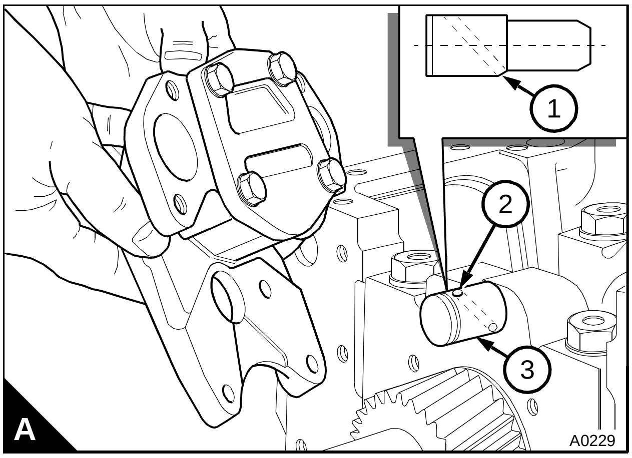
1 Follow the procedure described in steps 1 and 2 above.

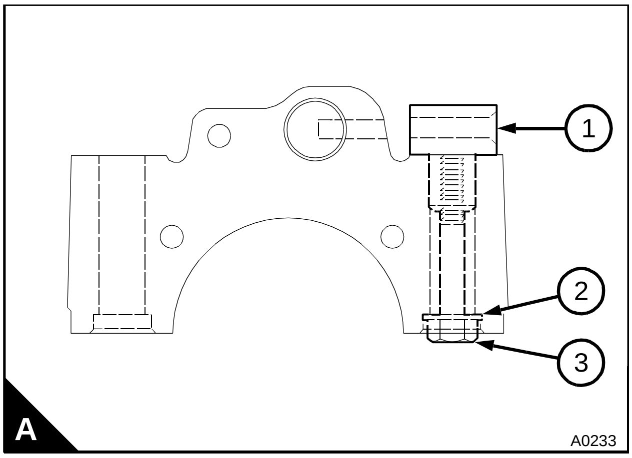
2 Put the drill guide (B1) into position in the right hand (seen from the front face of the bearing cap) setscrew hole of the bearing cap. Ensure that the countersink in the guide faces to the outside and that the edge of the guide is aligned with the front edge of the bearing cap. Use a 5/16 UNF setscrew (B3) and a plain washer (B2) to retain the guide in position.

3 Drill a 6,35 mm (0.25 in) diameter hole in the bearing cap 25,4 mm (1.0 in) deep.

4 Remove the drill and the drill guide.

5 Fit a pin, part number 2116087, into the bearing cap and idler shaft.





To remove and to fit (four cylinder engines) **Operation 10-11**

Special requirements

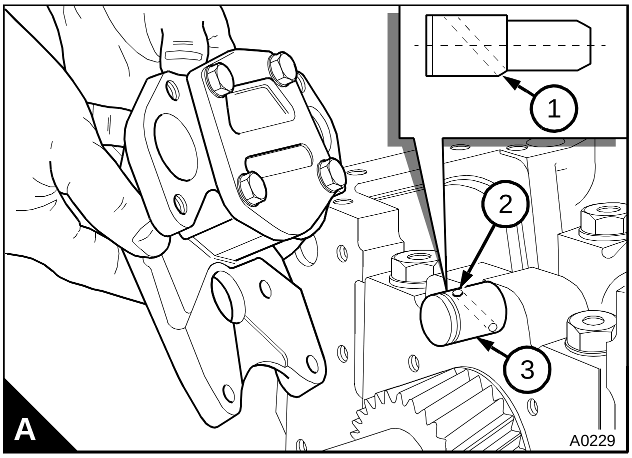
Consumable products	
Description	**Part number**
POWERPART Retainer (oil tolerant)	21820603

1 Support the front of the bearing cap. Put a suitable adaptor on the small diameter of the idler shaft and press the idler shaft out of the bearing cap.

2 Ensure that the idler shaft and the hole in the bearing cap are clean. Support the rear of the bearing cap and ensure that the cap will not move when the idler shaft is pressed in. Apply POWERPART Retainer (oil tolerant) to the small diameter of the idler shaft. The idler shaft for four cylinder engines is not retained by a pin.

If the idler shaft (A3) has an oil hole ensure that the hole (A2) in the idler shaft is at the top and that the flat (A1) is at the bottom before the shaft is pressed into the bearing cap.

Enter the chamfer of the idler shaft into the hole. Ensure that the idler shaft is square to the bearing cap and press in the shaft onto its shoulder. Remove the surplus POWERPART retainer.



Relief valve

To remove and to fit **Operation 10-12**

Four cylinder engines that have a balancer unit have a relief valve fitted inside the balancer frame. The relief valve of these engines cannot be removed as an assembly.

To remove

1 Drain the lubricating oil and remove the sump, see Operation 10-3.

2 For four cylinder engines: Release the setscrew and rotate the relief valve to withdraw the thimble from the cylinder block (A1). Pull the relief valve from the delivery pipe and pull the delivery pipe from the oil pump.

3 For six cylinder engines: Remove the setscrews which fasten the cross flow pipe to the relief valve (B2). The cross flow pipe is only fitted to engines which have the oil filter on the right side of the engine. Remove the flange joint. Release the two setscrews (B1) which fasten the relief valve to the cylinder block and remove the valve.

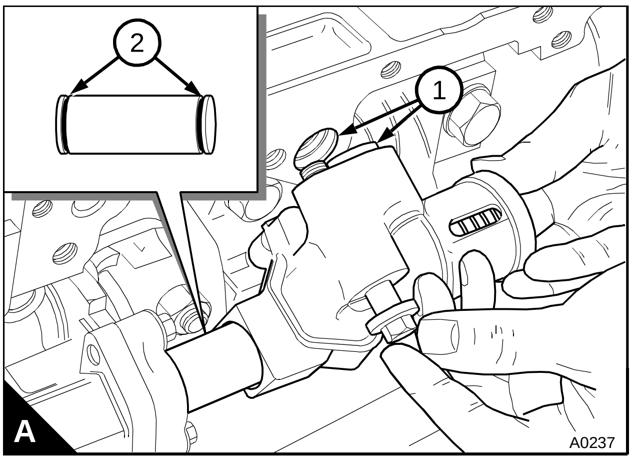
To fit

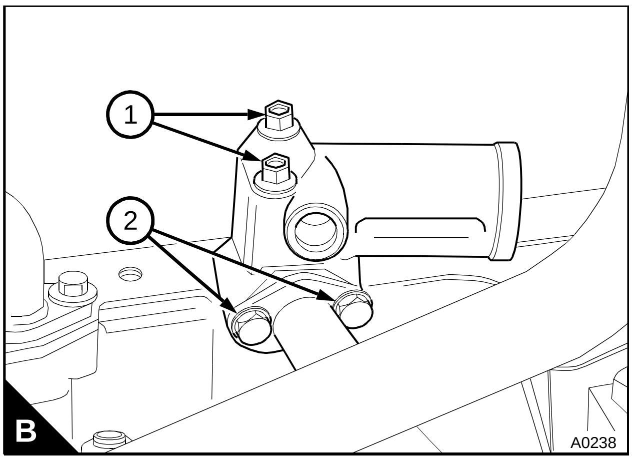
1 For four cylinder engines: Renew the "O" rings (A2). Lightly lubricate the "O" rings with clean engine lubricating oil and push the delivery pipe into the oil pump.

2 Push the relief valve onto the delivery pipe and fit the relief valve to the cylinder block; ensure that the thimble is correctly fitted and tighten the setscrew.

3 For six cylinder engines: Ensure that the faces of the cross flow pipe and the relief valve are clean. Put the valve in position, complete with a new flange joint.

4 Engage the four setscrews and tighten the flange setscrews and then the valve setscrews.





To dismantle and to assemble **Operation 10-13**

If necessary, the relief valve can be dismantled and assembled while it is fitted to the engine.

1 Apply pressure to the end plate (A4 or B5) of the spring assembly; release the circlip (A5) or remove the pin (B1) and carefully release the pressure to remove the end plate and the spring (A3 or B4) from the valve body. Remove the plunger (A2 or B3) from the bore of the body (A1 or B2).

2 Ensure that all the components are cleaned and then lubricated lightly with clean engine lubricating oil.

3 Fit the plunger into the bore with its hollow end to the inside. Fit the spring and the end cap into the bore with the ends of the spring fitted around the bosses of the plunger and the end plate. Apply pressure to the end plate and fit the circlip into its groove or fit the pin into the holes in the balancer frame.

To inspect **Operation 10-14**

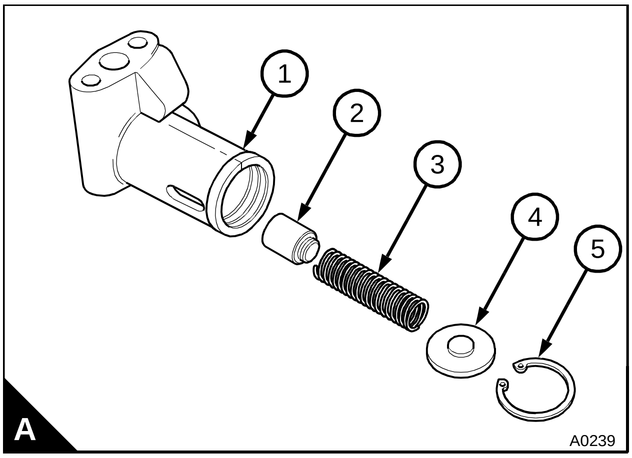
Caution: *Do not try to change the operation pressure of the relief valve by a method other than the installation of new components.*

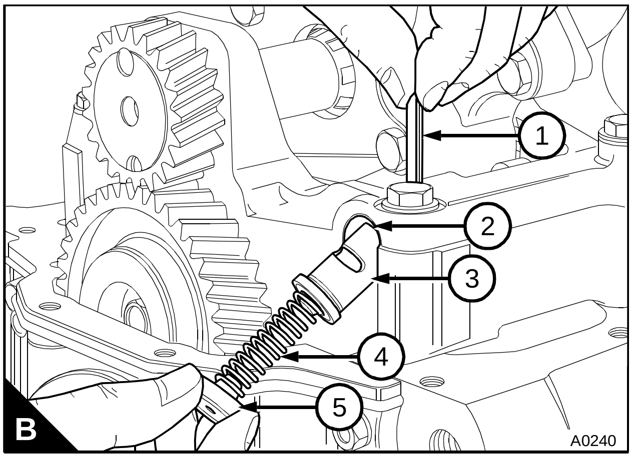
1 Check the spring for wear and other damage and, if possible, check the load necessary to compress the spring to its fitted length, refer to the Data and dimensions for "Oil pressure relief valve (standard)" on page 30 and "Oil pressure relief valve (with balancer)" on page 30.

2 Check the plunger for wear and other damage and ensure that it slides easily in the bore of the relief valve.

3 Check the body and the end plate for wear and other damage.

4 Renew worn or damaged components.





Flexible oil pipes

The oil cooler pipes fitted to 6 cylinder engines do not have metal braid and are separate pipes. The part number of the pipes is stamped on a clip which is fastened to one end of each pipe. The pipes are not interchangeable and it is important that the correct pipes are fitted to the engine.

There are three arrangements for the pipes which are used in accordance with the application and the type of oil cooler fitted to the engine.

To remove **Operation 10-15**

Warning! *The engine oil may be hot, allow the engine temperature to cool before the oil pipes are released.*

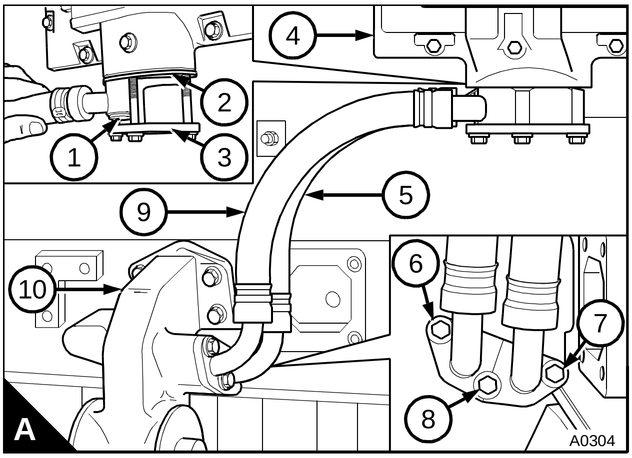
Caution: *For oil coolers that have a pressed steel cover. Do not remove both of the oil pipes together.*

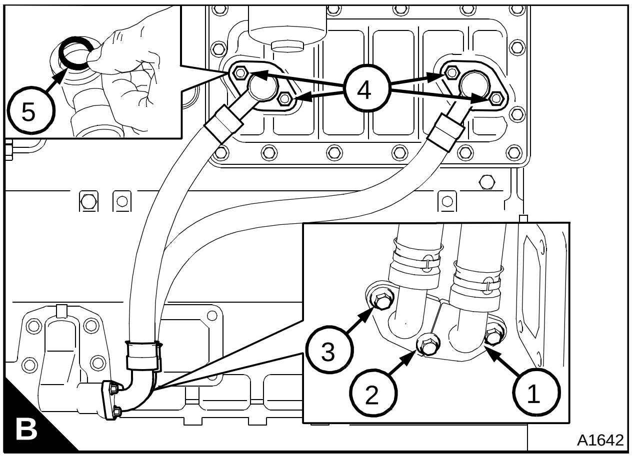
1 Allow the engine temperature to cool down and put a suitable container under the filter head.

2 Remove the three setscrews which retain the oil pipes to the filter head (A). Release the oil pipes and allow the oil to drain into the drip tray. Discard the joint.

3 Remove the three setscrews which retain the oil pipes to the oil cooler (A). Discard the joint.

4 For oil coolers that have a pressed steel cover: Remove one of the pipes from the oil cooler, then fit the flanges and nuts (B4) onto the studs again, before the other pipe is removed. This will ensure that the element remains fastened to the cover. Discard the “O” rings (B5).





To fit **Operation 10-16**

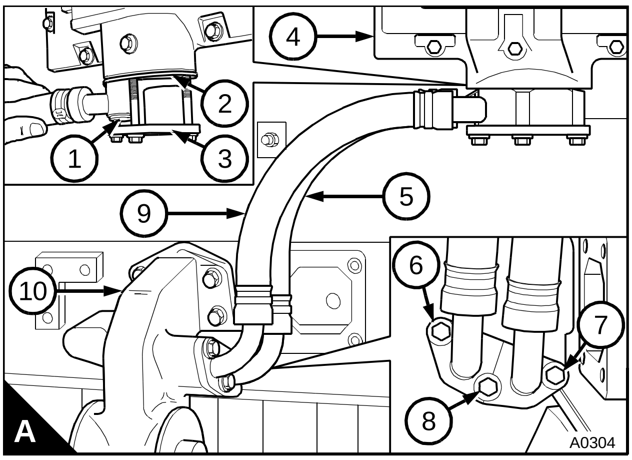
Arrangement 1 (A)

1 Put the three setscrews into position in the flange (A3) of the inner pipe (A5). Put a new joint (A2) in position on the setscrews.

2 Engage the setscrews by three or four threads in the flange of the oil cooler (A4). Engage the spigot (A1) of the outer pipe (A9), in the hole in the flange (A3) of the first pipe, ensure that it fits squarely in the flange.

3 Support the pipes by hand and tighten the centre setscrew finger tight. Tighten the other setscrews until they are finger tight. Ensure that the pipes are as close together as possible, then tighten the setscrews gradually and evenly to 22 Nm (16 lbf ft) 2,2 kgf m.

4 Put a setscrew (A7) in position in the flange of the inner pipe (A5) for the oil filter head (A10). Put a new joint in position on the setscrew. Hold the flange and the joint in position and fit the centre setscrew (A8). Tighten the setscrews finger tight. Put the flange of the outer pipe (A9) in position and fit the third setscrew (A6), tighten it finger tight. Beginning with the centre setscrew, tighten the three setscrews to 22 Nm (16 lbf ft) 2,2 kgf m.



Arrangement 2 (B)

1 Put a setscrew (B5) in position in the flange of the inner oil cooler pipe (B6). Put a new joint (B4) in position on the setscrew. Hold the flange and the joint in position and fit the centre setscrew (B8). Tighten the setscrews finger tight.

2 Put the outer pipe (B7), in position on the flange of the oil cooler and fit the third setscrew (B9) finger tight. Beginning with the centre setscrew, tighten the three setscrews to 22 Nm (16 lbf ft) 2,2 kgf m.

3 Put a setscrew (B3) in position in the flange of the inner pipe for the oil filter head. Put a new joint in position on the setscrew. Hold the flange and the joint in position and fit the centre setscrew (B2). Tighten the setscrew finger tight.

4 Put the flange of the outer pipe in position and fit the third setscrew (B1), tighten it finger tight. Beginning with the centre setscrew, tighten the three setscrews to 22 Nm (16 lbf ft) 2,2 kgf m.

For engines fitted with a pressed steel oil cooler cover - arrangement 3 (C)

Caution: *Do not remove both sets of nuts and flanges at the same time.*

1 Put a setscrew (C1) in position in the flange of the inner pipe for the oil filter head. Put a new joint in position on the setscrew. Hold the flange and the joint in position and fit the centre setscrew (C2). Tighten the setscrew finger tight.

2 Put the flange of the outer pipe in position and fit the third setscrew (C3), tighten it finger tight. Beginning with the centre setscrew, tighten the three setscrews to 22 Nm (16 lbf ft) 2,2 kgf m.

3 Fit new “O” rings to the recess in the oil pipes at the oil cooler end (C5).

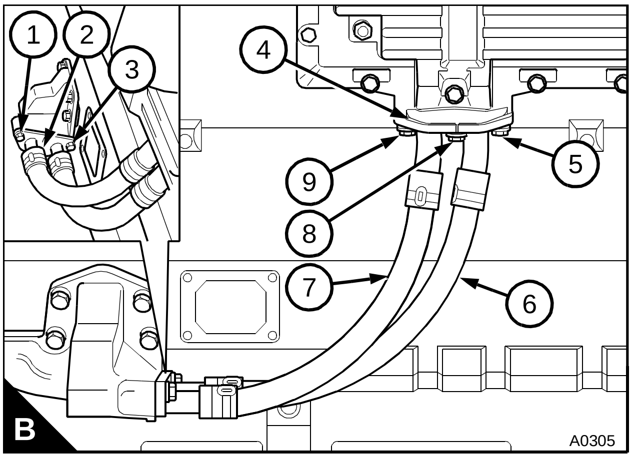
4 Remove the nuts (C4) and flanges from one set of studs and fit the oil pipe. Tighten the nuts to 22 Nm (16 lbf ft) 2,2 kgf m. Remove the nuts and flanges from the second set of studs and fit the remaining oil pipe. Tighten the nuts to 22 Nm (16 lbf ft) 2,2 kgf m.

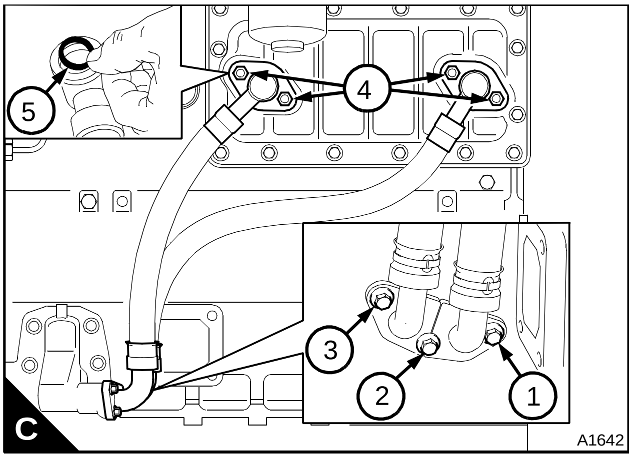
To Inspect **Operation 10-17**

1 Remove any old pieces of the joint and clean the flange faces of the oil pipes.

2 Thoroughly clean the oil pipes in an approved detergent cleaning solution.

3 Check the outer cover of the pipes for signs of leakage, cracks or splits. If the outer cover or the flanges are damaged the pipe must be renewed.





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11

Fuel system

General description

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

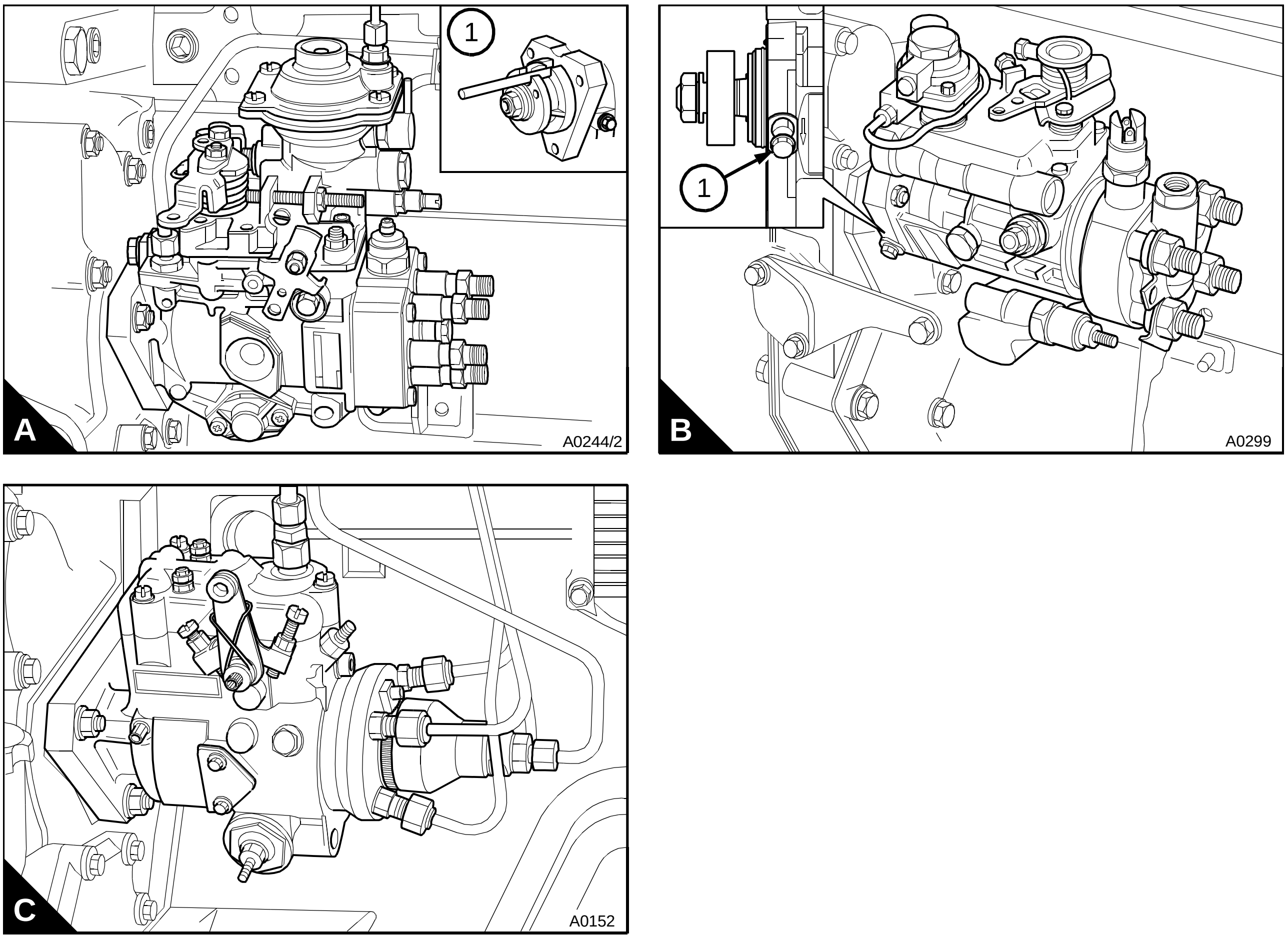
New 1000 Series engines are used for industrial and agricultural applications and use various fuel injection pumps. Either Bosch (A), Lucas/Delphi (B) or Stanadyne (C) pumps may be fitted.

All of the fuel pumps conform to emissions legislation. Both the pump timing and the speed adjustment are tamper proof. For engines (models AP, AQ and AS) the fuel injection pump gear is retained by four Torx screws that are fitted with special washers. All other engine models have the fuel injection pump gears retained by four flanged setscrews.

All of the fuel injection pumps have mechanical governors to control the engine speed.

Bosch and Lucas/Delphi fuel injection pumps have locking screws (B1) which lock the shaft. It is important that the lock screw is released and the pump shaft is free to turn when the pump is fitted to the engine. Stanadyne pumps do not have a locking screw fitted.

Continued



All of the fuel injection pumps have a pin timing hole (D1). Refer to Operation 8-4 for the correct method to time the pump.

Turbocharged engines have pumps with a boost control. The boost control is a device which is affected by boost pressure (from the turbocharger) and reduces the maximum fuel delivery at lower engine speeds to match the reduced air supply to the cylinders.

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

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

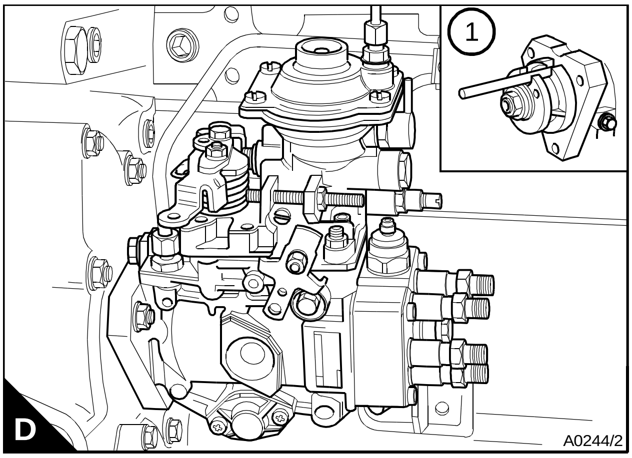
The maximum no-load speed is shown on the emissions data plate fitted to the left side of the cylinder block.

Atomisers

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. Each atomiser is fastened to the cylinder head by a gland nut.

The atomisers are set in the factory, but they must be checked in accordance with the preventive maintenance schedules. The pressure at which atomisers operate can be adjusted by a change of shims fitted above the spring.

For details of the atomiser setting pressures for the engine, refer to the Data and dimensions for "Atomiser service setting" on page 31.



Fuel injection pump types

Bosch fuel injection pump

The boost control fitted to the Bosch fuel pump is a diaphragm type (A1). A KSB type cold starting aid and a stop solenoid may also be fitted to these pumps.

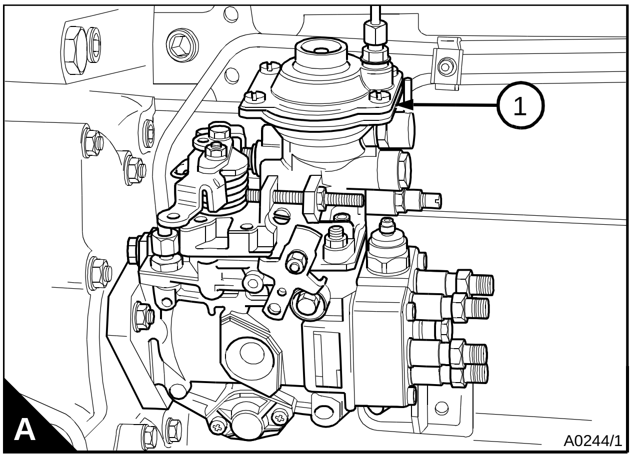
Lucas/Delphi DP200 Series fuel injection pump

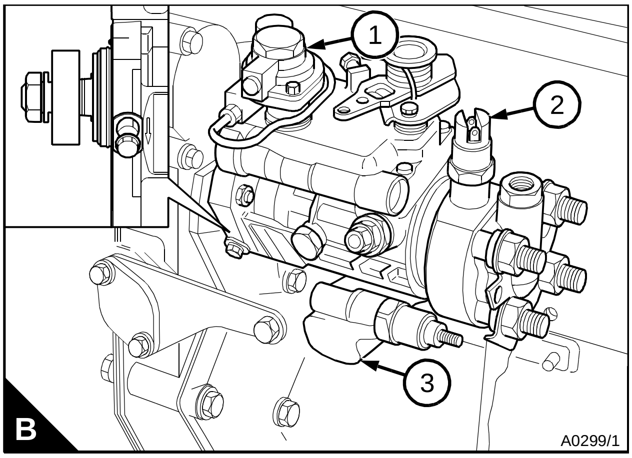
Lucas/Delphi DP200 Series fuel injection pumps are fitted to naturally aspirated engines and turbocharged engines.

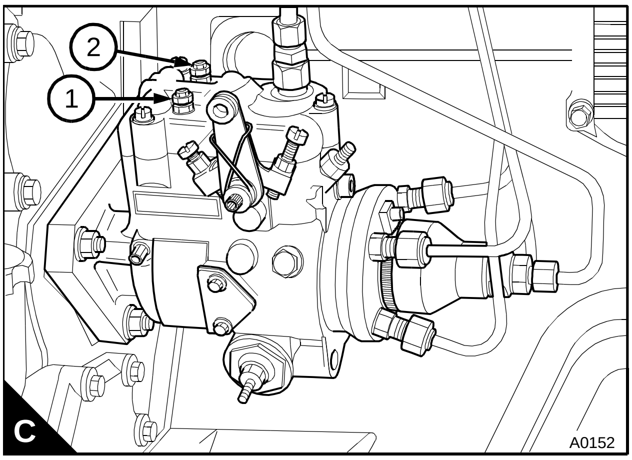
These pumps have an electrically operated cold start device (B3) which retards the timing for normal operation. Other features of this pump include a boost control (B1) and a stop solenoid (B2). These pumps are fitted with a self-vent feature.

Stanadyne fuel injection pump

Some naturally aspirated engines have a Stanadyne fuel injection pump (C) fitted. The electrical stop solenoid on these fuel pumps is fitted inside the governor housing. The earth connection (C1) and the electrical supply connection (C2) are on top of the governor housing.







Cold start advance unit

Some Lucas/Delphi, Bosch and Stanadyne rotary 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 starting aid to operate correctly could result in damage to the engine as the timing will be fully advanced for normal operation.*

The sender unit, for engines fitted with belt driven coolant pumps, is on the top of the thermostat housing. The sender unit, for engines fitted with gear driven coolant pumps, is on the rear of the timing case on the left side of the engine.

As the engine warms, the sender unit energises to retard the pump timing to the correct timing for normal operation of the Lucas/Delphi and Bosch fuel injection pumps. The sender unit for the Stanadyne cold start unit de-energises to retard the pump timing to the correct timing for normal operation.

Note: The wiring diagrams on the following page show the sender unit (component 3) position when the engine is cold.

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

Caution: *Damage to the engine will occur if the engine is load tested at more than 80% of full load with the cold start device disconnected.*

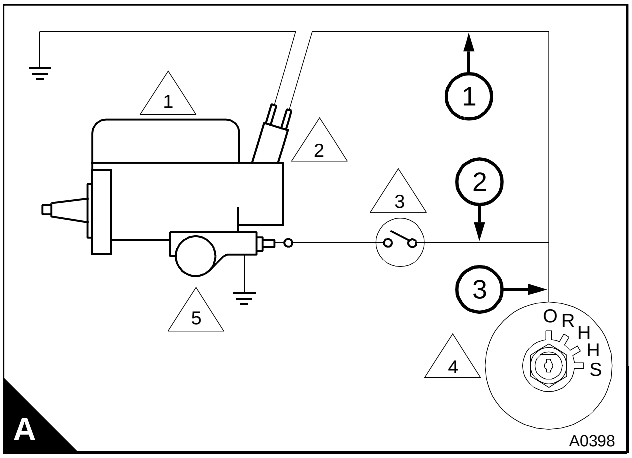
Continued

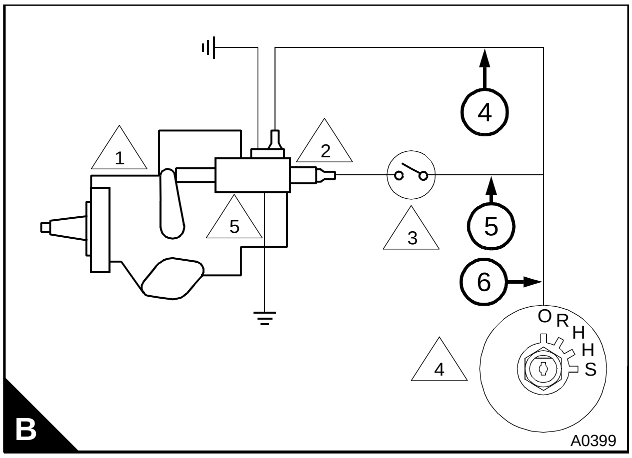
Wiring diagrams for the cold start advance unit fitted to some Lucas/Delphi DP200 Series, Bosch and Stanadyne fuel injection pumps are shown in the illustrations (A), (B) and (C) respectively. For easy identification the cables are shown in circles on the illustrations.

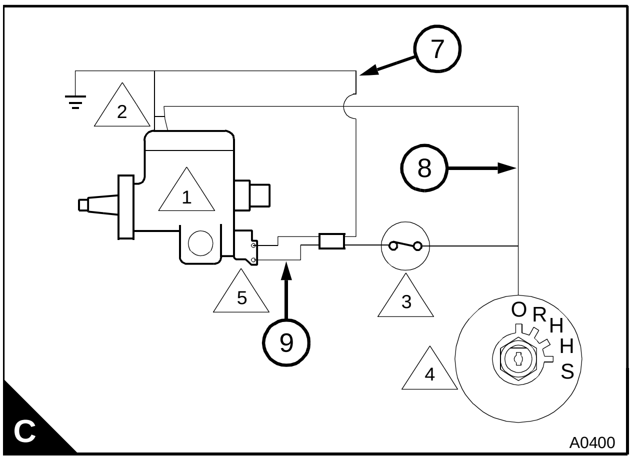
The amperage of each of the cables is listed in the cable identification table below. The identification numbers for the electrical components are shown in triangles. Refer to the component identification list to find a component.

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
6	6		
7	3		
8	6		
9	3		

(1) For numbers shown in circles
(2) For numbers shown in triangles







Cold start advance unit (KSB)

Bosch EPVE rotary fuel injection pump has a starting aid that holds the timing of the pump in an advanced position when cold.

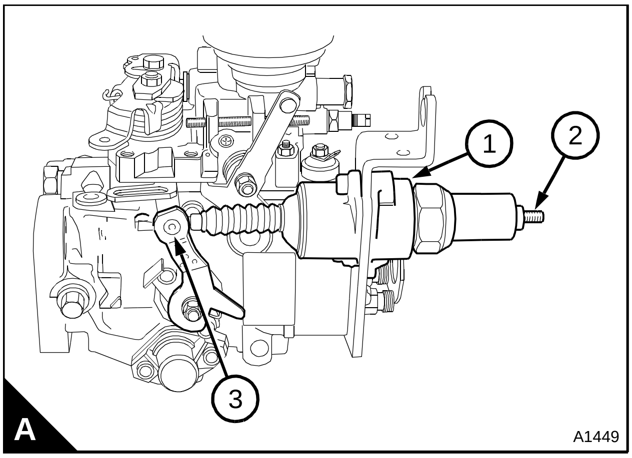
The device (A) is operated electrically and is connected by a shaft to the advance lever (A3) of the fuel injection pump.

Warning! *Do not touch the body (A1) of the hot wax filled element during operation of the engine.*

As the engine warms, a sender unit in the coolant passage at the rear of the timing case energises to apply 24V to the wax filled element (A1). As the wax expands it causes a rod connected to a lever to retard the pump timing to the correct timing for normal operation.

***Cautions*:**

- *It is important that the electrical connection (A2) and the connection to the sender unit on the rear of the timing case are correctly connected. Failure of the starting aid to operate correctly could result in damage to the engine as the timing will be fully advanced.*
- *Do not release the connection (A3) from the pull rod; this will result in the loss of adjustment set in the factory.*



Typical fuel system

Six cylinder engines

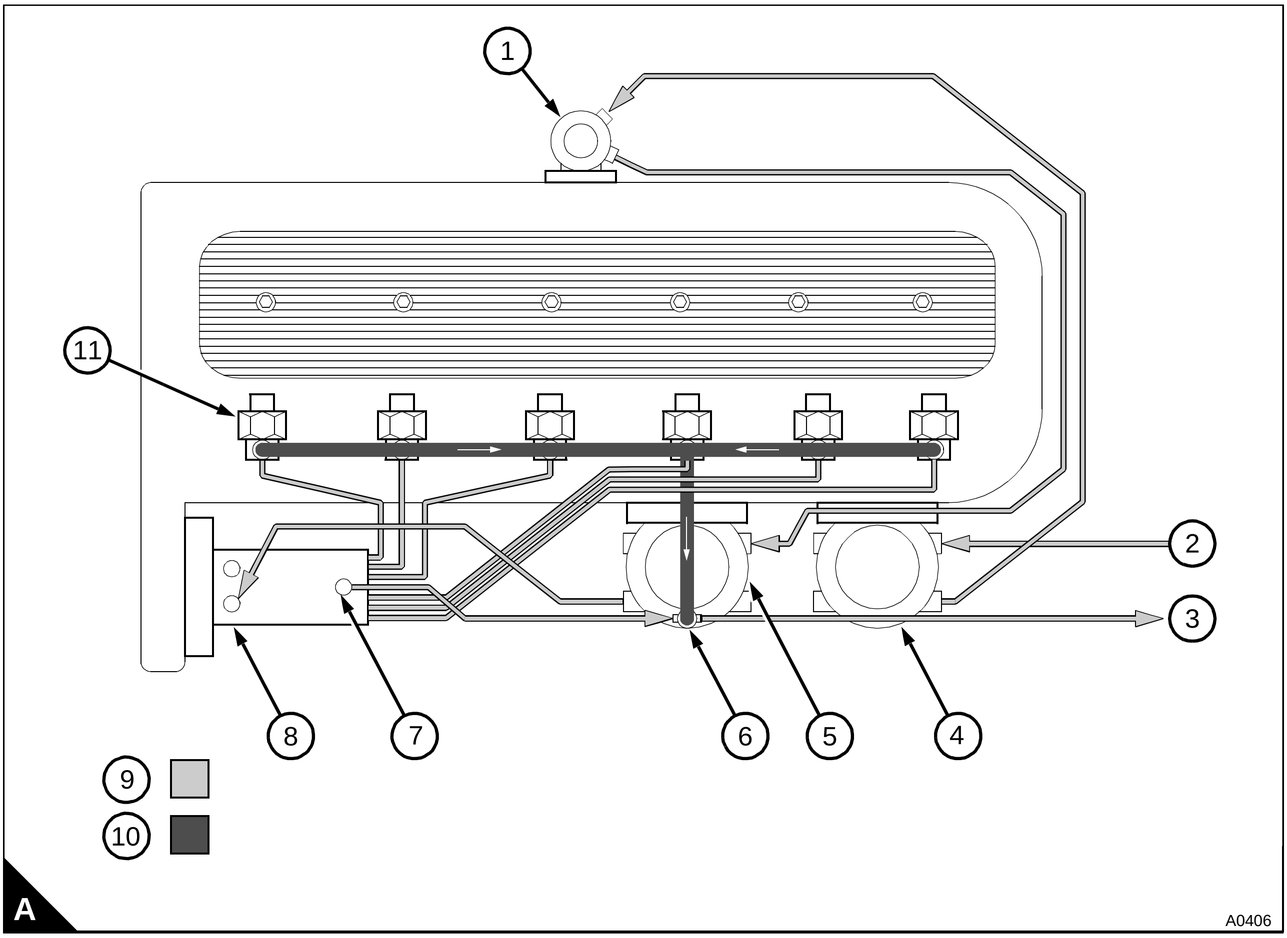
Fuel systems vary from application to application, this information is provided for training purposes only.

Fuel (A9) from the tank (A2) leaves the pre-filter (A4) and then passes to the diaphragm type lift pump (A1), which is driven by an eccentric on the camshaft. Fuel leaves the lift pump under pressure and passes through a full flow filter (A5) to the fuel injection pump (A8).

Some fuel injection pumps have a self-vent pipe (A7) to remove air from the fuel system back into the fuel tank. The fuel in the injection pump also lubricates and cools the pump. A fuel heater or cooler may be fitted between the filter head and filter canister. The pump has a mechanical governor to control the engine speed.

The pumps also have an electrical stop solenoid and an electrically operated cold start advance unit fitted.

The fuel injection pump increases the fuel pressure and injects high-pressure fuel at the correct time and sequence through pipes to the atomisers (A11). A fuel leak-off rail is fitted to the top of each atomiser and leak-off fuel (A10), used to lubricate the atomisers, is returned to the fuel tank through a pipe (A3).



Fuel filters

***Cautions*:**

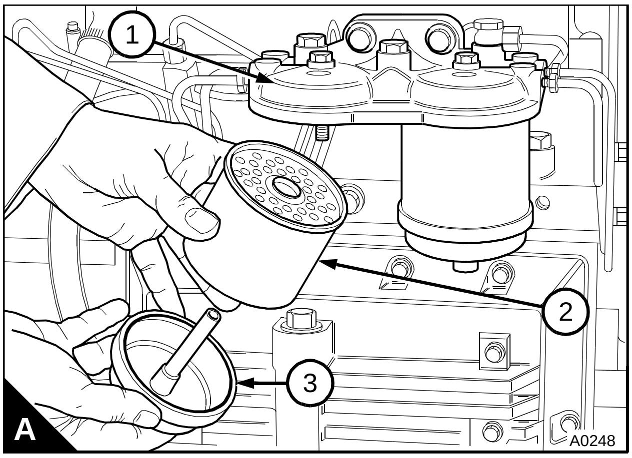
- *It is important that only the genuine Perkins parts are used. The use of a wrong canister or element can damage the fuel injection pump.*
- *The pre-filter and main filter canisters must be renewed at the same time.*
- *Do not allow dirt to enter the fuel system. Before a connection is disconnected, clean thoroughly the area around the connection. After a component has been disconnected, fit a suitable cover to all open connections.*

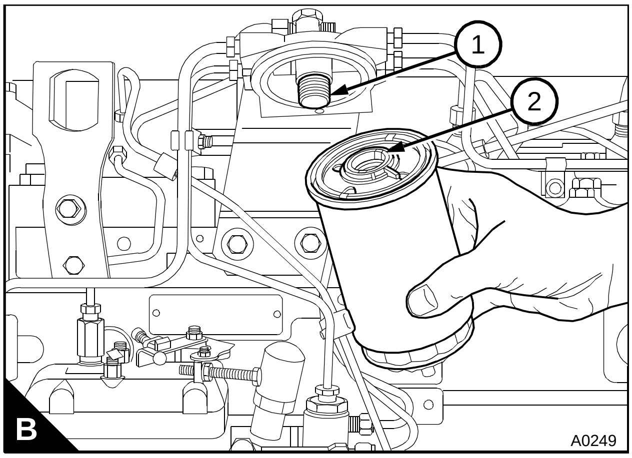
There are three types of fuel filter element in use:

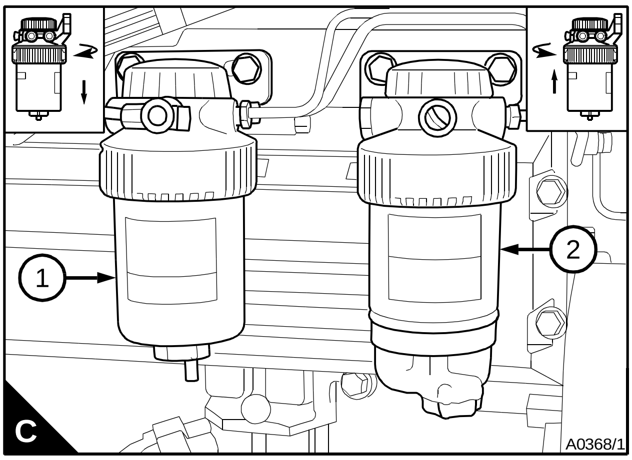
The separate element type (A2) where the filter element is held between the filter head (A1) and the bottom cover (A3). The filter can have two elements (A).

The canister type where the filter element has an internal thread at the top (B2) and is fastened to a threaded adaptor in the filter head (B1).

A fuel filter with a quick release canister (C). The filter can have two canisters. Some engines are fitted with a pre-filter of the same type (C2). This filter is fitted next to the main filter (C1), but connected in the fuel system before the fuel lift pump. It is important to ensure that the main and pre-filters are fitted in the correct positions.







Fuel filter element

To renew - separate element type **Operation 11-1**

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

***Cautions*:**

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

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

2 Hold the bottom cover of the filter element and release the setscrew (A3) which is fitted through the filter head (A1) above the centre of the element.

3 Lower the bottom cover of the filter.

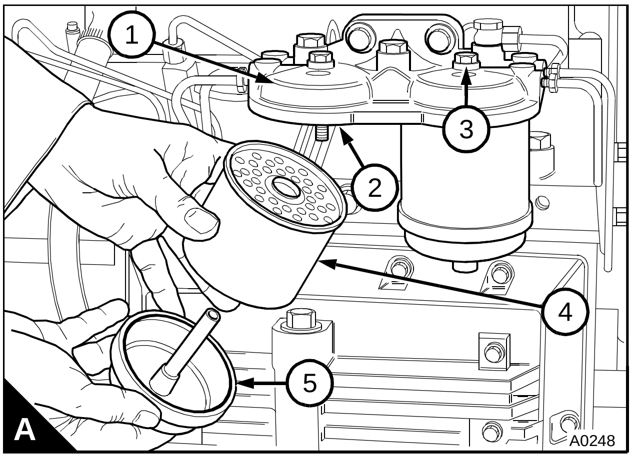
4 Remove the element (A4) and discard it.

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

6 Renew the seals (A2) and (A5) and lightly lubricate them with clean fuel.

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

8 Eliminate the air from the fuel filter, see Operation 11-20.



To renew - canister type **Operation 11-2**

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

***Cautions*:**

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

1 Thoroughly clean the outside surfaces of the fuel filter assembly.

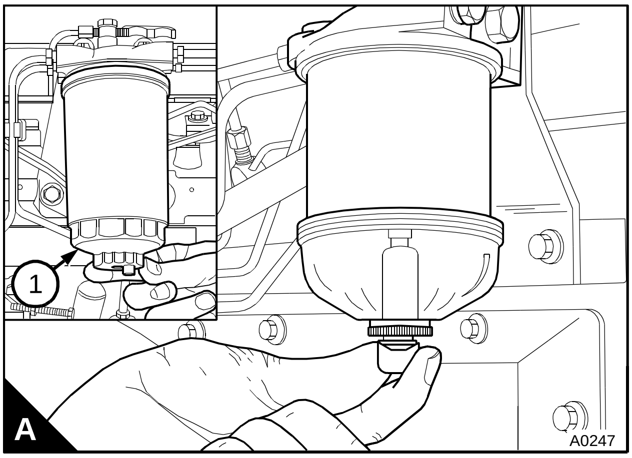
2 Loosen the drain device at the bottom of the filter (A) and allow the water / fuel to drain into a suitable container.

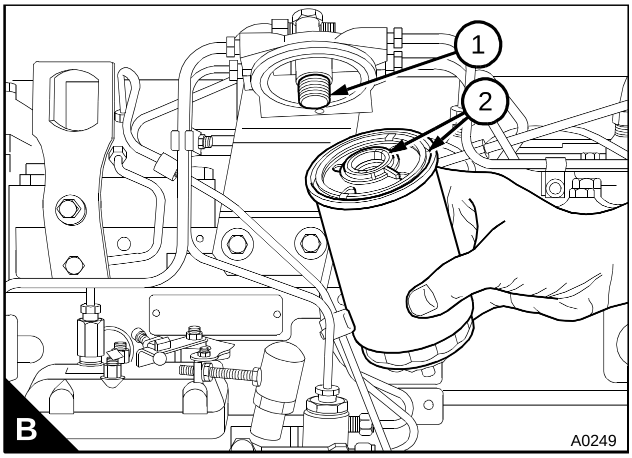
3 Use a strap wrench or similar tool to loosen the filter canister and remove the canister.

4 Ensure that the threaded adaptor (B1) is secure in the filter head and that the inside of the head is clean.

5 Lubricate lightly the top seals (B2) of the new canister with clean fuel. Fit the new canister to the filter head and tighten, by hand only.

6 Eliminate the air from the fuel filter, see Operation 11-20.





To renew - quick release canister type **Operation 11-3**

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

***Cautions*:**

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

1 Thoroughly clean the outside surfaces of the filter assembly.

2 Loosen the drain device (A4), if one is fitted, at the bottom of the canister and allow the water/fuel to drain into a suitable container.

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

3 Unscrew the sediment bowl at the bottom of the canister, if one is fitted.

4 Support the filter canister and rotate the clamp ring (A2) to the left, see the direction arrow, and remove the clamp ring.

5 Remove the canister from the filter head by a direct pull downwards, and discard the old canister (A3). Retain the clamp ring.

6 Ensure the filter head is clean and that the seals (A5) and (A6) are in good condition or renew them. Align the spline (A8) with the groove in the filter head and push the new canister fully into the filter head.

7 Support the canister, fit the clamp ring (A7) and rotate it to the right, see the direction arrow, to fasten the canister to the filter head.

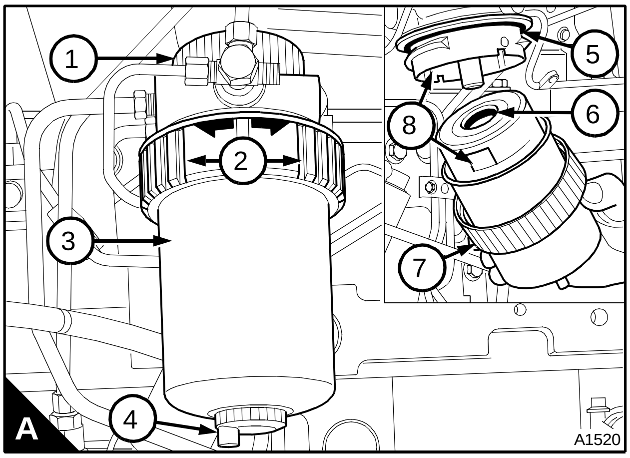
8 If a sediment bowl is fitted, remove the bowl and thoroughly clean the cover of the bowl.

9 Check the two 'O' ring seals of the sediment bowl for damage and renew if necessary.

10 Clean the threads of the sediment bowl and fit the bowl to the canister and tighten by hand only.

11 If it was removed, fit the nylon insert used to lower the level of the fuel in the filter canister and fasten the cap.

12 Eliminate the air from the fuel filter, see Operation 11-20.



Atomisers

Regular maintenance of the atomisers is not necessary. The atomiser nozzles should be renewed and not cleaned, and renewed only if an atomiser fault occurs. The major problems that may indicate that new nozzles 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.*

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

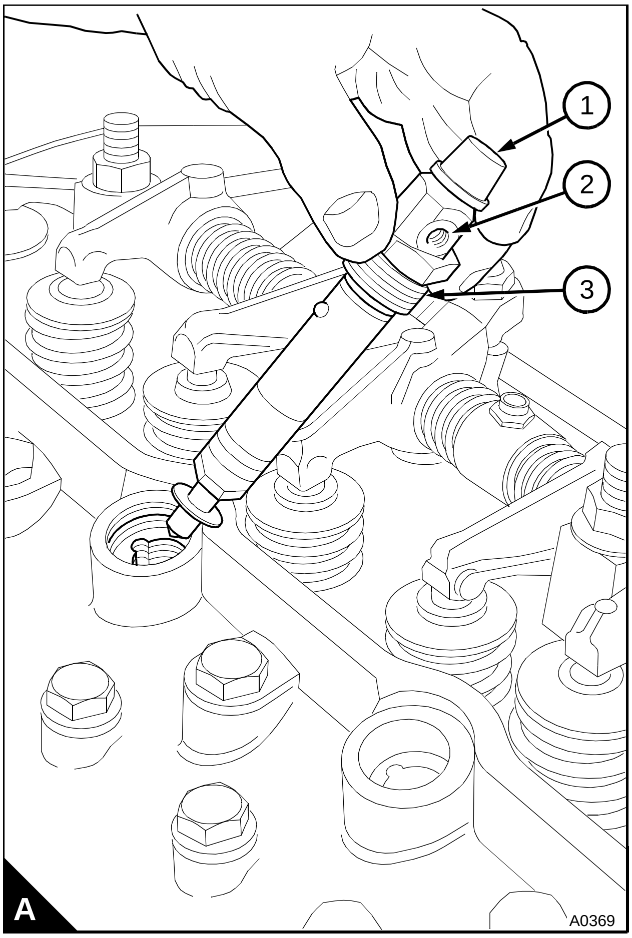
To remove **Operation 11-4**

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

1 Remove the fuel leak-off pipe from the connection (A2).

2 Remove the union nuts of the high-pressure pipe from the atomiser and from the fuel injection pump. Do not bend the pipe. If necessary, remove the pipe clamp. Fit a plastic cap (A1) to cover the fuel inlet connection and the nozzle.

3 Release the gland nut (A3) and remove the atomiser and its seat washer from the recess in the cylinder head.



To fit **Operation 11-5**

Special requirements

Consumable products	
Description	**Part number**
POWERPART Universal jointing compound	1861117

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

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

2 Ensure that the wire clip (A4) is in position. Put a 2 mm (0.08 in) bead of POWERPART Universal jointing compound onto the first two threads of the gland nut (A8). The bead should extend approximately 6 mm (0.24 in) around each of the threads. Ensure that the sealant does not contact the body of the atomiser.

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

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

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

Caution: *Do not move the thread after it has been tightened, the seal that is made when torque has been applied will be broken and leakage past the atomiser seat may occur.*

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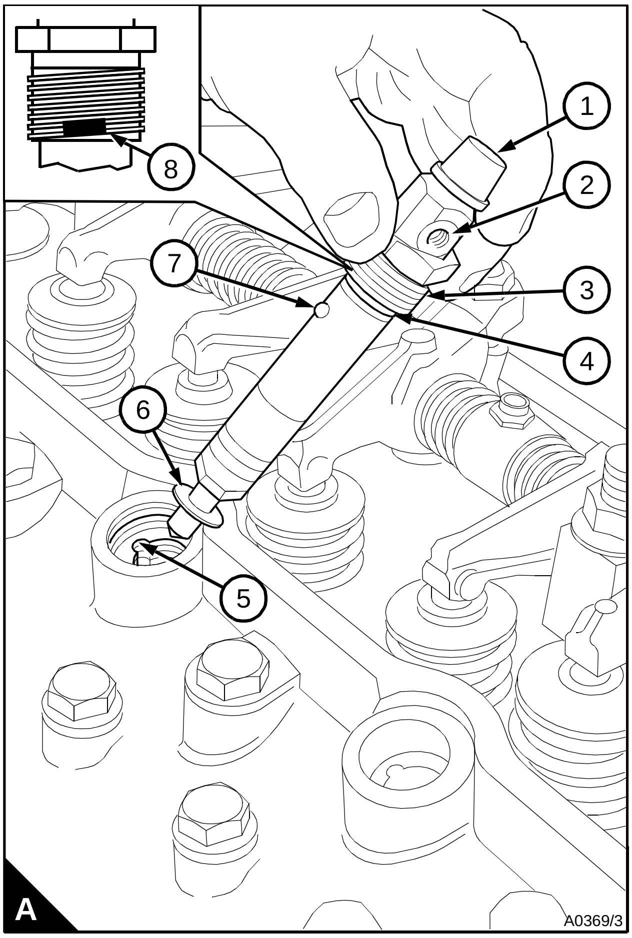


Tighten the nut gradually and evenly to 40 Nm (30 lbf ft) 4,1 kgf m. As the nut is tightened the atomiser will rotate clockwise as the ball moves in the slot, this is acceptable. Remove any excess thread sealant.

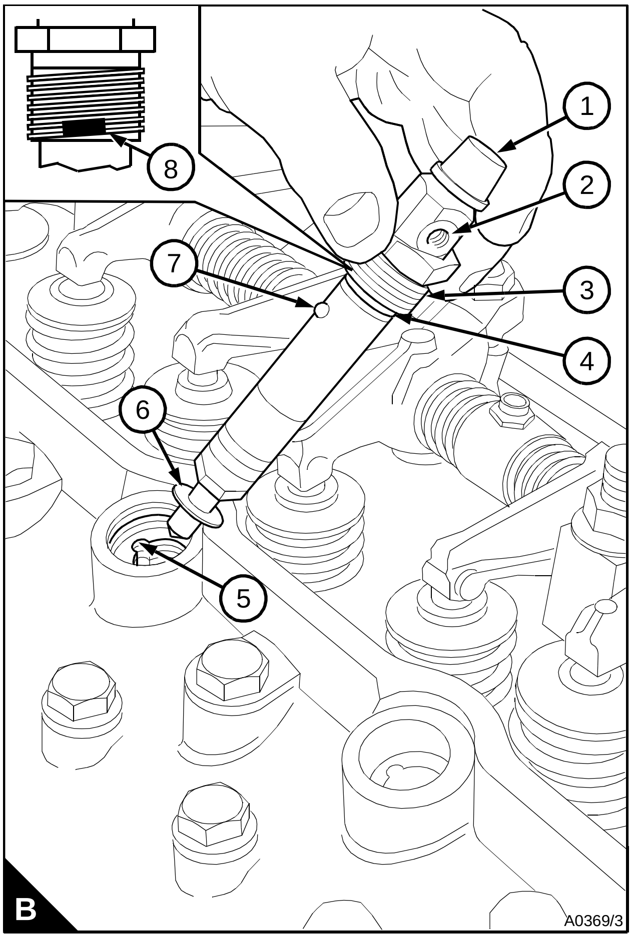
Caution: *Do not tighten the union nuts of the high-pressure pipes more than the recommended torque tension. If there is a leakage from the union nut, ensure that the pipe is correctly aligned with the atomiser inlet. Do not tighten the atomiser union nut more, as this can cause a restriction at the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

3 Remove the plastic cap (B1) and fit the high-pressure fuel pipe and tighten the union nuts to 22 Nm (16 lbf ft) 2,2 kgf m. If necessary, fit the pipe clamps.

4 Renew the sealing washers and fit the leak-off pipe to the leak off connection (B2). Tighten the banjo bolt to 9,5 Nm (7,0 lbf ft) 1,0 kgf m.

Note: On later engines the leak-off pipe banjo has Dowty washers instead of copper washers and a longer banjo bolt, ensure that the correct parts are used.

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



Fuel lift pump

To remove and to fit **Operation 11-6**

Special requirements

Consumable products	
Description	**Part number**
POWERPART Silicone rubber sealant	1861108

Notes:

- A new fuel lift pump (B) is fitted to the latest four cylinder engines. The new fuel lift pump is a one-piece assembly and should not be dismantled. A strainer is fitted inside the fuel inlet connection (B1). The strainer is serviced at the same interval as the early fuel lift pump, refer to the User's Handbook for servicing details. The procedure to remove and to fit this fuel lift pump is as the earlier fuel lift pump.
- Reflective heat shields if fitted to the fuel lift pump must be kept clean and free from dust, oil or paint. If the surface of the heat shield is not shiny, the fuel lift pump protected by the heat shield could be damaged.

To remove

1 If a heat shield is fitted, remove it. Disconnect the fuel pipes from the fuel lift pump.

2 Release the setscrews, remove the fuel lift pump (A). The lift pump may be difficult to remove from the engine. If this occurs, the crankshaft must be rotated until the camshaft eccentric, which operates the lift pump, is in a position that will free the rocker lever of the lift pump.

To fit

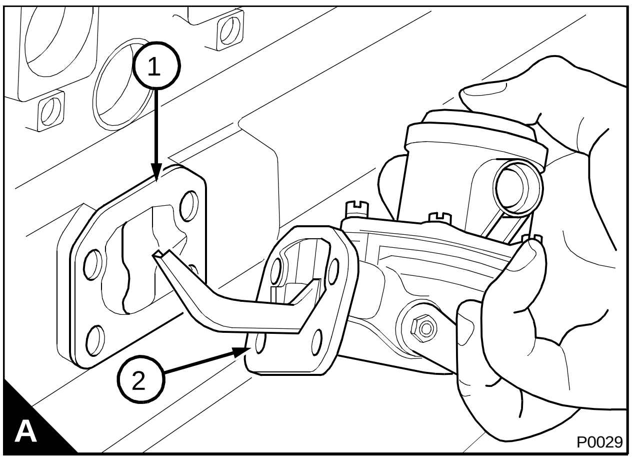
Note: Some setscrews for securing the lift pump have a sealant (MEAS) applied by the manufacturer to the first 13,0 mm (0.50 in) of the threads. If the setscrews are used again, the sealant must be removed from the male and female threads and POWERPART Silicone rubber sealant applied to the first 13,0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

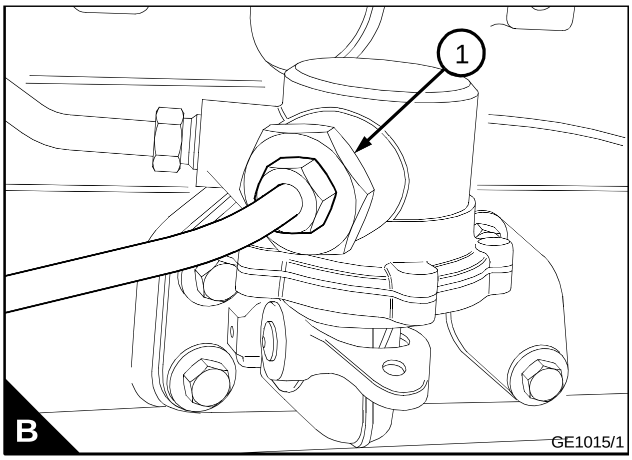
1 Ensure that the camshaft eccentric is in the minimum lift position before the lift pump is fitted. Clean the joint face of the lift pump (A2) and the cylinder block and fit the lift pump together with a new joint (A1). Tighten the setscrews gradually and evenly to 22 Nm (16 lbf ft) 2,2 kgf m.

2 Connect the fuel pipes and, if necessary, fit the heat shield.

3 Release the vent screw on the fuel filter head and operate the priming lever of the fuel lift pump to eliminate any air between the lift pump and the fuel filter. Operate the lift pump until fuel, free of air, comes from the vent screw. Tighten the vent screw.

4 Operate the engine and check for any fuel or air leakage.





To dismantle **Operation 11-7**

Note: The new fuel lift pump is a one-piece assembly and should not be dismantled.

1 Clean the outside surfaces of the fuel lift pump.

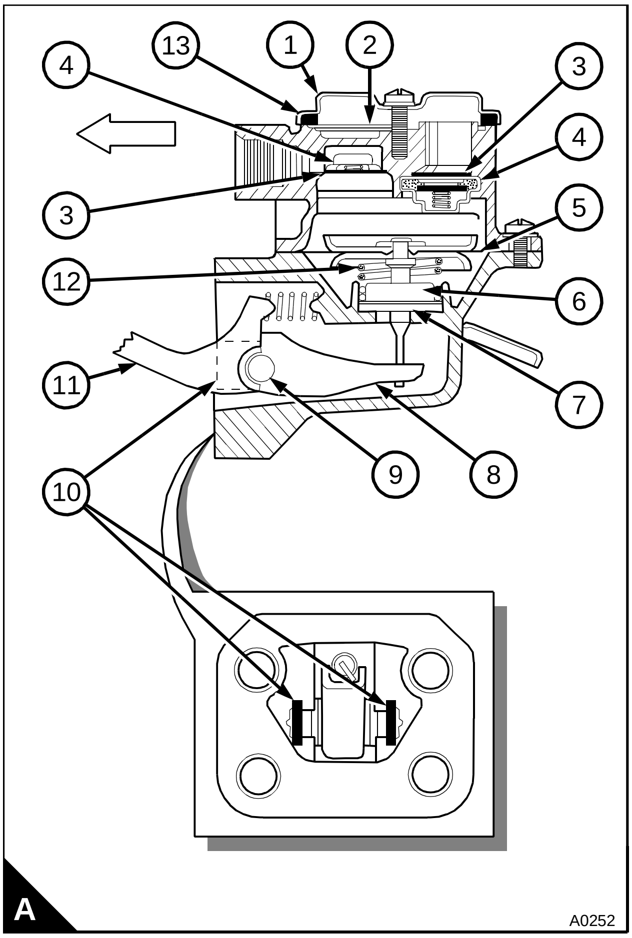
2 Make a mark across the flanges of the two halves of the pump to ensure correct relationship when the pump is assembled.

3 Remove the cover (A1) and the gauze (A2). Release the setscrews and separate the two halves of the pump.

4 Turn the diaphragm assembly (A5) 90° to release the pull rod from the link arm (A8) and remove the diaphragm assembly. Remove the stem seal (A6), the spring seat washer (A7) and the spring (A12) from the pull rod. The diaphragm and pull rod assembly is renewed as an assembly and no service is possible on the diaphragm.

5 The valves (A4) are peened in and can be removed with a suitable lever. Some of the peened metal will have to be removed before the valves can be removed.

6 To remove the link arm: Hold the rocker lever (A11) in a vice and hit the body of the lift pump with a soft face hammer to release the two retainers (A10). Be careful not to damage the joint face of the pump body. Remove the rocker lever, the pin (A9), the link arm and the return spring. Check the components for wear and other damage.



To assemble **Operation 11-8**

1 Thoroughly clean the valve housings. Fit new seat washers (A3) and push the new valves (A4) into position. As the valves are the same, but one valve is fitted in reverse of the other, it is possible to fit the valves upside down. To ensure that the valves are fitted correctly, fit them as shown in A. When the valves are correctly fitted, peen the edge of the valve housings in six places, evenly divided, to keep the valves in position.

2 Fit the rocker lever (A11), pin (A9) and link arm assembly (A8) into the bottom half of the lift pump. Fit the return spring; ensure that the ends of the spring are in their correct location.

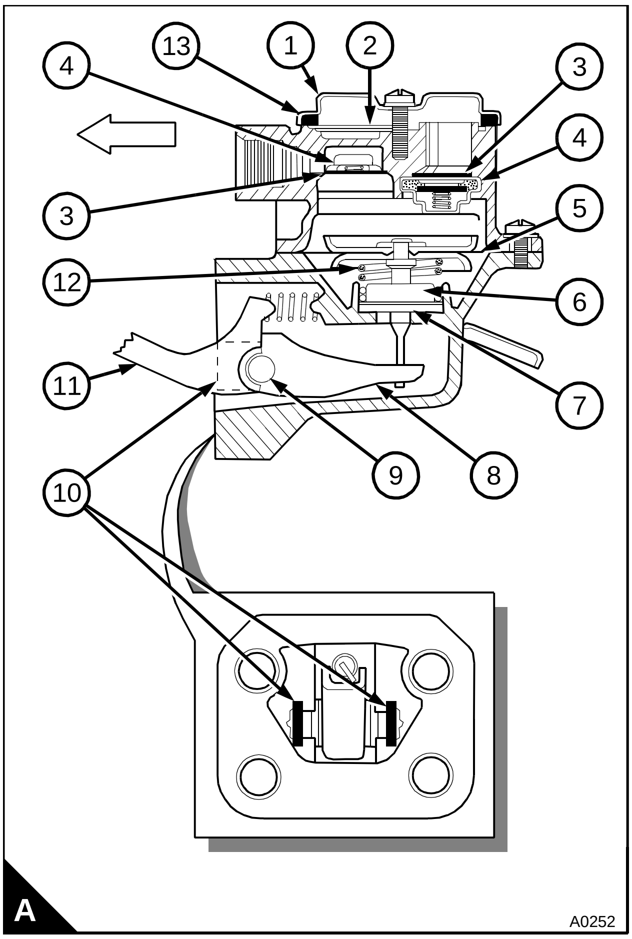
3 With a light hammer and a suitable adaptor, fit two new retainers (A10) in their grooves in the casing until they fasten the pin. Peen the open ends of the grooves to fasten the retainers in position.

4 Fit the diaphragm spring (A12) into its location under the diaphragm (A5) and put the spring seat washer (A7) and a new stem seal (A6) into position on the pull rod. Ensure that the small diameter at the top of the seal is on the round section of the pull rod.

5 Put the diaphragm assembly in position over the lower half of the body with the blade of the pull rod aligned with the slot in the link arm. Press lightly down on the diaphragm until the notch in the pull rod is in the slot in the link arm and turn the diaphragm 90° in either direction. This action will engage and retain the pull rod in the slot of the link arm.

6 Push the rocker arm towards the pump body until the diaphragm is level with the body flange and fit the top half of the body in position with the marks on the flanges aligned. Keep the pressure on the rocker arm; fit the spring washers and the screws and tighten them evenly.

7 Fit the gauze filter (A2) and the cover (A1), ensure that the rubber seal (A13) is fitted correctly and tighten the screw.



To test

Operation 11-9

1 Disconnect the fuel outlet pipe from the fuel lift pump. Fit a 0-70 kPa (0-10 lbf/in^2) 0-0,7 kgf/cm^2 pressure gauge to the outlet of the lift pump. Release the connection at the gauge and operate the priming lever of the lift pump to eliminate air from the pipe. When fuel, free of air, flows from the pipe tighten the connection. Ensure that there are no leaks at the connections between the pump and the gauge.

2 Operate the starter motor for 10 seconds with the engine stop control in the stop position or with the stop solenoid disconnected.

3 Note the maximum pressure indicated on the gauge. If the pressure indicated is less than the test pressure shown in the data and dimensions, see "Fuel lift pump - four cylinder engines" on page 30 or "Fuel lift pump - Six cylinder engines" on page 30, repair or renew the pump. Also check the rate at which the pressure reduces to half the maximum pressure obtained. If this is less than 30 seconds, repair or renew the pump.

4 Remove the gauge and connect the outlet pipe to the lift pump. Release the vent screw on the fuel filter head and operate the priming lever until fuel, free of air, flows from the vent screw. Tighten the vent screw.

5 Connect the engine stop solenoid.

Bosch fuel injection pump

General description

Caution: *Do not release the nut (A6) from the fuel injection pump. Illustration (B) shows the nut (B2) in position when the fuel pump is fitted to the engine. The fuel pump hub is fitted to the shaft in the factory to ensure that the fuel pump is in the correct position for timing. If the nut is removed and the hub moves, the hub will need to be accurately fitted to the pump by use of specialist equipment before the pump can be fitted to the engine.*

The manufacturer fits the hub (A2) to the pump to ensure very accurate timing. Engines that have this arrangement have the drive gear fastened to the hub instead of to the shaft of the pump.

To prevent incorrect adjustments to the engine timing by rotation of the fuel pump, the mounting flange (A5) has holes instead of slots.

Accurate timing of the pump to the engine is by a pin (A1) used to align the fuel pump gear and the hub (A2), with a hole in the body (A3) of the fuel pump. The gear is passed over the pin and fastened to the hub with four fasteners (B1).

Note: For engine models AP, AQ and AS with belt driven coolant pumps, either four tamper proof fasteners (B3) or one tamper proof fastener and three flanged setscrews are used to retain the fuel pump gear. All Torx screws are fitted with a special hardened flat washer. A special Torx socket part number 27610122 is needed to remove and to fit these tamper proof fasteners, refer to your Perkins distributor. All other engine models have four flanged setscrews to secure the gear.

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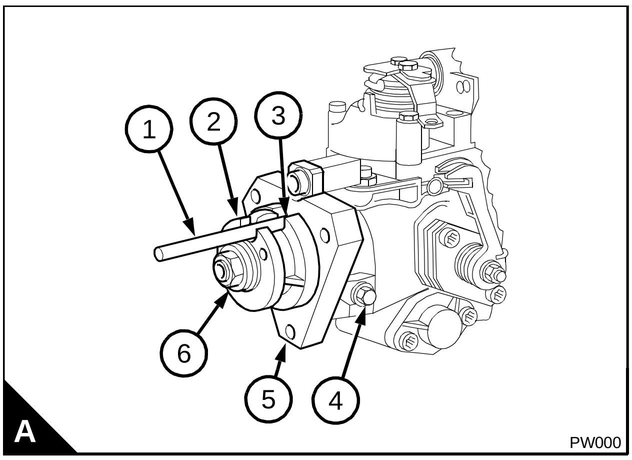
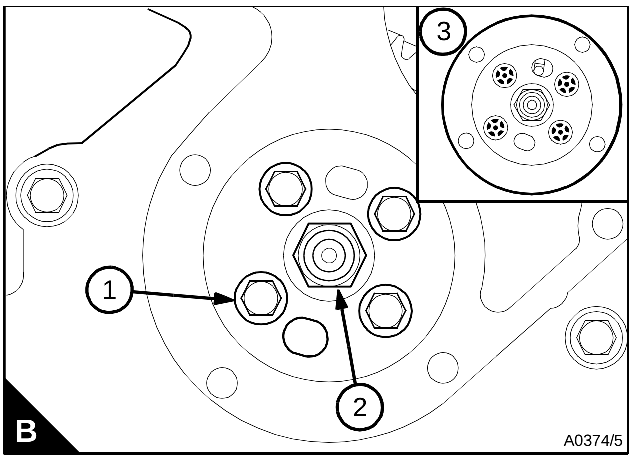


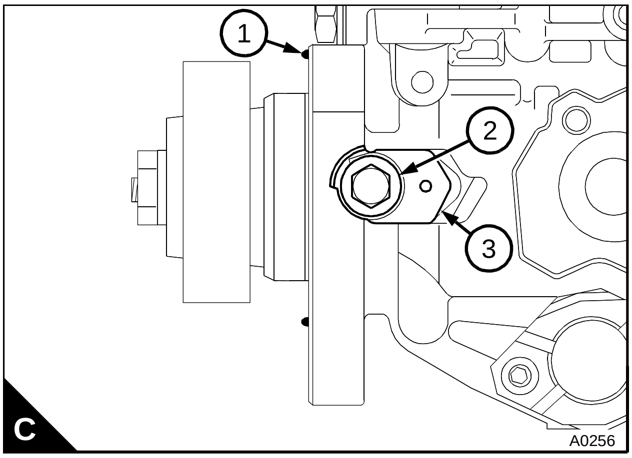


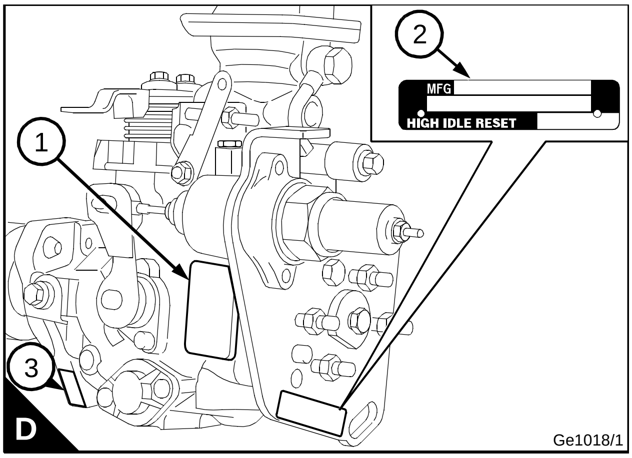
Caution: *A new fuel injection pump may be supplied with the pump shaft in the locked position. The drive shaft of the pump must not be turned without the spacer (C3) in position under the locking screw (C2)*

The fuel injection pump has a locking screw (C2) and a spacer (C3). The locking screw prevents the rotation of the drive shaft.

An "O" ring (C1) 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.

Note: Later Bosch fuel injection pumps may be fitted with an additional data plate, the additional data plate is fitted in one of two places; either on the flange (D3) or on the rear mounting bracket (D2). The additional data plates are used by Perkins to identify fuel injection pumps after a minor modification to alter the pump and/or the engine performance. Information on the additional data plate will supersede the information found in the original Bosch data on the fuel injection pump body (D1).





To remove **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
Torx socket	27610122		

1 Disconnect the battery before the fuel injection pump is removed from the engine.

2 Set the engine to TDC on the number 1 cylinder on the compression stroke, see Operation 8-1 or Operation 8-2.

3 Remove the gear cover from the cover of the timing case. For gear driven coolant pumps: Remove the coolant pump:

For early gear driven coolant pumps, see Operation 12-4.

For latest gear driven coolant pumps, see Operation 12-9.

4 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 when the union nut for each high-pressure pipe is released.*

5 Remove the pipes, the cables and the connections for the cold start device and the electrical stop solenoid from the fuel pump.

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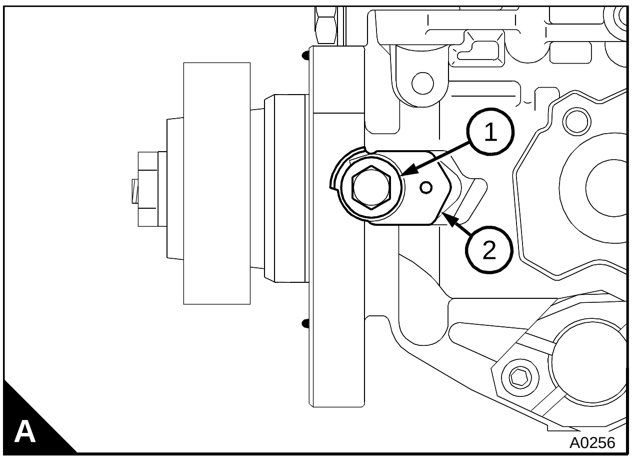
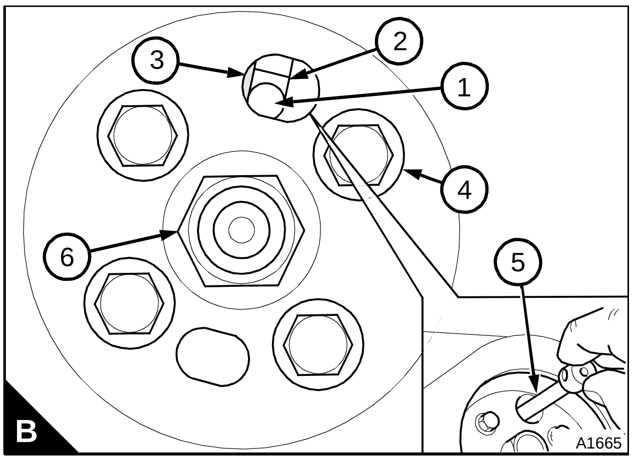




***Cautions*:**

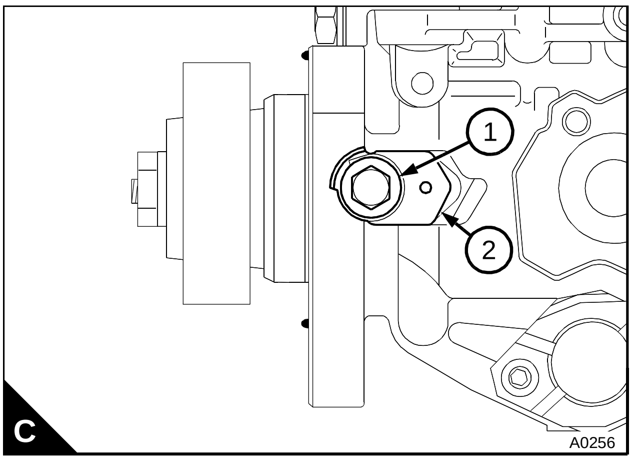
- *Do not rotate the crankshaft when the pump is not on the engine; the loose fuel pump gear may damage the timing case. If it is necessary to rotate the crankshaft, fit the fuel pump temporarily to ensure that the gear is in the correct position. If the fuel pump is fitted temporarily in order to rotate the crankshaft, the locking screw (C1) must be released and a spacer (C2) fitted.*
- *Do not release the nut (D6) 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 available to Perkins distributors.*

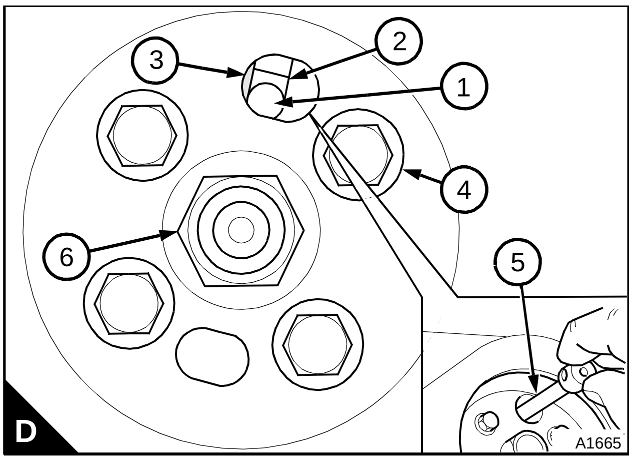
6 Remove the four fasteners (D4) and release the fuel pump gear from the hub of the fuel injection pump.

Note: For engines fitted with a belt driven coolant pump a special Torx socket will be required to remove the fuel pump gear fasteners.

7 If the pump has a support bracket, remove its retaining setscrew and nut.

8 Remove the nuts from the mounting flange of the fuel pump and remove the pump. If access to the nuts is restricted by, for example, a compressor, use tool 21825964 to release the nuts.





To fit **Operation 11-11**

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. If the crankshaft needs to be rotated, the pump must be fitted temporarily, or the loose gear could damage the timing case.*
- *A new fuel injection pump may be supplied with the pump shaft in the locked position. The drive shaft of the pump must not be turned without the spacer (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 Inspect the "O" ring (A3) in the pump flange and, if necessary, fit a new "O" ring.

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

3 Put the fuel pump into position on the three studs and fit the flange nuts.

4 If the pump has a support bracket, fit the setscrew and nut of the support bracket. Ensure that force is not applied to the fuel pump when the support bracket is fitted.

5 Tighten the flange nuts of the fuel pump to 22 Nm (16 lbf ft) 2,2 kgf m. If access to the nuts is restricted by, for example, a compressor, use tool 21825964 to tighten the nuts.

Caution: *Do not release the nut (B6) 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 available to Perkins distributors.*

6 Put the fuel pump gear onto the hub of the fuel pump. The fasteners (B4) for the fuel pump gear should be in the centre of the slots to allow for the removal of the backlash. Tighten the setscrews finger tight.

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

7 Insert the timing pin (B5) through the hole (B3) of the fuel pump gear and the slot of the hub (B1) until it can be pushed fully into the hole (B2) in the body of the fuel pump. If the timing pin cannot be pushed into the pump body, check that the engine is correctly set at TDC on the number 1 cylinder, see Operation 8-1 or Operation 8-2.

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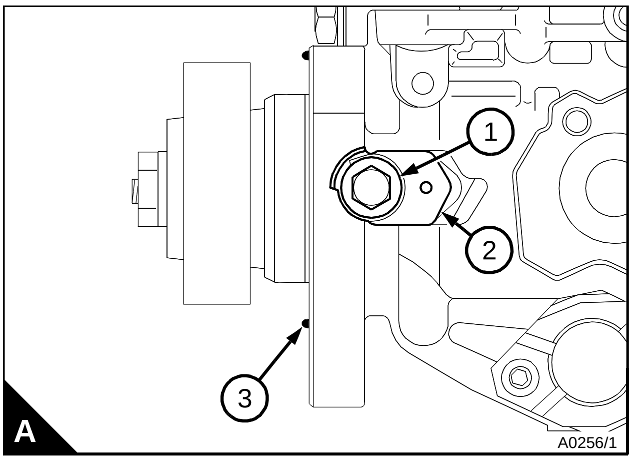
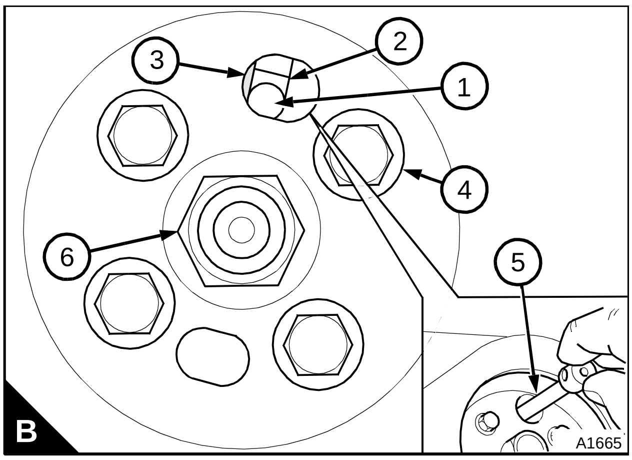




Caution: *The fuel pump gear must be fitted to the engine before the crankshaft is rotated.*

8 Carefully turn the gear counter-clockwise, by hand (C1), to remove the backlash between the idler gear and the fuel pump gear. Do not rotate the crankshaft or the fuel pump shaft. Tighten the setscrews for the fuel pump gear to 28 Nm (20 lbf ft) 2,8 kgf m.

Note: For engine models AP, AQ and AS with belt driven coolant pumps, either four tamper proof fasteners or one tamper proof fastener and three flanged setscrews are used to retain the fuel pump gear. All Torx screws are fitted with a special hardened flat washer. A special Torx socket part number 27610122 is needed to remove and to fit these tamper proof fasteners, refer to your Perkins distributor. All other engine models have four flanged setscrews to secure the gear.

9 Remove the timing pin.

10 Fit the gear cover to the cover of the timing case. For gear driven coolant pumps. Fit the coolant pump:

For early gear driven coolant pumps, see Operation 12-4.

For latest gear driven coolant pumps, see Operation 12-10.

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

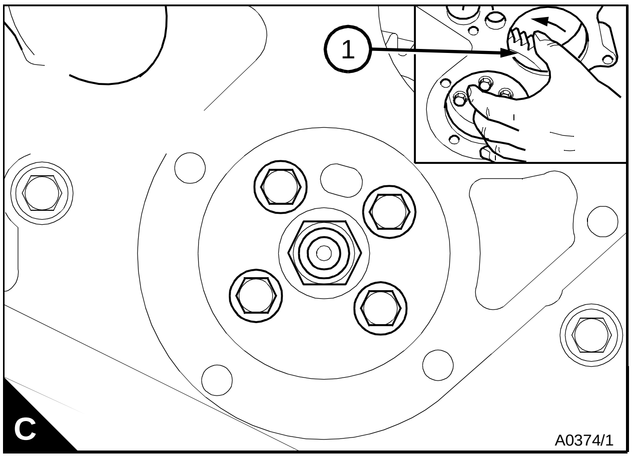
11 Fit all the pipes. Connect the stop control and the control rod of the fuel injection pump. Fit the cables and connection for the cold start device and electrical stop solenoid to the pump. Ensure that a spanner is used to prevent movement of the pump outlets when the high-pressure pipes are fitted and tighten the union nuts to 22 Nm (16 lbf ft) 2,2 kgf m.

12 Eliminate air from the fuel system, see Operation 11-20.

13 Fit the cylinder head rocker cover.

14 Connect the battery.

15 Operate the engine and check for leakage. With the engine at the normal temperature of operation, check that the idle speed and the maximum no-load speed are correct, see Operation 11-12.



To adjust **Operation 11-12**

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

The idle or maximum speed settings must not be changed by the engine operator, because this can damage the engine or the transmission.

The adjusting screws for the idle and maximum speed settings on later engines are tamper-proof, this is either by means of lockwire and a seal or by the fitting of tamper-proof caps. The lockwire and seal or the cap must be renewed after adjustment to the fuel pump. The tamper-proof caps are red.

The warranty of the engine can be affected if the seals on the fuel injection pump are broken during the warranty period by a person who is not approved by Perkins.

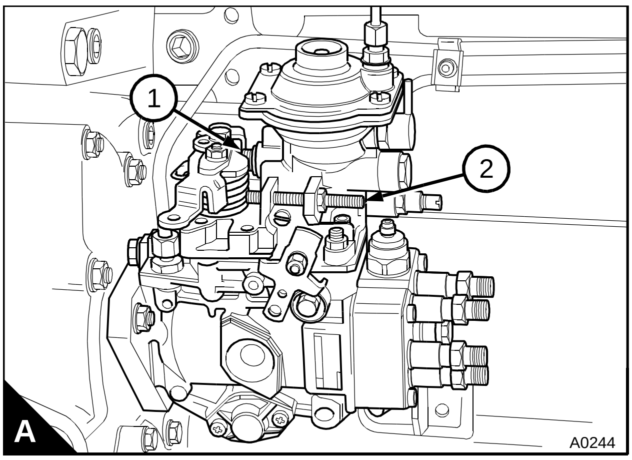
1 Remove any tamper-proof devices that are fitted to the adjustment screws.

2 Operate the engine until it reaches its normal temperature of operation and check the idle speed. If necessary, adjustment can be made by the inner adjustment screw (A1). Release the lock nut and rotate the adjustment screw clockwise to increase the speed, or counter-clockwise to decrease the speed. When the speed is correct, tighten the lock nut. The setting of the idle speed can change for different applications. Normally the correct speed will be given in the manufacturer's handbook for the application. If it is not given, refer to your nearest Perkins distributor.

Caution: *The setting for the maximum no load speed can change for different applications. For the correct maximum no-load speed, check the emissions data plate fitted to the left side of the cylinder block before any adjustment is made to the maximum no load speed.*

3 With the engine at its normal temperature of operation, check the maximum no load speed. A typical maximum no load speed is 2860 rev/min. If necessary, this speed can be adjusted by the outer adjustment screw (A2). Release the lock nut and rotate the adjustment screw counter-clockwise to increase the speed or clockwise to decrease the speed. When the speed is correct, tighten the lock nut and seal the screw.

Note: The person who adjusts the settings for the pump must ensure that the adjustment screws are suitably sealed against interference after it has been set initially.



Lucas/Delphi DP 200 Series fuel injection pump

General description

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

The manufacturer fits the hub (B2) to the pump to ensure very accurate timing. Engines that have this arrangement have the drive gear fastened to the hub instead of to the shaft of the pump.

The hub is permanently mounted onto the drive shaft by the pump manufacturer to allow the pump timing to be set accurately when the engine is in service.

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

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

Note: For engine models AP, AQ and AS with belt driven coolant pumps, either four tamper proof fasteners (A7) or one tamper proof fastener and three flanged setscrews are used to retain the fuel pump gear. All Torx screws are fitted with a special hardened flat washer. A special Torx socket part number 27610122 is needed to remove and to fit these tamper proof fasteners, refer to your Perkins distributor. All other engine models have four flanged setscrews to secure the gear.

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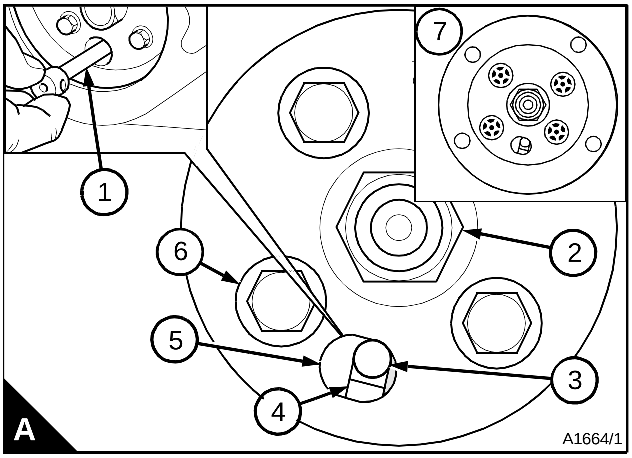
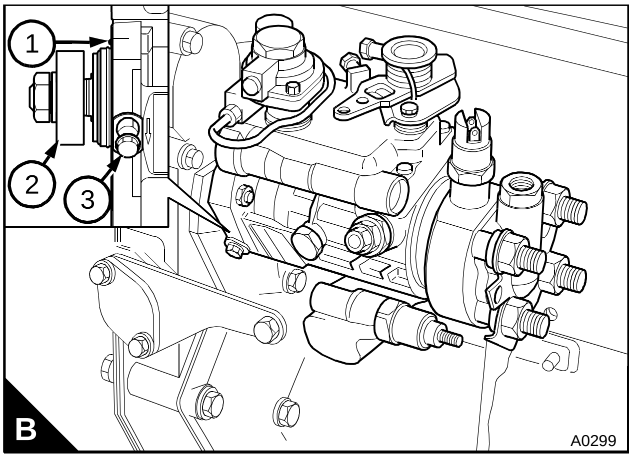
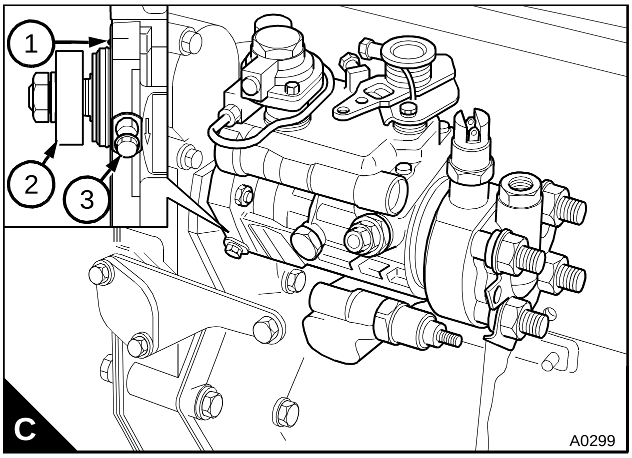


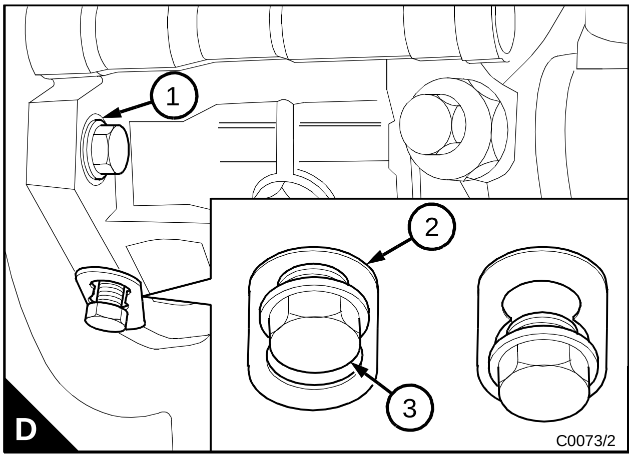


***Caution:** A new fuel injection pump may be supplied with the pump shaft in the locked position. The drive shaft of the pump must not be turned without the spacer (D2) in position under the locking screw (D3).*

The fuel injection pump has a locking screw (D3) and a spacer (D2). The locking screw prevents the rotation of the drive shaft.

An "O" ring (C1) 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**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Timing pin Lucas/Delphi fuel injection pumps	27610033	Torx socket	27610122

1 Disconnect the battery before the fuel injection pump is removed from the engine.

2 Set the engine to TDC on the number 1 cylinder on the compression stroke, see Operation 8-1 or Operation 8-2.

3 Remove the gear cover from the cover of the timing case. For gear driven coolant pumps: Remove the coolant pump:

For early gear driven coolant pumps, see Operation 12-4.

For latest gear driven coolant pumps, see Operation 12-9.

4 Insert the timing pin (B1) through the hole (B5) in the fuel pump gear and the slot of the hub (B4). Push the pin fully into the hole (B3) 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 when the union nut for each high-pressure pipe is released.*

5 Remove the pipes, the cables and the connections for the cold start device and the electrical stop solenoid from the fuel pump.

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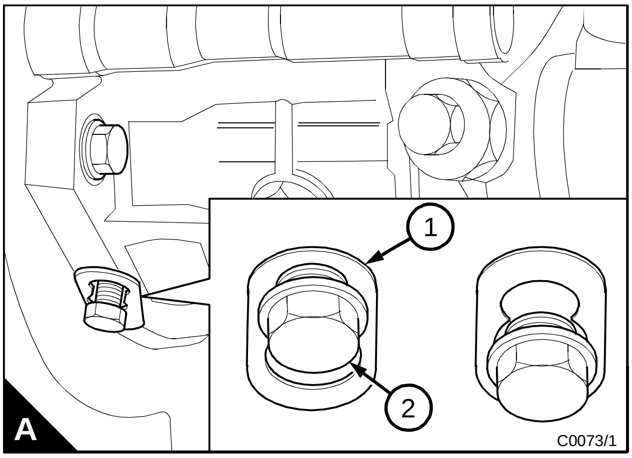
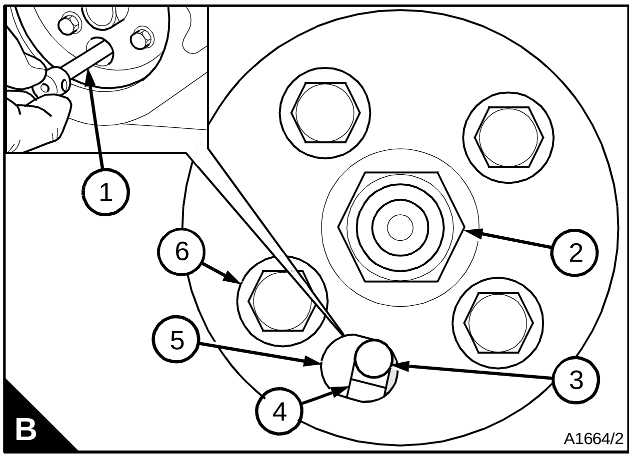




***Cautions*:**

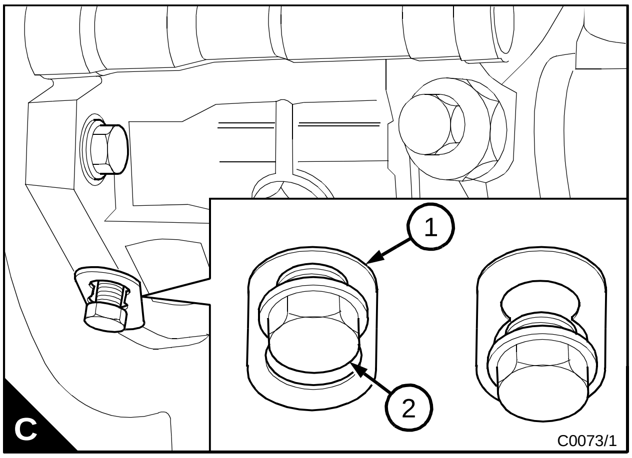
- *Do not rotate the crankshaft when the pump is not on the engine; the loose fuel pump gear may damage the timing case. If it is necessary to rotate the crankshaft, fit the fuel pump temporarily to ensure that the gear is in the correct position. If the fuel pump is fitted temporarily in order to rotate the crankshaft, the locking screw (C2) must be released and a spacer (C1) fitted.*
- *Do not release the nut (D2) from the fuel injection pump. The fuel pump hub is fitted to the shaft in the factory to ensure that the fuel pump is in the correct position for timing. If the hub is removed, the hub will need to be accurately fitted to the pump by use of special equipment available to Perkins distributors.*

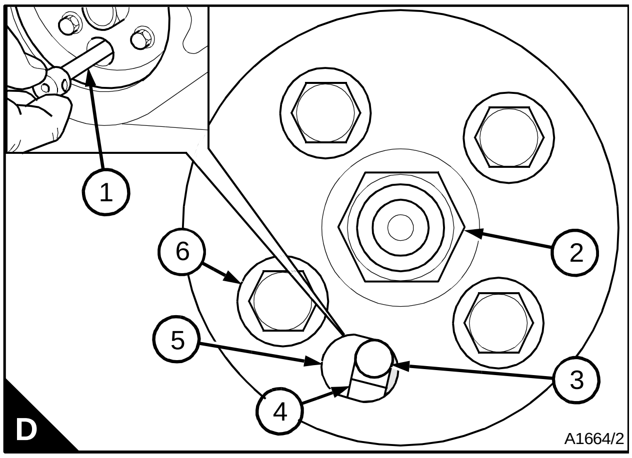
6 Remove the four fasteners (D6) and release the fuel pump gear from the hub of the fuel injection pump.

Note: For engines fitted with a belt driven coolant pump a special Torx socket will be required to remove the fuel pump gear fasteners.

7 If the pump has a support bracket, remove its retaining setscrew and nut.

8 Remove the nuts from the flange of the fuel pump and remove the pump.





To fit **Operation 11-14**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Timing pin Lucas/Delphi fuel injection pumps	27610033	Torx socket	27610122

***Cautions*:**

- *The engine must be set to TDC number 1 cylinder, compression stroke before the pump is fitted. If the crankshaft needs to be rotated, the pump must be fitted temporarily, or the loose gear could damage the timing case.*
- *A new fuel injection pump may be supplied with the pump shaft in the locked position. The drive shaft of the pump must not be turned without the spacer (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 Inspect the “O” ring (B1) in the pump flange and, if necessary, fit a new "O" ring.

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

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

4 Fit the setscrew and nut of the support bracket. Ensure that force is not applied to the fuel pump when the support bracket is fitted.

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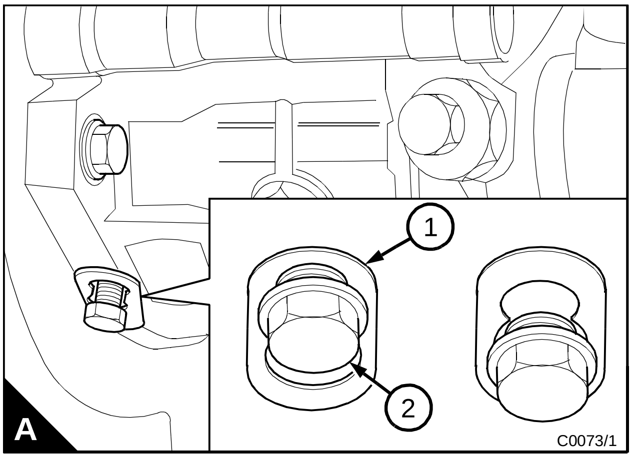

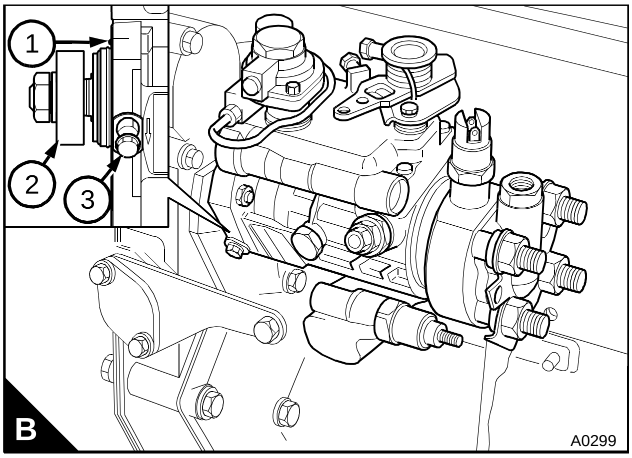

5 Tighten the flange nuts of the fuel pump to 22 Nm (16 lbf ft) 2,2 kgf m.

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

6 Put the fuel pump gear onto the hub of the fuel pump. The fasteners (C6) for the fuel pump gear should be in the centre of the slots to allow for the removal of the backlash. Tighten the setscrews finger tight.

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

7 Insert the timing pin (C1) through the hole (C5) of the fuel pump gear and the slot of the hub (C4) until it can be pushed fully into the hole (C3) in the body of the fuel pump. If the timing pin cannot be pushed into the pump body, check that the engine is correctly set at TDC on the number 1 cylinder, see Operation 8-1 or Operation 8-2.

Caution: *The fuel pump gear must be fitted to the engine before the crankshaft is rotated.*

8 Carefully turn the gear counter-clockwise, by hand (D1), to remove the backlash between the idler gear and the fuel pump gear. Do not rotate the crankshaft or the fuel pump shaft. Tighten the setscrews for the fuel pump gear to 28 Nm (20 lbf ft) 2,8 kgf m.

Note: For engine models AP, AQ and AS with belt driven coolant pumps, either four tamper proof fasteners or one tamper proof fastener and three flanged setscrews are used to retain the fuel pump gear. All Torx screws are fitted with a special hardened flat washer. A special Torx socket part number 27610122 is needed to remove and to fit these tamper proof fasteners, refer to your Perkins distributor. All other engine models have four flanged setscrews to secure the gear.

9 Remove the timing pin.

10 Fit the gear cover to the cover of the timing case. For gear driven coolant pumps. Fit the coolant pump:

For early gear driven coolant pumps, see Operation 12-4.

For latest gear driven coolant pumps, see Operation 12-10.

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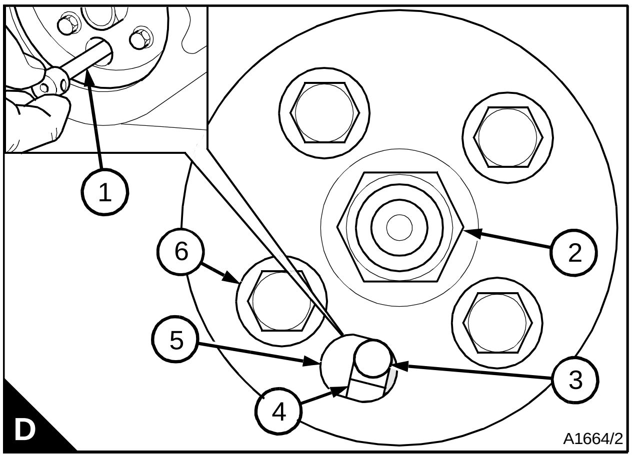
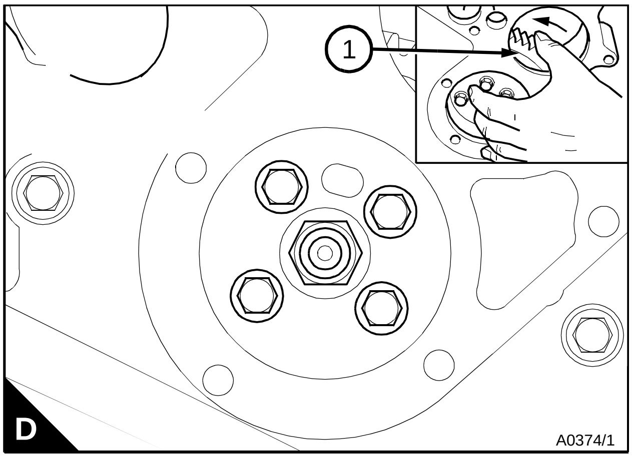




Caution: *Do not tighten the union nuts of the high-pressure pipes more than the recommended torque tension. If there is a leakage from the union nut, ensure that the pipe is correctly aligned with the atomiser inlet. Do not tighten the atomiser union nut more, as this can cause a restriction at the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

11 Fit all the pipes. Connect the control rod of the fuel injection pump. Fit the cables and connection for the cold start device and electrical stop solenoid to the pump. Ensure that a spanner is used to prevent movement of the pump outlets when the high-pressure pipes are fitted and tighten the union nuts to 22 Nm (16 lbf ft) 2,2 kgf m.

12 Eliminate air from the fuel system, see Operation 11-20.

13 Fit the cylinder head rocker cover.

14 Connect the battery.

15 Operate the engine and check for leakage. With the engine at the normal temperature of operation, check that the idle speed and the maximum no-load speed are correct, see Operation 11-15.

To adjust **Operation 11-15**

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

The idle or maximum speed settings must not be changed by the engine operator, because this can damage the engine or the transmission.

The adjusting screws for the idle and maximum speed settings on later engines are tamper-proof, this is either by means of lockwire and a seal or by the fitting of tamper-proof caps. The lockwire and seal or the cap must be renewed after adjustment to the fuel pump. Early tamper-proof caps are green, later tamper-proof caps are red.

The warranty of the engine can be affected if the seals on the fuel injection pump are broken during the warranty period by a person who is not approved by Perkins.

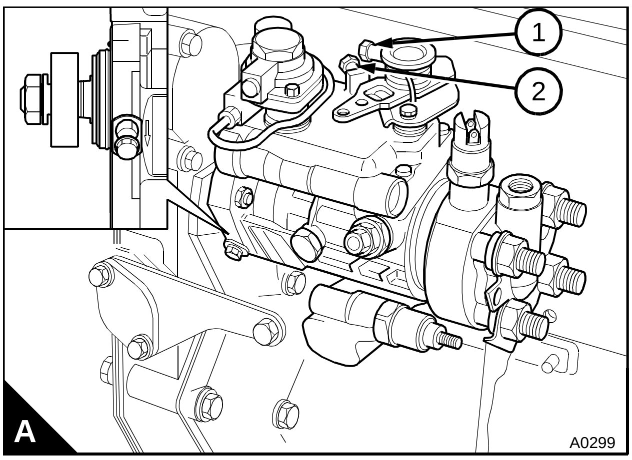
1 Remove any tamper-proof devices that are fitted to the adjustment screws.

2 Operate the engine until it reaches its normal temperature of operation and check the idle speed. If necessary, adjustment can be made by the inner adjustment screw (A1). Release the lock nut and rotate the adjustment screw clockwise to increase the speed, or counter-clockwise to decrease the speed. When the speed is correct, tighten the lock nut. The setting of the idle speed can change for different applications. Normally the correct speed will be given in the manufacturer’s handbook for the application. If it is not given, refer to your nearest Perkins distributor.

Caution: *The setting for the maximum no load speed can change for different applications. For the correct maximum no-load speed, check the emissions data plate fitted to the left side of the cylinder block before any adjustment is made to the maximum no load speed.*

3 With the engine at its normal temperature of operation, check the maximum no load speed. A typical maximum no load speed is 2860 rev/min. If necessary, this speed can be adjusted by the outer adjustment screw (A2). Release the lock nut and rotate the adjustment screw counter-clockwise to increase the speed or clockwise to decrease the speed. When the speed is correct, tighten the lock nut and seal the screw.

Note: The person who adjusts the settings for the pump must ensure that the adjustment screws are suitably sealed against interference after it has been set initially.



Electrical shut off solenoid (ESOS) **Operation 11-16**

General description

A new Junior Power Timer (JPT) ESOS was introduced to all new engines fitted with Lucas/Delphi fuel injection pumps. A conversion kit is available to enable the new (JPT) ESOS male connector (A1) to be connected to the Twin Lucar terminals (A4) on the wiring loom. The parts kit consists of a female adaptor (A2) with two male Lucar terminals (A3).

To fit the conversion kit

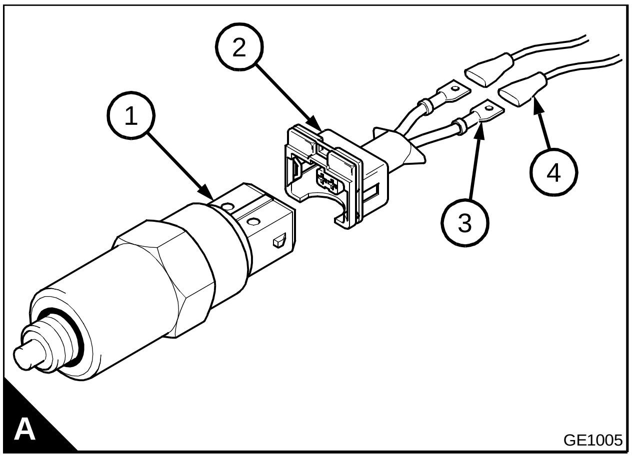
1 Align and fit the female adaptor (A2) on the male connector (A1). Ensure that the two components are fully engaged.

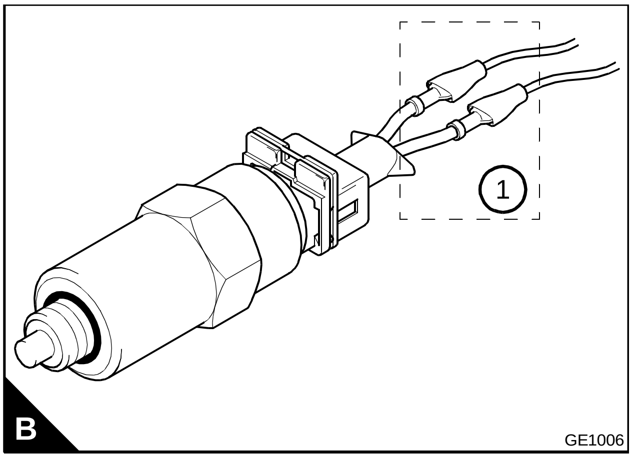
2 Insert the male Lucar terminals (A3) on the adaptor into the insulated female Lucar terminals (A4) on the wiring loom. Ensure that both components are fully engaged.

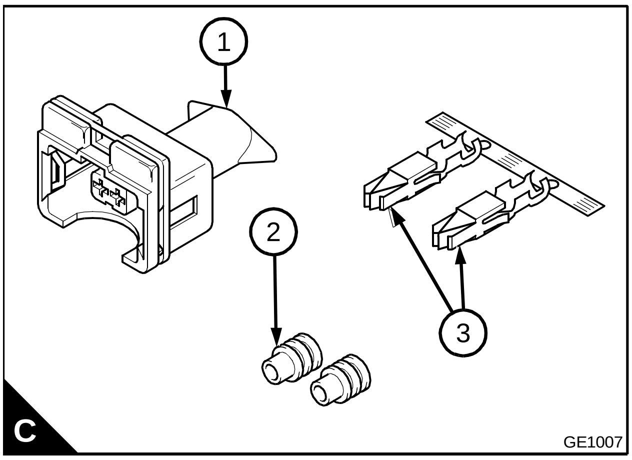
Caution: *This connection (B1) is compatible with IP67 waterproofing standards.*

Wiring loom modification

To ensure that the connection from the new ESOS to the wiring loom is compatible with IP67 water proofing standards, the twin Lucar terminals must be removed and a JPT adaptor kit fitted. The adaptor kit consists of a female JPT adaptor (C1), two cable seals (C2) and two metal terminals (C3).







To fit the adaptor kit

1 With a suitable tool, cut the cables near to the Lucar terminals and remove them from the wiring loom.

2 Remove 4,0 mm (0.17 in) of insulation from the ends of the two cables (D2) and put the cable seals (D4) on to each cable, the narrow end (D3) towards the 4 mm strip.

3 Insert the first cable into the terminal so that the bare wire (D2) is within the clamp (D1).

4 With a suitable tool, close the clamps (D1) until the bare wire is secure. Heat the terminal with a soldering iron and apply solder to the joint (E1). When the joint is cool, push the cable seal (E2) until the narrow end of the cable seal (E3) is within the clamp (E4). With a suitable tool close the clamp until the cable seal is secure.

5 Repeat sequence 3 and 4 for the second cable.

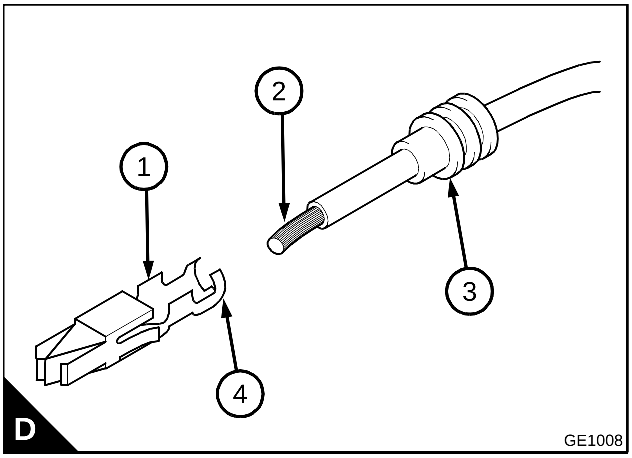
6 Put the adaptor (F2) on a flat surface with the spring clip (F1) at the top. Rotate the terminal, cable and cable seal so that the location tags (F4) on the terminal are at the top and the bottom.

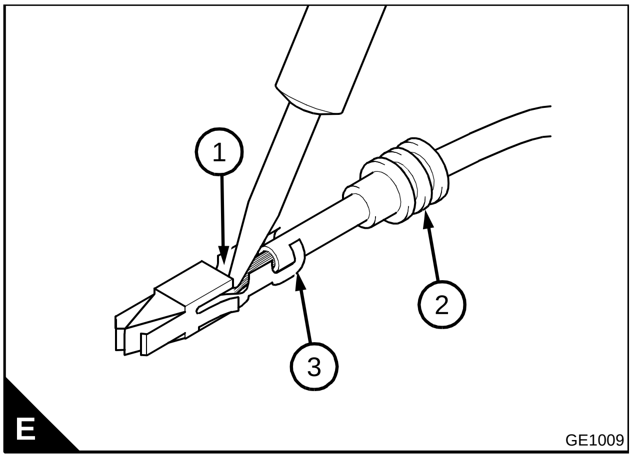
7 Insert the cable asseF3).

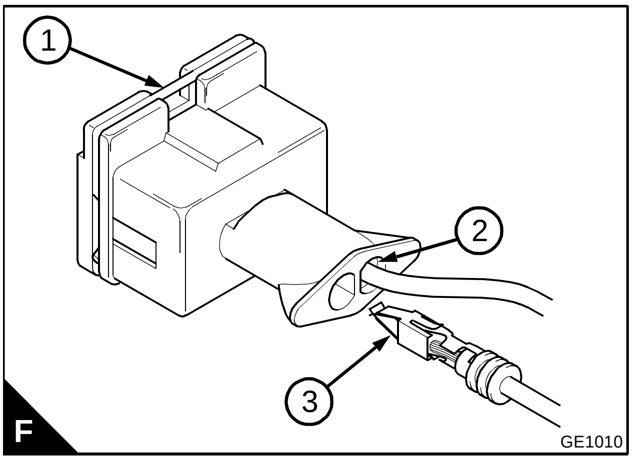
8 Repeat the process for the second cable.

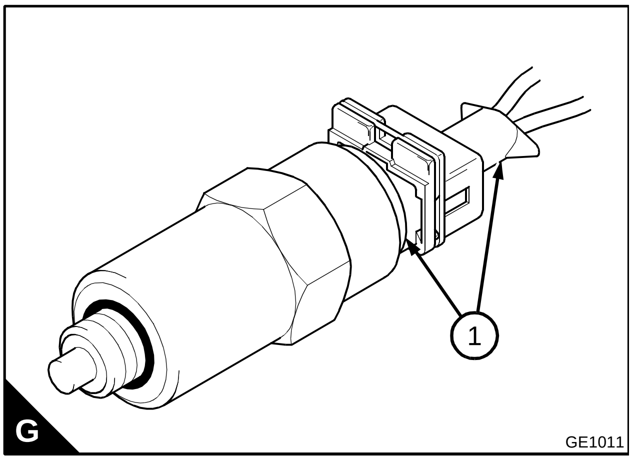
Notes:

- The modified wiring loom used with the (JPT) ESOS (G1) is compatible with IP67 Waterproofing Standards.
- If your current 24V wiring system uses a 12V (JPT) ESOS and an in-line ballast resistor, it is recommended that a 16 Ohm 50W ballast resistor is fitted.









Stanadyne fuel injection pump

General description

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

The manufacturer fits the hub (B3) to the pump to ensure very accurate timing. Engines that have this arrangement have the drive gear fastened to the hub instead of to the shaft of the pump.

The hub (B3) is permanently mounted onto drive shaft by the pump manufacturer to allow the pump timing to be set accurately when the engine is in service.

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

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

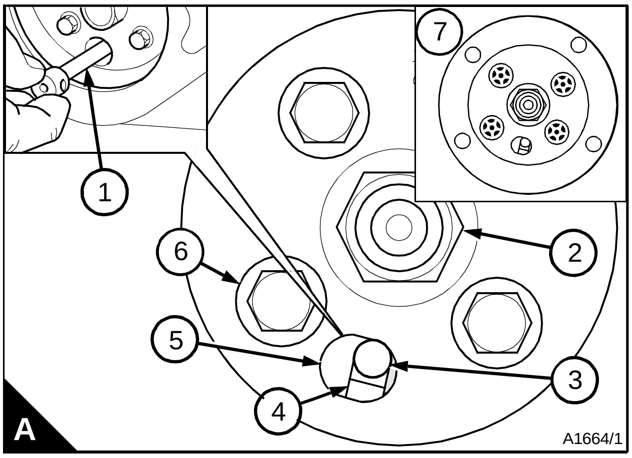
Note: For engine models AP, AQ and AS with belt driven coolant pumps, either four tamper proof fasteners (A7) or one tamper proof fastener and three flanged setscrews are used to retain the fuel pump gear. All Torx screws are fitted with a special hardened flat washer. A special Torx socket part number 27610122 is needed to remove and to fit these tamper proof fasteners, refer to your Perkins distributor. All other engine models have four flanged setscrews to secure the gear.

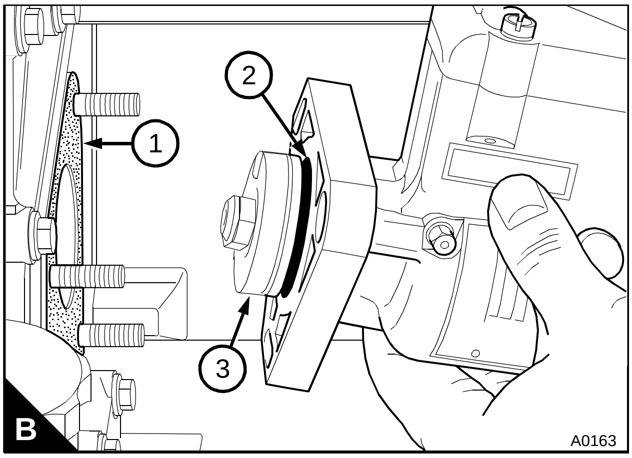
The fuel injection pump is sealed to the timing case by a joint (B1) and an “O” ring (B2) that is fitted to the fuel pump housing.

Note: DB4 fuel pumps are fitted with a rubber seal which has a square shape instead of an "O" ring. When a rubber seal is fitted it is not necessary to fit a joint.

A requirement of emissions legislation is that access to adjustments that affect the engine’s exhaust emissions is limited to personnel approved by Perkins. The adjustment screw for the high idle speed, is sealed by the manufacturer. The setting must not be changed, unless approved, as it could affect the warranty of the engine.

Note: The person who adjusts the pump must ensure that the adjustment screw is suitably sealed against interference after the adjustment.





Stanadyne Data plates

In order to match engine performance to a wide range of applications, two extra data plates (C1) and (D1) have been fitted onto the pump housing flange of Stanadyne fuel injection pumps. The data plates are used to identify pumps after a minor modification to alter the pump and/or the engine performance.

Note: Stanadyne and Perkins must give authority for all modifications.

Information added to the data plates will supersede the information found on the standard Stanadyne pump data plate (C2). It is important that details added to these plates are correct in order to provide accurate calibration and service in the future.

Permitted modifications and the correct use of the two types of data plates is as follows:

Engine speed modifications to range pumps (without component changes)

"Range Pumps" is a name that Perkins uses for pumps that can be fitted to those applications which are specifically designed to operate at various high idle speeds. Modifications to these pumps are limited to high idle speed adjustments, and do not include governor spring or other component changes. The high idle speeds are listed in the "Special Notes" section of the Stanadyne specification sheet. Stanadyne will normally calibrate these pumps at the highest optional speed.

Perkins fastens a data plate (C1) to all “Range Pump” models, even if no change has been made to the original Stanadyne calibration, since the engines on which they are installed do not have a single specific speed rating.

If Perkins changes the high idle speed of an application, the new high idle speed will be added to the modification data plate (C1). The data plate also has space to record one "In Service" high idle reset by a Perkins approved distributor or O.E.M. customer. Since this is an acceptable modification in accordance with the Stanadyne specification sheet, there will be no change to either the Perkins customer part number or the Stanadyne pump model number.

If it is necessary for Perkins to change the high idle speed on an application, but it is not an acceptable modification in accordance with the Stanadyne specification sheet, the change must be approved by Stanadyne and Perkins. If the new high idle speed rating is approved, it will be etched on the modification data plate and the information will be added to the "Special notes" section of the Stanadyne specification sheet.

Engine speed modifications to range pumps (with component changes)

Some engine speed changes need a different governor spring. This occurs when a reduction in the engine high idle speed does not allow the governor to operate correctly with the original governor spring. This change does not need a new Stanadyne model number, but will need a new Perkins customer part number. The new part number will be etched onto the data plate (D1) that Perkins will fasten to the side of the pump mounting flange. The new Perkins customer part number and the conversion information (spring part number) will be listed in the "Special notes" section of the Stanadyne specification sheet.

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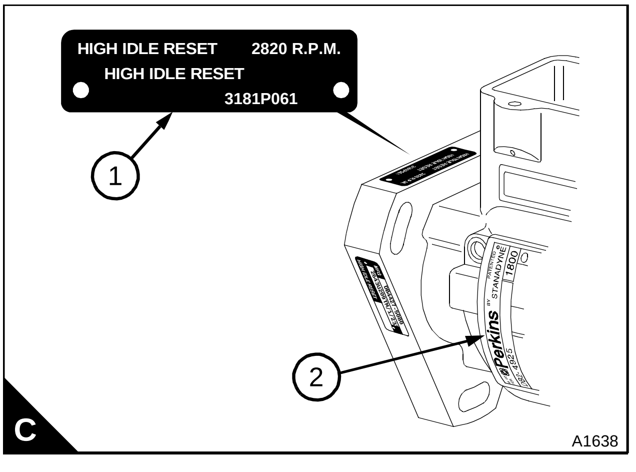
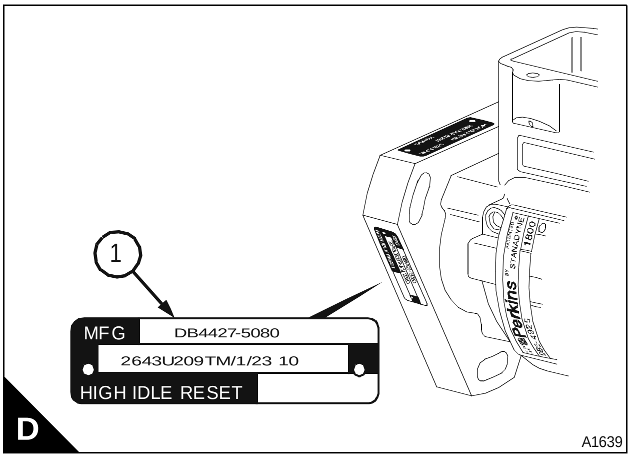




Pump conversions

Pump conversions that change a pump from one Stanadyne number to another will need both a new Stanadyne number and a new Perkins customer part number. These conversions need major pump component changes or calibration changes and should only be done when a Stanadyne specification suitable for conversion is available.

When the conversions of this type are made in the Perkins factory the original Stanadyne data plate will remain in position. A modification data plate (E1), etched with the new Perkins customer part number, the new Stanadyne model number, and the high idle speed will be fitted.

If an approved Stanadyne service distributor make this type of conversion, they will fit a new Stanadyne data plate. The new data plate will show a new Stanadyne model number, a new Perkins customer part number and the original pump serial number and data code. When this occurs, modification data plates fitted by Perkins should be removed.

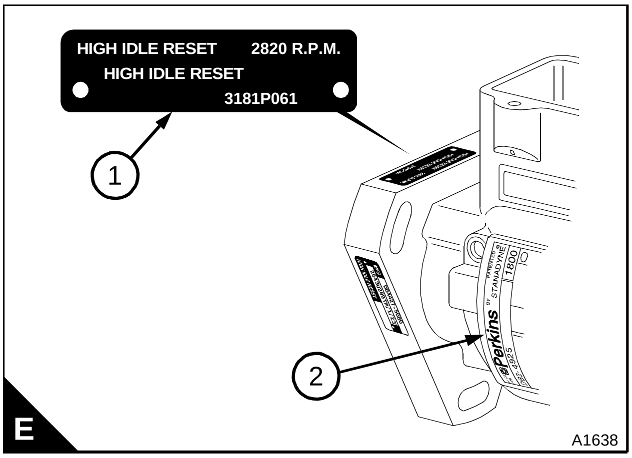
Warranty

Pump modifications or conversions done by Perkins and “Range Pumps” which have their high idle reset by approved Perkins distributors or O.E.M. customers are protected by Stanadyne’s warranty in accordance with the Stanadyne Service Policies and Procedures Manual. Any failures which occur as a direct result of the Perkins conversion is not protected by the Stanadyne warranty, for example: pump modifications and conversions.

Electric shut off solenoid (E.S.O.S) changes

Perkins has the option to change the electric shut off solenoid to conform with the voltage or shut off requirements of an application.

Perkins can change the voltage of operation from 12V to 24V or from 24V to 12V DC or from “Energised - Run” (ETR) to “Energised - Shut off” (ETOS). A new Perkins customer part number for the pump must be etched on the modification data plate shown in (E1). An E.S.O.S change will not normally need a new Stanadyne model number, therefore the new Perkins customer part number will be added to the “Special notes”, section of the Stanadyne pump specification together with the identification of the new solenoid.



To remove **Operation 11-17**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Timing pin Stanadyne fuel injection pumps	27610033	Torx socket	27610122

1 Disconnect the battery before the fuel injection pump is removed from the engine.

2 Set the engine to TDC on the number 1 cylinder on the compression stroke, see Operation 8-1 or Operation 8-2.

3 Remove the gear cover from the cover of the timing case. For gear driven coolant pumps. Remove the coolant pump:

For early gear driven coolant pumps, see Operation 12-4.

For latest gear driven coolant pumps, see Operation 12-9.

4 Insert the timing pin (A1) through the hole (A5) in the fuel pump gear and the slot of the hub (A4). Push the pin fully into the hole (A3) 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 when the union nut for each high-pressure pipe is released.*

5 Remove the pipes, the cables and the connections for the cold start device (B2) and the electrical stop solenoid (B1) from the fuel pump.

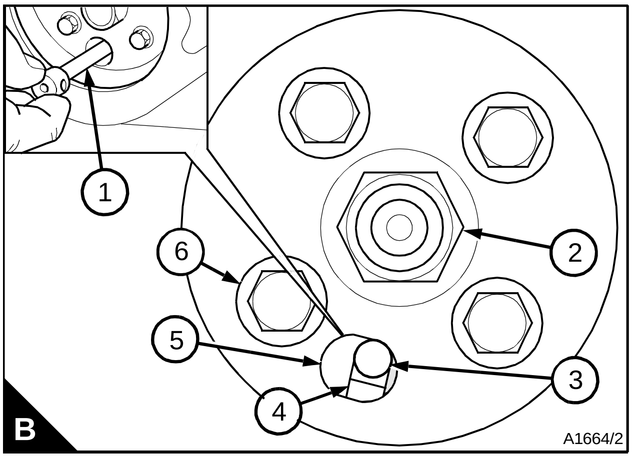
***Cautions*:**

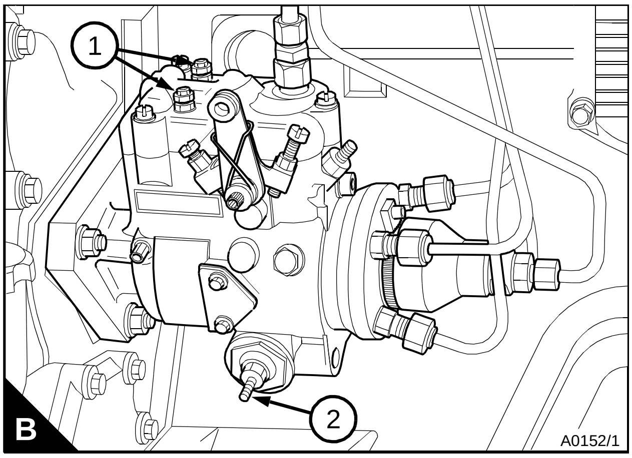
- *Do not rotate the crankshaft when the pump is not on the engine; the loose fuel pump gear may damage the timing case. If it is necessary to rotate the crankshaft, fit the fuel pump temporarily to ensure that the gear is in the correct position. If the fuel pump is fitted temporarily in order to rotate the crankshaft.*
- *Do not release 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 removed, the hub will need to be accurately fitted to the pump by use of special equipment available to Perkins distributors.*

6 Remove the four fasteners (A6) and release the fuel pump gear from the hub of the fuel injection pump.

Note: For engines fitted with a belt driven coolant pump a special Torx socket will be required to remove the fuel pump gear fasteners.

7 Remove the nuts from the flange of the fuel pump and remove the pump.





To fit **Operation 11-18**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Timing pin Stanadyne fuel injection pumps	27610033	Torx socket	27610122

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

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

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

3 Put the fuel pump in to position on the three studs and fit the flange nuts.

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

Caution: *Do not remove the nut (B2) from the shaft of the fuel injection pump. The fuel pump hub is fitted to the shaft in the factory to ensure that the fuel pump is in the correct position for timing. If the hub is removed, the hub will need to be accurately fitted to the pump by use of special equipment available to Perkins distributors.*

5 Put the fuel pump gear onto the hub of the fuel pump. The fasteners (B6) for the fuel pump gear should be in the centre of the slots to allow for the removal of the backlash. Tighten the setscrews finger tight.

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

6 Insert the timing pin (B1) through the hole (B5) of the fuel pump gear and the slot of the hub (B4) until it can be pushed fully into the hole (B3) in the body of the fuel pump. If the timing pin cannot be pushed into the pump body, check that the engine is correctly set at TDC on the number 1 cylinder, see Operation 8-1 or Operation 8-2.

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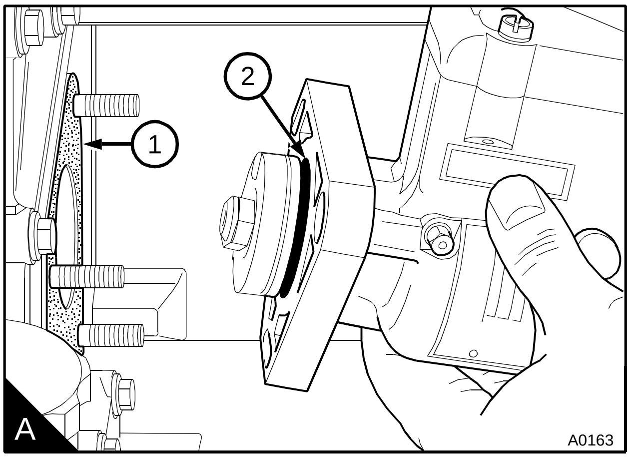
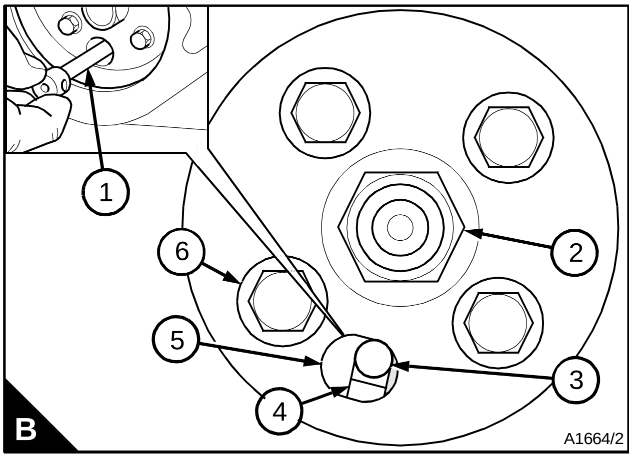




***Caution:** The fuel pump gear must be fitted to the engine before the crankshaft is rotated.*

7 Carefully turn the gear counter-clockwise, by hand (C1), to remove the backlash between the idler gear and the fuel pump gear. Do not rotate the crankshaft or the fuel pump shaft. Tighten the setscrews for the fuel pump gear to 28 Nm (20 lbf ft) 2,8 kgf m.

Note: For engine models AP, AQ and AS with belt driven coolant pumps, either four tamper proof fasteners or one tamper proof fastener and three flanged setscrews are used to retain the fuel pump gear. All Torx screws are fitted with a special hardened flat washer. A special Torx socket part number 27610122 is needed to remove and to fit these tamper proof fasteners, refer to your Perkins distributor. All other engine models have four flanged setscrews to secure the gear.

8 Remove the timing pin.

9 Fit the gear cover to the cover of the timing case. For gear driven coolant pumps. Fit the coolant pump:

For early gear driven coolant pumps, see Operation 12-4.

For latest gear driven coolant pumps, see Operation 12-10.

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

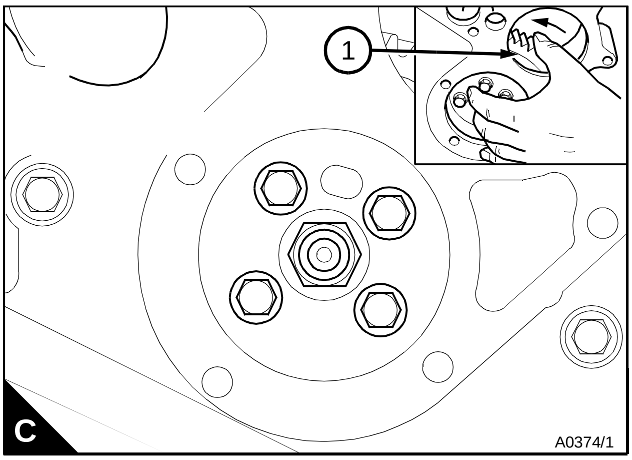
10 Fit all the pipes. Connect the control rod of the fuel injection pump. Fit the cables and connection for the cold start device and electrical stop solenoid to the pump. Ensure that a spanner is used to prevent movement of the pump outlets when the high-pressure pipes are fitted and tighten the union nuts to 22 Nm (16 lbf ft) 2,2 kgf m.

11 Eliminate air from the fuel system, see Operation 11-20.

12 Fit the cylinder head rocker cover.

13 Connect the battery.

14 Operate the engine and check for leakage. With the engine at the normal temperature of operation, check that the idle speed and the maximum no-load speed are correct, see Operation 11-19.



To adjust **Operation 11-19**

Special requirements

Special tools	
Description	**Part number**
Idle adjustment locknut wrench	27610145
Torque screw locknut wrench	27610144

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

The idle or maximum speed settings must not be changed by the engine operator, because this can damage the engine or the transmission.

The adjusting screws for the idle and maximum speed settings on later engines are tamper-proof, this is either by means of lockwire and a seal or by the fitting of tamper-proof caps. The lockwire and seal or the cap must be renewed after adjustment to the fuel pump. Early tamper-proof caps are green, later tamper-proof caps are red.

The warranty of the engine can be affected if the seals on the fuel injection pump are broken during the warranty period by a person who is not approved by Perkins.

The latest fuel injection pumps have a mechanism (B) that consists of a sleeve (B5), an adjustment screw (B4) and a locknut (B3), these are for the adjustment of the idle speed and the maximum no-load speed.

Special tools (B1) and (B2) available at your Perkins distributor, are needed to adjust the idle or maximum speed settings on later engines.

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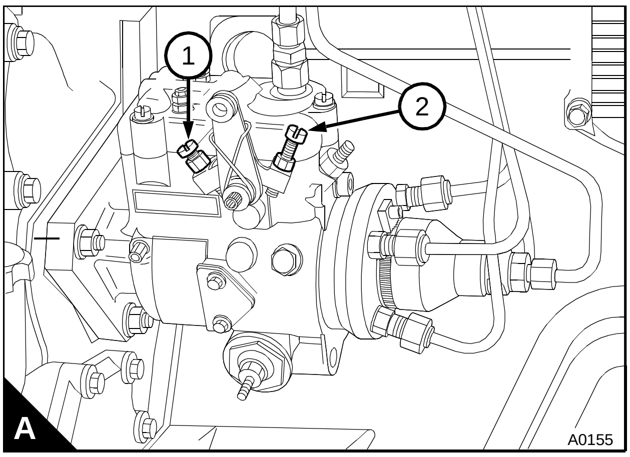

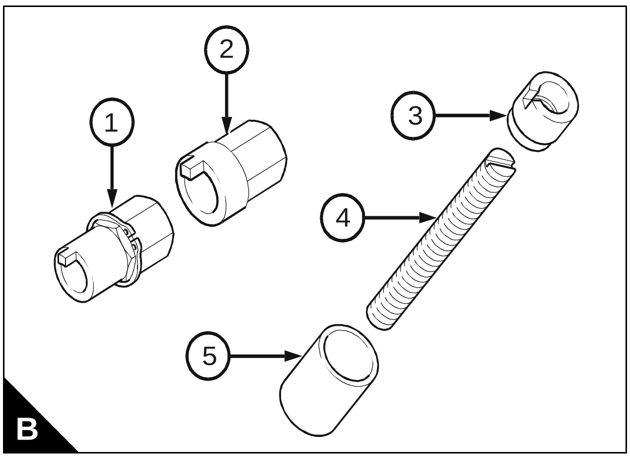

To adjust (early engines)

1 Remove any tamper-proof devices that are fitted to the adjustment screws.

2 Operate the engine until it reaches its normal temperature of operation and check the idle speed. If necessary, adjustment can be made by the inner adjustment screw (C1). Release the lock nut and rotate the adjustment screw clockwise to increase the speed, or counter-clockwise to decrease the speed. When the speed is correct, tighten the lock nut. The setting of the idle speed can change for different applications. Normally the correct speed will be given in the manufacturer's handbook for the application. If it is not given, refer to your nearest Perkins distributor.

Caution: *The setting for the maximum no load speed can change for different applications. For the correct maximum no-load speed, check the emissions data plate fitted to the left side of the cylinder block before any adjustment is made to the maximum no load speed.*

3 With the engine at its normal temperature of operation, check the maximum no load speed. A typical maximum no load speed is 2860 rev/min. If necessary, this speed can be adjusted by the outer adjustment screw (C2). Release the lock nut and rotate the adjustment screw counter-clockwise to increase the speed or clockwise to decrease the speed. When the speed is correct, tighten the lock nut and seal the screw.

Note: The person who adjusts the settings for the pump must ensure that the adjustment screws are suitably sealed against interference after it has been set initially.

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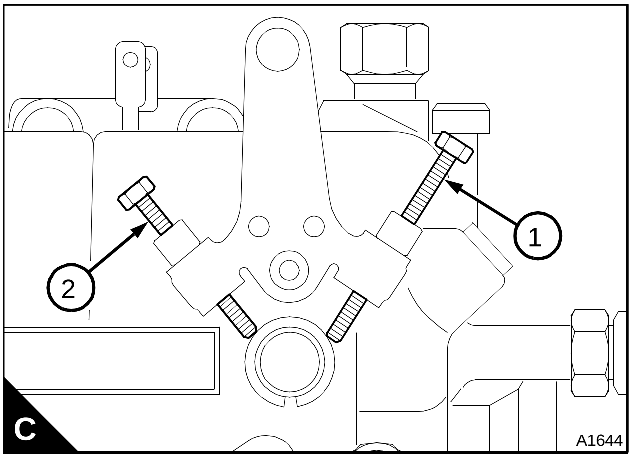


To adjust (later engines)

1 Operate the engine until it reaches its normal temperature of operation and check the idle speed. If necessary, adjustment can be made by the adjustment screw (E1).

2 Fit the tool (D2) part number 27610145 into the sleeve on the pump (D5) so that it engages in the slot in the locknut (D3).

3 Put a screwdriver into the tool so that it engages in the slot in the adjustment screw (E). Put a spanner onto the hexagon of the tool.

4 Hold the adjustment screw (D4) with the screwdriver and use the spanner to loosen the locknut.

5 Use the screwdriver to rotate the adjustment screw until the engine runs at the correct speed.

6 Hold the adjustment screw with the screwdriver and use the spanner to tighten the locknut.

7 Remove the screwdriver, the spanner and the tool.

The setting of the idle speed can change for different applications. Normally the correct speed will be given in the manufacturer's handbook for the application. If it is not given, refer to your nearest Perkins distributor.

Caution: *The setting for the maximum no load speed can change for different applications. For the correct maximum no-load speed, check the emissions data plate fitted to the left side of the cylinder block before any adjustment is made to the maximum no load speed.*

8 With the engine at its normal temperature of operation, check the maximum no-load speed. A typical maximum no-load speed is 2860 rev/min. If necessary, this speed can be adjusted by the adjustment screw (E2).

9 Fit the tool (D1) part number 27610144 into the sleeve on the pump (D5) so that it engages in the slot in the locknut (D3).

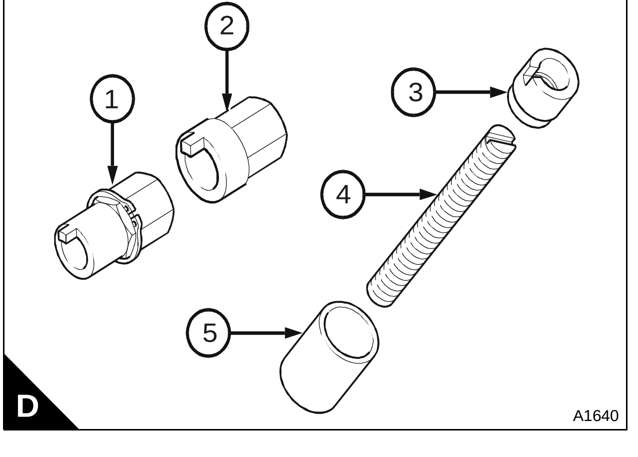
10 Put a screwdriver into the tool so that it engages in the slot in the adjustment screw (E). Put a spanner onto the hexagon of the tool.

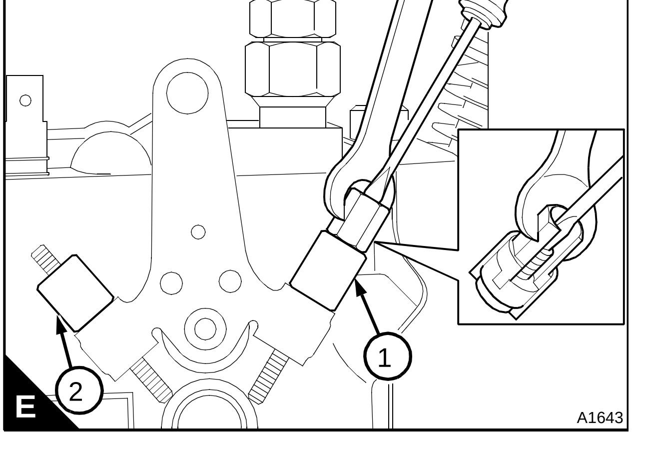
11 Hold the adjustment screw (D4) with the screwdriver and use the spanner to loosen the locknut.

12 Use the screwdriver to rotate the adjustment screw until the engine runs at the correct speed.

13 Hold the adjustment screw with the screwdriver and use the spanner to tighten the locknut.

14 Remove the screwdriver, the spanner and the tool.





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.

To eliminate air from the fuel system **Operation 11-20**

Warnings!

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

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

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

1 Loosen the vent plug, (A1) (C1) or the banjo bolt on the filter head (B1). If a separate pre-fuel filter is fitted, air must be eliminated from this filter first using the same procedure as described for the main fuel filter.

2 Operate the priming lever of the fuel lift pump (D) until fuel, free from air, comes from the vent plug or the banjo bolt. Tighten the vent plug or the banjo bolt.

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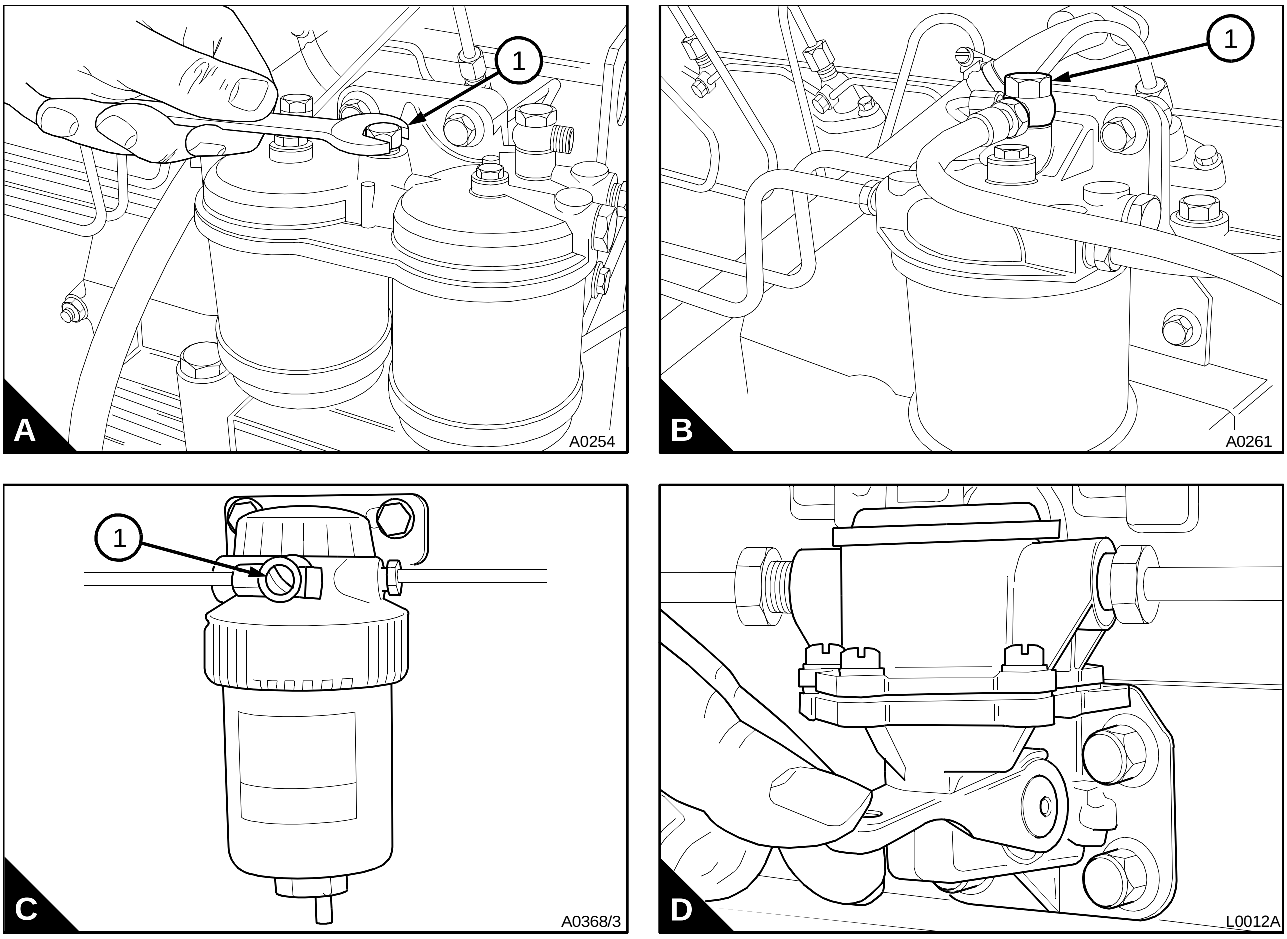

Note: If the drive cam of the fuel lift pump is at the point of maximum lift, it will not be possible to operate the priming lever. In this situation, the crankshaft must be rotated one revolution.

Caution: *Use a spanner to prevent movement of the fuelled starting aid (E1) when the union nut (E2) is loosened or tightened.*

3 Loosen the union nut (E2) at the fuelled starting aid and operate the priming lever of the fuel lift pump until fuel, free of air, comes from the connection. Tighten the union nut at the starting aid.

4 Loosen the fuel pipe union at the fuel injection pump return outlet connection to the fuel filter. Operate the priming lever of the fuel lift pump (F) until fuel, free from air, comes from the fuel injection pump union. Tighten the union.

5 Loosen the high-pressure connections at two of the atomisers (G1).

Warning! *When the starter motor is operated to eliminate air from the high pressure pipes, the engine may run.*

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

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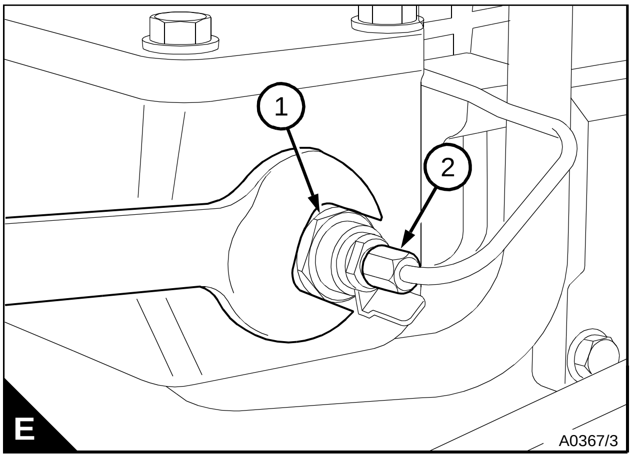
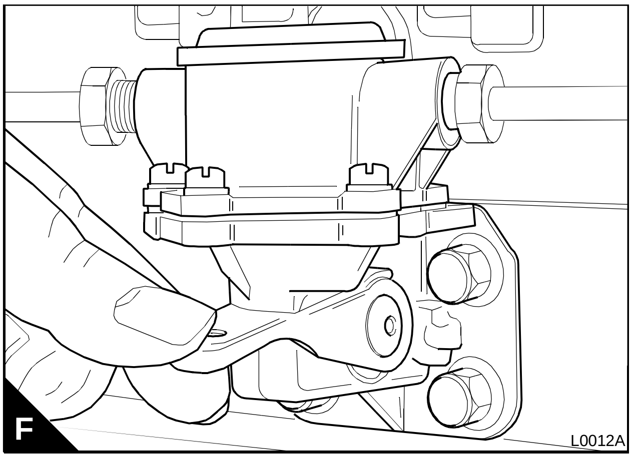
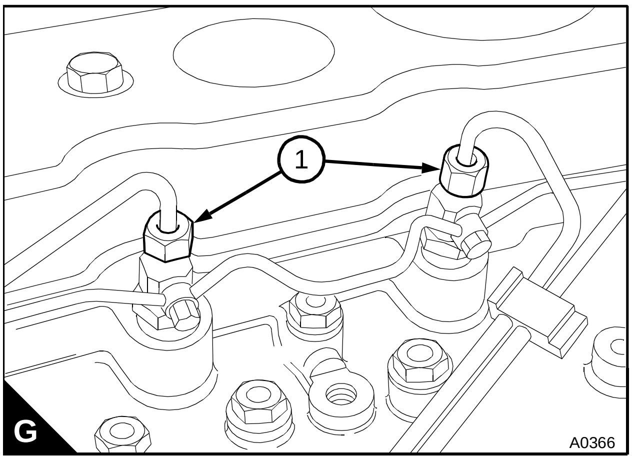






6 Put the electrical system switch to the "ON" position. Ensure that the manual stop control, if one is fitted, is in the "RUN" position. Operate the starter motor until fuel, free from air, comes from the pipe connections. Tighten the high-pressure pipe connections to 22 Nm (16 lbf ft) 2,2 kgf m. Return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

7 The engine is now ready to start.

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

If the engine runs correctly for a short time and then stops or runs roughly, check for air in the fuel system. If there is air in the fuel system, there is probably a leakage in the low pressure system.

12

Cooling system

General description

Coolant from the bottom of the radiator passes through the centrifugal coolant pump, which is fitted onto the front of the timing case to assist the flow of the coolant through the system.

The pump is normally gear driven from the gear of the fuel injection pump. On certain four cylinder applications the pump is driven by a "V" belt from the crankshaft pulley. Some engines are fitted with a belt driven coolant pump in a high position, these are identified by the thermostat housing which is part of the pump rear body. The rear body of these pumps has a connection to a coolant transfer plate, which allows coolant from the pump impeller to pass into the cylinder block.

Two types oil cooler are available for use on four cylinder engines: An integral oil cooler which is fitted to the left side of the cylinder block or a separate (cassette type cooler) fitted to the filter head.

The integral oil cooler has an aluminium cover with plate element and is fitted to the left side of the cylinder block.

The latest integral oil coolers for 6 cylinder engines have a pressed steel cover.

Four cylinder engines

From the pump, the coolant passes through a passage in the timing case to the water jacket in the left side of the cylinder block. Coolant pumps driven by a "V" belt do not pass the coolant through a passage in the timing case but direct to the front 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.

Some four cylinder engines have a cassette type oil cooler fitted between the oil filter canister and the oil filter head. If the cassette oil cooler is fitted on the left side of the engine, coolant from the by-pass connection at the rear of the coolant pump passes through a pipe to the oil cooler. If the cassette oil cooler is fitted to the right side of the engine, a pipe is connected between the thermostat housing and the oil cooler. The coolant passes around the plates of the cooler and passes through a pipe to 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.

Some engines are fitted with two thermostats.

Six cylinder engines

On six cylinder engines the coolant divides as it enters the cylinder block. Most of the coolant passes along the right hand side of the cylinder block and around the outside of the cylinders to the rear of the cylinder block.

The remainder of the coolant passes along a passage on the left hand side of the cylinder block to the lubricating oil cooler.

The coolant flows around the element of the lubricating oil cooler to the rear of the cylinder block. The coolant then passes to the rear of the cylinder head.

Coolant passes forward through the cylinder head and into the thermostat housing. These engines have one thermostat. If the thermostat is closed, the coolant goes, through a by-pass, directly to the inlet side of the coolant pump. If the thermostat is open, the coolant passes to the top of the radiator.

Some engines are fitted with two thermostats.

Thermostats

To remove **Operation 12-1**

Most engines are fitted with a single thermostat (A), some engines have twin thermostats fitted (B) Identification of the thermostat is by the nominal temperature which is stamped on the by-pass valve (A6) of the thermostat.

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.

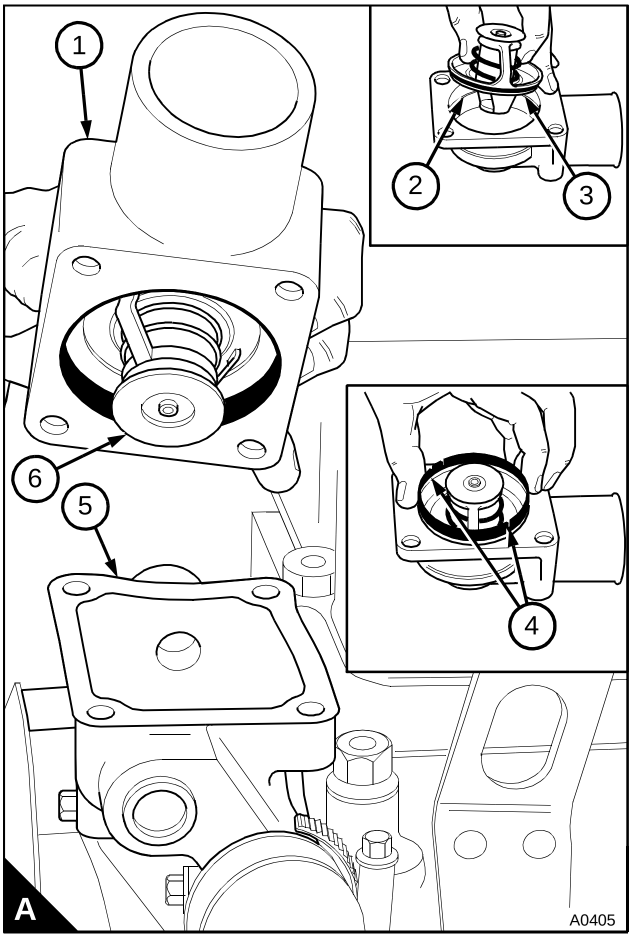
2 Release the four setscrews and remove the thermostat housing (A1) from the lower body. Discard the joint (A5).

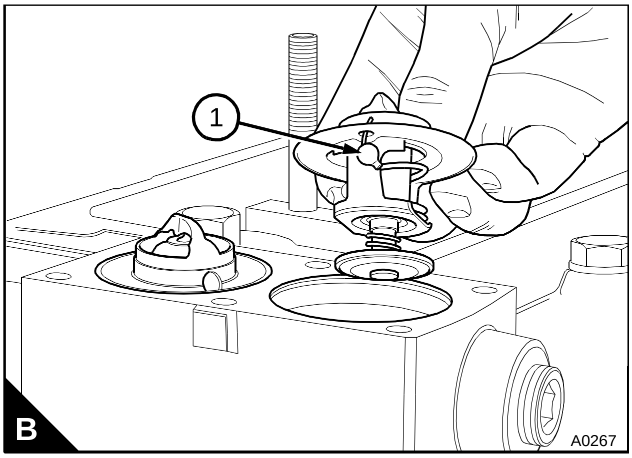
Note: Engines with a plastic thermostat housing have an “O” ring fitted to the flange face of the housing instead of a joint.

3 Press the retainer clips (A4) away from the groove in the thermostat body, and lift the plastic collar from the thermostat housing. If the retainer clips are damaged or the collar is loose discard and renew the plastic collar.

Caution: *It is important that the correct collar is fitted.*

4 Remove the thermostat and "O" ring assembly (A3) from the thermostat housing. Discard the "O" ring.





To fit

Operation 12-2

1 Clean the thermostat housing. Ensure that the groove (A2) for the clip retainers and the seat for the "O" ring are free of debris.

2 Ensure that the joint faces of the thermostat housing and the lower body are clean and that the jiggle pin (B1) in the thermostat is free to move.

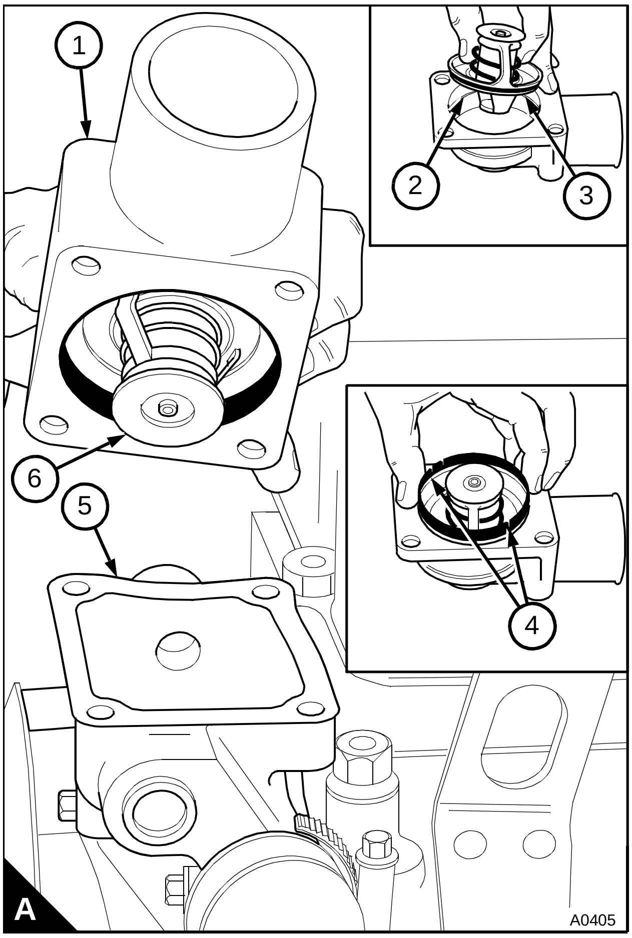
3 Renew the "O" ring and put the thermostat in position in the housing.

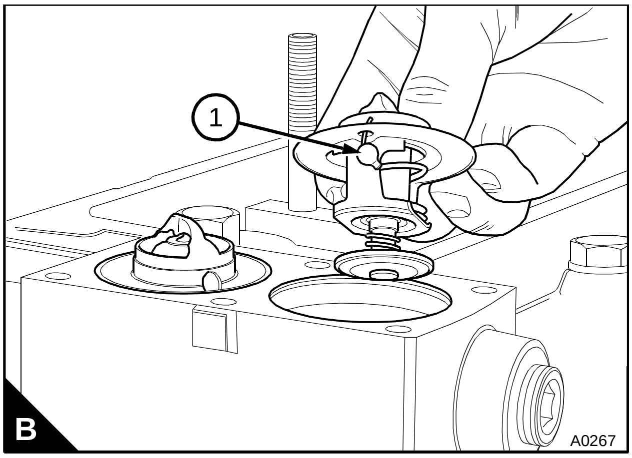
Caution: *If the clips on the plastic collar are not fitted correctly into the groove, the collar will not be secure and the thermostat will move out of position when the engine is in operation.*

4 Press the retainer clips, and push the plastic collar into the thermostat housing until the clip retainers engage the groove. Check that the plastic collar is a tight fit in the thermostat housing. If the collar is loose it must be renewed.

5 Fit a new joint, the joint is fitted dry. Fit and tighten the setscrews.

6 Connect the top hose and fill the cooling system.





To test **Operation 12-3**

1 Hang the thermostat 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 33.

Caution: *If the thermostat does not operate correctly, it must be renewed. Do not try to adjust the settings.*

Coolant pump - early gear driven pumps

Identification of the coolant pump is by the last four digits of the part number, for example 4131E011, stamped on the front of the pump body.

Early gear driven coolant pumps have either a cover and a joint secured by four setscrews or a pressed steel cover that is pressed into the pump housing, for details on how to remove the pressed steel cover, see "To dismantle" on page 263.

Note: A small amount of leakage of coolant across the surface of the face seal in the coolant pump is normal. It's purpose is to provide lubrication for the seal. There is a hole in the coolant pump body to allow coolant to drain. Small amounts of coolant might be seen to leak intermittently from the drain hole during the engine operation cycle.

Signs of a small leakage through the drain hole are not an indication that the pump is faulty. Coolant stains or intermittent drops of coolant from the hole, indicate normal operation of the pump.

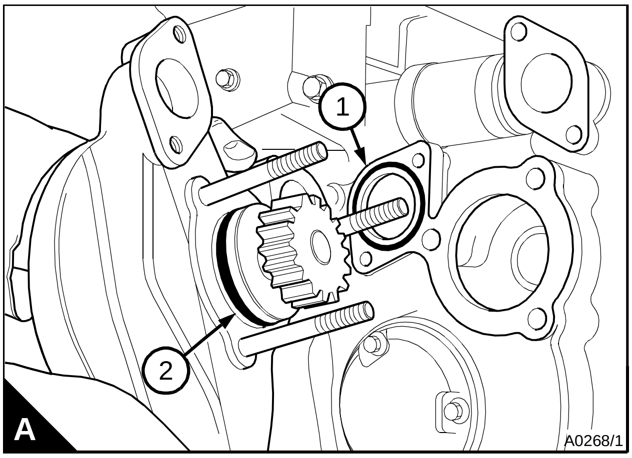
To remove **Operation 12-4**

1 Drain the cooling system and disconnect the hose at the inlet connection of the coolant pump.

2 Release the setscrews from the flange of the coolant by-pass. Discard the joint.

3 Release the three setscrews which retain the coolant pump to the cover of the timing case - two from the front and one from the rear.

4 Release the three nuts from the rear face of the timing case, which fasten the pump to the timing case, and remove the coolant pump (A). Ensure that the "O" ring (A1) on the cover of the timing case is not lost.



To fit **Operation 12-5**

Special requirements

Consumable products	
Description	**Part number**
POWERPART Silicone rubber sealant	1861108

1 Check the "O" rings on the pump body (A2) and on the cover of the timing case (A1) for damage. If either of the "O" rings are damaged, they must be renewed. 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, it must be renewed.

3 Lightly lubricate the "O" ring on the pump body with clean engine lubricating oil. Fit the pump to the timing case cover with its gear in mesh with the gear of the fuel injection pump. The pump is a tight fit in the cover, but can be pulled into position if the nuts for the pump studs are gradually and evenly tightened. Ensure that the "O" ring in the cover remains in position while the pump is fitted.

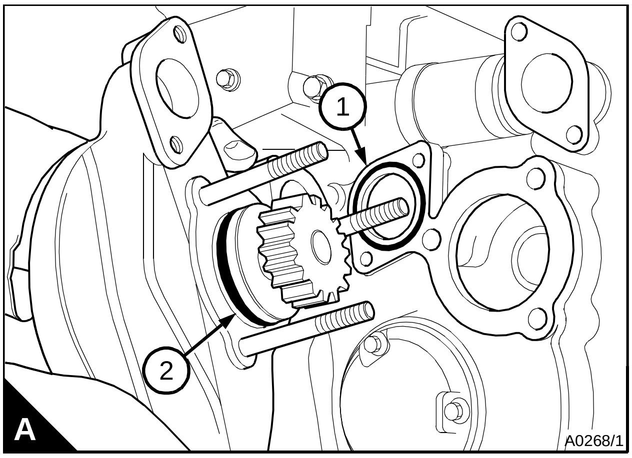
4 Fit the three nuts to the studs at the rear of the timing case.

Note: The setscrews for securing 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 new POWERPART Silicone rubber sealant applied to the first 13,0 mm (0.50 in) of the setscrew threads.

5 Fit and tighten the three setscrews which retain the pump to the cover of the timing case - two from the front and one from the rear.

6 Fit a new joint to the flange of the coolant bypass. Fit the by-pass and tighten the setscrews.

7 Connect the hose to the inlet connection of the coolant pump and fill the cooling system. Operate the engine and check for leakage.



To dismantle **Operation 12-6**

The coolant pump has a bearing assembly which has an integral oil seal. Identification of the coolant pump is by the last four digits of the part numbers, (4131E011) stamped on the front of the coolant pump body and by the bearing which extends approximately 5 mm (0.2 in) past the end of the pump body.

1 Remove the coolant pump, see Operation 12-4.

2 Remove the "O" ring (A2) from the pump body (A5).

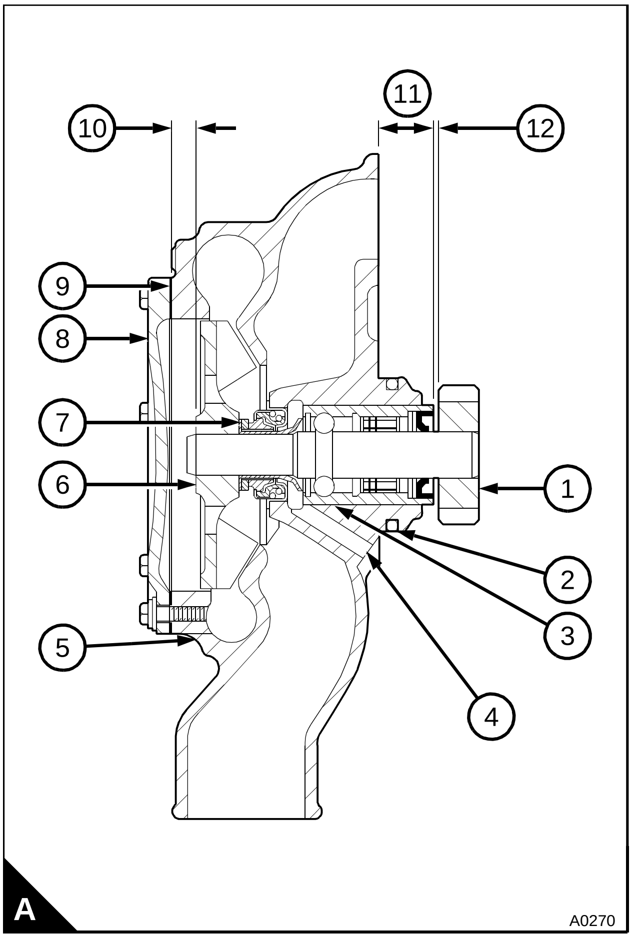
3 Remove the front cover (A8) and the joint (A9).

For coolant pumps with a pressed steel cover, see Operation 12-8.

4 Remove the gear (A1) with a suitable puller.

5 With a support under the drive end of the pump, use a suitable adaptor to press out the shaft and bearing assembly (A3) and discard it. Remove and discard the impeller (A6) from the body.

6 With a suitable support under the impeller end of the pump, press out the coolant seal and discard it.



To assemble **Operation 12-7**

Special requirements

Consumable products			
Description	**Part number**	**Description**	**Part number**
POWERPART Retainer (high strength)	21820638	POWERPART Threadlock and nutlock	21820117

Caution: *It is important that all of the components in the coolant pump kit are used during the overhaul of the pump. Coolant pump kits include the latest components which may be of a different design to the original components fitted to the engine.*

1 Clean thoroughly the inside of the pump body (A5). Ensure that the bore for the bearing and the chamfer at the coolant seal end of the bore are clean and free from corrosion.

2 Make a suitable adaptor which will apply force to the outer edge of the bearing and not to the shaft. Apply a thin layer of POWERPART Retainer (high strength) to the outer surface of the bearing (A3), but keep the retainer away from the ends of the bearing.

3 Provide a suitable support under the impeller end of the pump body. Put the bearing and shaft assembly in position with the bearing square to the pump body and the longest end of the shaft in the pump body. Use the adaptor to press in the bearing and shaft assembly. Press in the bearing until the rear face of the bearing is 21,0/21,5 mm (0.83/0.85 in) (A11) above the rear face of the pump body.

4 If the original gear is used, POWERPART Retainer (high strength) must be applied to the bore of the gear. Press the gear (A1) onto the shaft until the clearance between the front face of the gear and the rear face of the bearing (A12) is 0,47/1,53 mm (0.018/0.060 in). Remove all excess retainer after the gear has been fitted.

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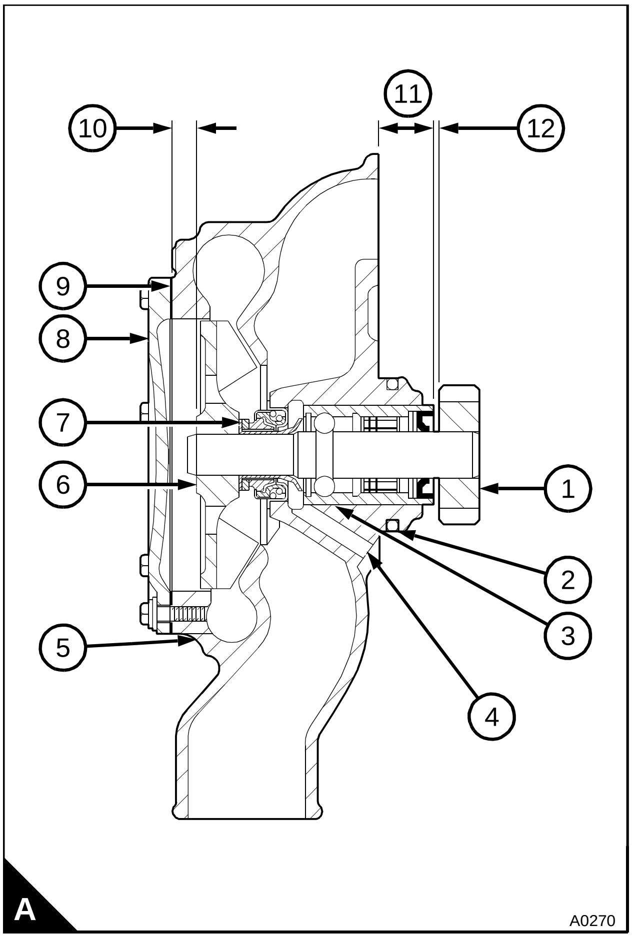

5 A tool (B) can be made to press the coolant seal into position. The tool should be made of a suitable material to the dimensions listed below:

A	44,0 mm (1.73 in)
B	40,0 mm (1.57 in)
C	11,6 mm (0.46 in)
D	35,8 mm (1.41 in)
E	16,1 mm (0.63 in)
F	1,00 mm (0.04 in) at 45°
G	2,00 mm (0.08 in) at 45°

The dimensions of the tool to fit the coolant seal, will ensure that the seal is the correct length after it is installed. It will also prevent axial distortion of the seal when it is pressed onto the shaft.

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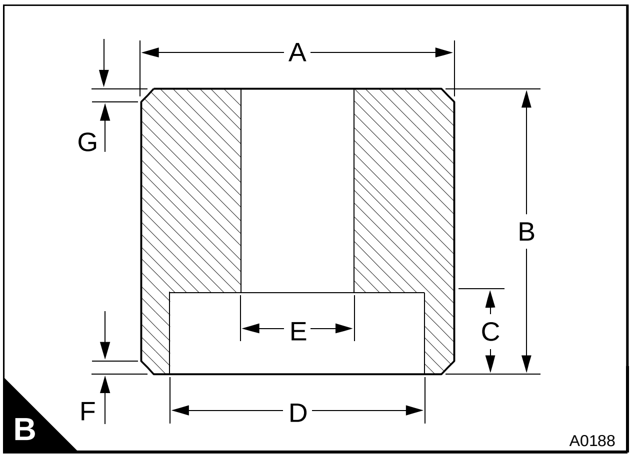
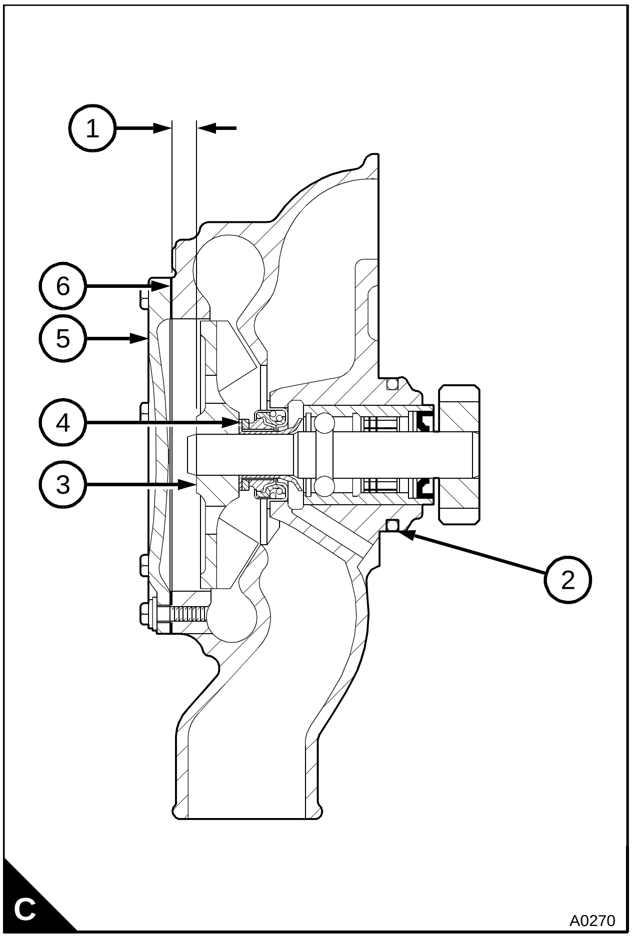


Turn the pump over and support the drive end of the body. Do not lubricate the coolant seal (C4). It is important that the seal is not contaminated by oil or grease and if it is held in the hand, it should be held by the edge of the flange. Do not damage the ring of green sealant applied to the body of the coolant seal just behind the flange. Put the seal into position on the end of the shaft. Ensure that the ring of sealant is towards the bearing. Use the tool to press the seal onto the shaft until the bottom of the seal flange is in complete contact with the pump body.

6 Hold the pump with the drive end of the shaft on a suitable support. With the use of a suitable distance piece and a flat bar, press the new impeller (C3) onto the shaft until the front face of the impeller is 6,7/7,0 mm (0.26/ 0.28 in) below the front face of the pump body (C1). Remove the flat bar and distance piece and ensure that the shaft is free to rotate.

7 Clean the threads in the front face of the pump body. Fit a new joint (C6) and the cover (C5). Fit the setscrews and tighten them to 9 Nm (6 lbf ft) 0,9 kgf m. To fit a pressed steel cover, see Operation 12-8. If the setscrews are new, a sealant will have been applied to the threads by the manufacturer. If the original setscrews are to be used again, the threads should be cleaned and POWERPART Threadlock and nutlock applied.

8 Fit a new "O" ring (C2) to the body of the pump.



To remove and to fit a pressed steel cover (early coolant pumps) **Operation 12-8**

Special requirements

Consumable products	
Description	**Part number**
POWERPART Gasket and flange sealant	21820518

To remove

Caution: *Do not remove the pressed steel cover when the coolant pump is removed or fitted. It is only necessary to remove the cover when the pump is to be dismantled.*

1 Use a suitable lever in the recesses (A1) to obtain access to the edge of the pressed steel cover. Operate the lever in each of the recesses to remove the cover. Discard the cover after removal, a new cover is available in the correct repair kit.

Caution: *Do not damage the surface of the bore for the cover during the cleaning operation.*

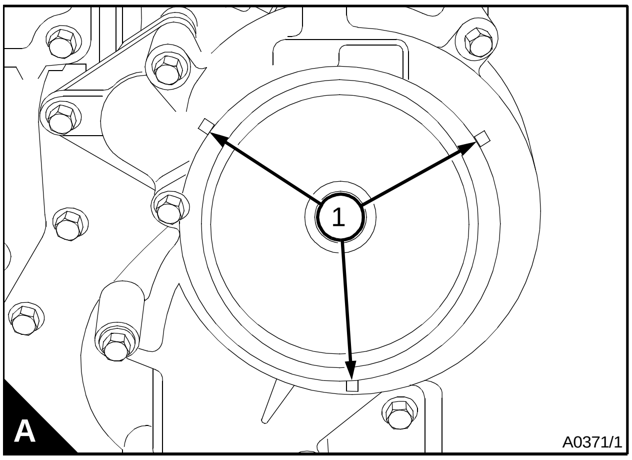
2 Clean the old sealant and any corrosion from the surface of the bore to a depth of 7 mm (0.28 in).

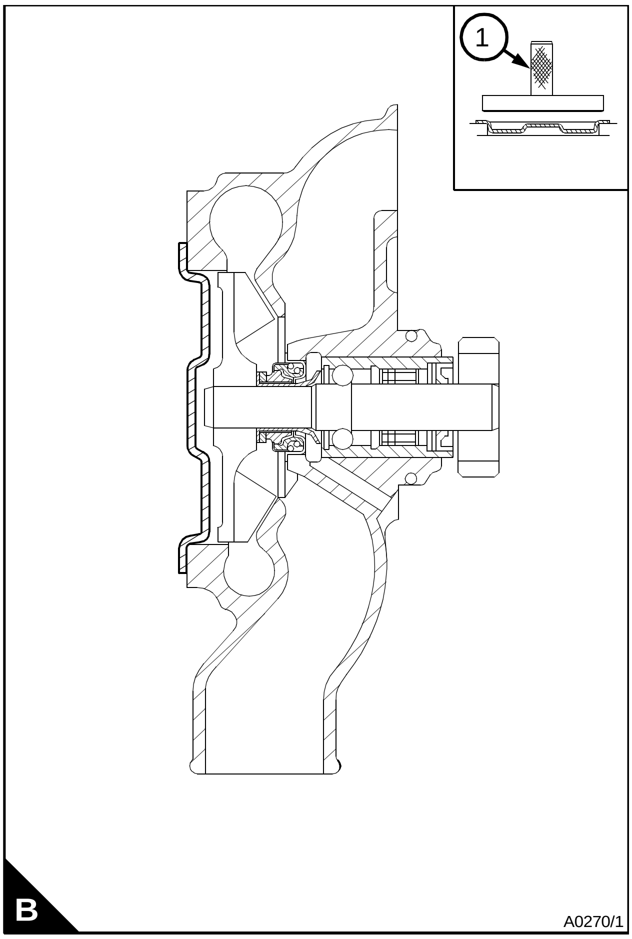
To fit

1 Put a bead of POWERPART Gasket and flange sealant on the contact surface of the pressed steel cover.

2 Support the body of the pump on the mounting flange.

3 Ensure that the cover is square with the body of the pump and use a press and a suitable adaptor (B1) to press the cover fully into the body of the pump.





Coolant pump - latest gear driven pumps

Note: A small amount of leakage of coolant across the surface of the face seal in the coolant pump is normal. It's purpose is to provide lubrication for the seal. There is a hole in the coolant pump body to allow coolant to drain. Small amounts of coolant might be seen to leak intermittently from the drain hole during the engine operation cycle.

Signs of a small leakage through the drain hole are not an indication that the pump is faulty. Coolant stains or intermittent drops of coolant from the hole, indicate normal operation of the pump.

The latest coolant pump has a pressed steel cover (A2) of the impeller housing. Early gear driven pumps have a steel cover fastened by setscrews.

To remove **Operation 12-9**

Caution: *Do not remove the pressed steel cover.*

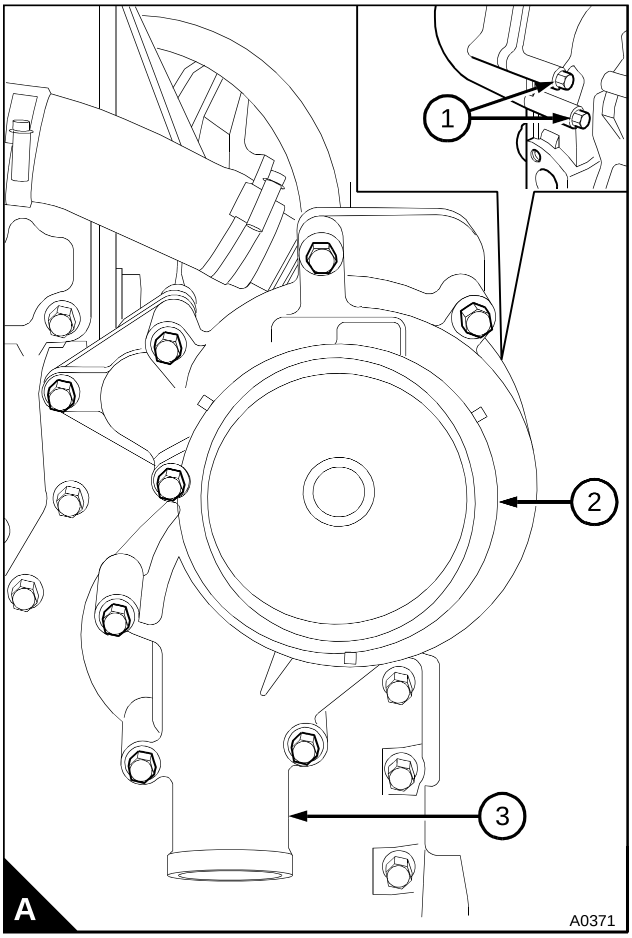
Identification of the coolant pump is by the last four digits of the part number, for example 4131E011, stamped on the front of the pump body.

1 Drain the cooling system and disconnect the hose at the inlet connection (A3) of the coolant pump.

2 Release the two fasteners from the rear face of the timing case (A1).

3 Release the eight setscrews in (A) which retain the coolant pump to the cover of the timing case and remove the coolant pump.

4 Remove and discard the joint.



To fit **Operation 12-10**

Special requirements

Consumable products			
Description	**Part number**	**Description**	**Part number**
POWERPART Threadlock and nutlock	21820117	POWERPART Silicon sealing and jointing compound	1861108

1 Ensure that the joint faces on the pump body (A3) and on the cover of the timing case (A1) are clean. Check the joint faces for damage. Check that the spigot (A4) is clean.

2 Check the drive gear of the coolant pump for wear or other damage. If the gear is damaged, it must be renewed.

3 Fit a new joint to the flange of the coolant pump. The joint is fitted without sealant.

4 Ensure that the studs (A2) are tightened into the body of the coolant pump.

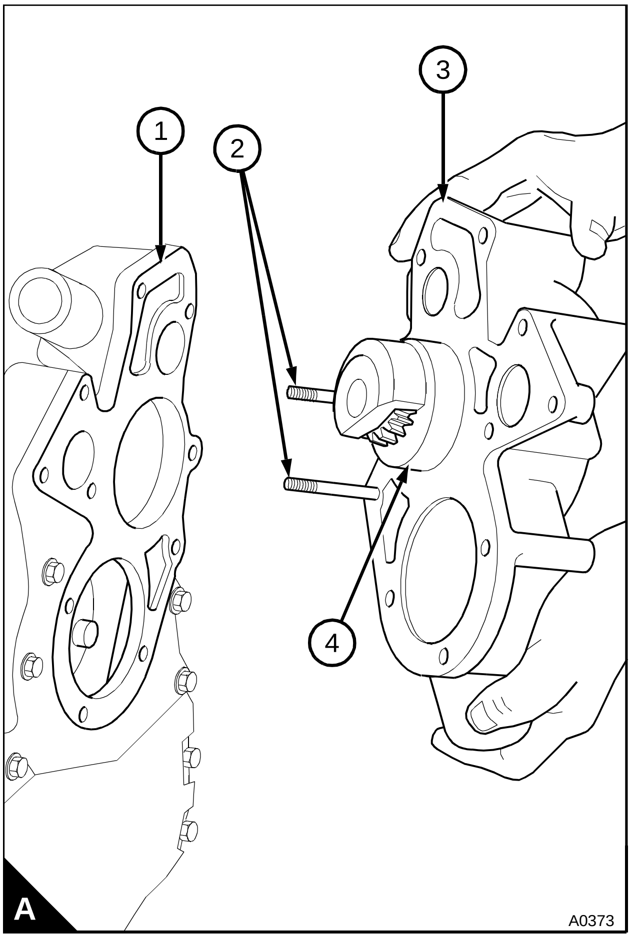
5 Fit the coolant pump to the timing case cover with its gear in mesh with the gear of the fuel injection pump.

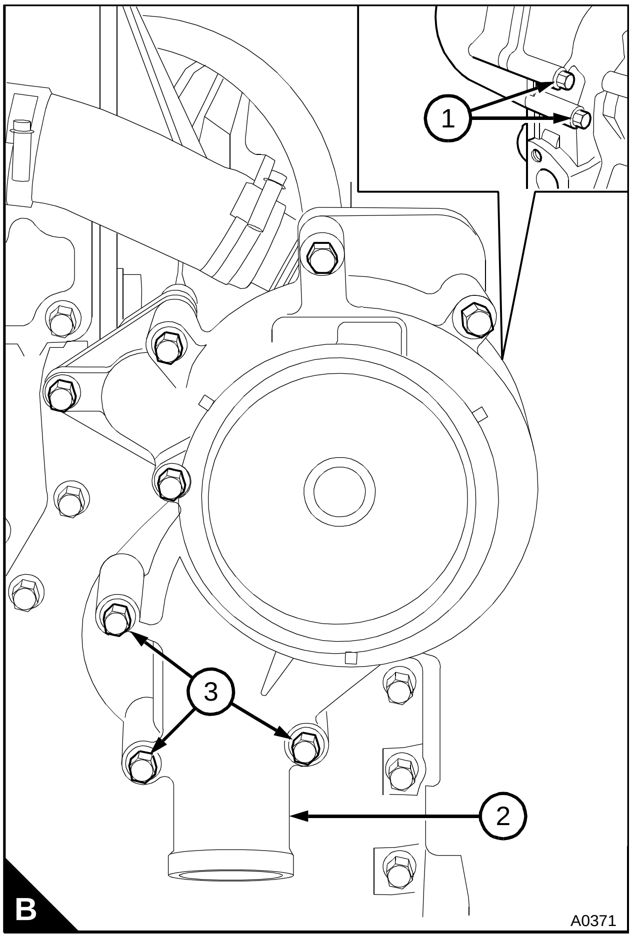
Note: The setscrews for securing the coolant pump have a sealant (MEAS) applied by the manufacturer to the first 13,0 mm (0.50 in) of the threads. If the setscrews are used again, the sealant must be removed from the male and female threads and new sealant POWERPART Silicon sealing and jointing compound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

6 Fit and tighten the two nuts (B1) at the rear face of the timing case.

7 Fit and tighten the eight setscrews which retain the pump to the cover of the timing case.

8 Connect the hose to the inlet connection (B2) of the coolant pump and fill the cooling system. Operate the engine and check for leakage.





To dismantle

Operation 12-11

Special requirements

Special tools	
Description	**Part number**
Basic puller	21825565

1 Remove the two studs from the pump body.

2 Use a lever under the edge of the pressed steel cover (A1) and remove the cover, there are three recesses (B1) around the edge of the pump body to give access for a lever. Discard the cover after removal.

3 Remove the impeller (A5) from the pump shaft: Drill four 6.35 mm (0.25 in) holes at equal distance around the end of the pump shaft, between the shaft and the hub for the impeller. These holes will break the interference fit between the impeller and the pump shaft and allow removal of the impeller.

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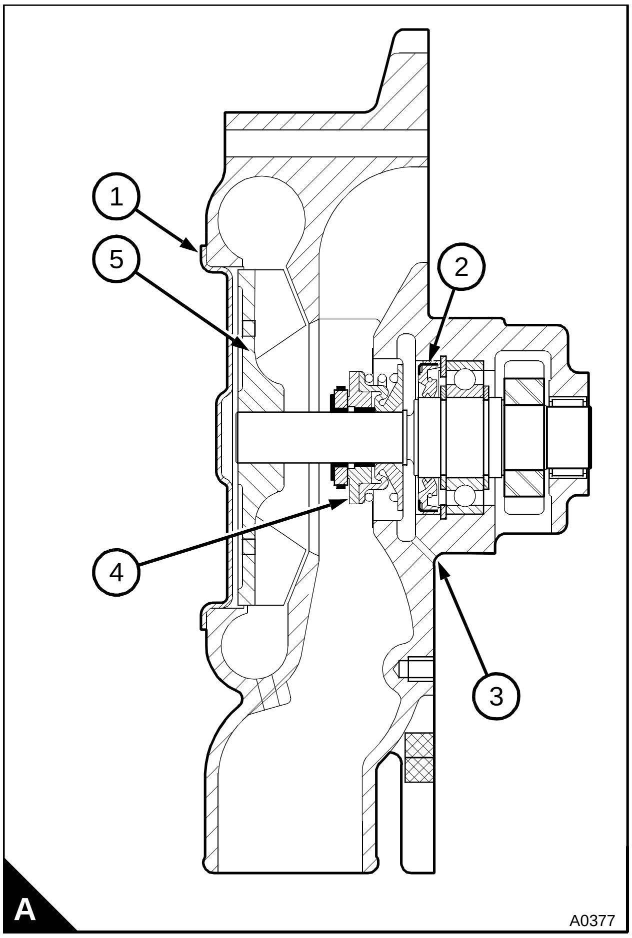

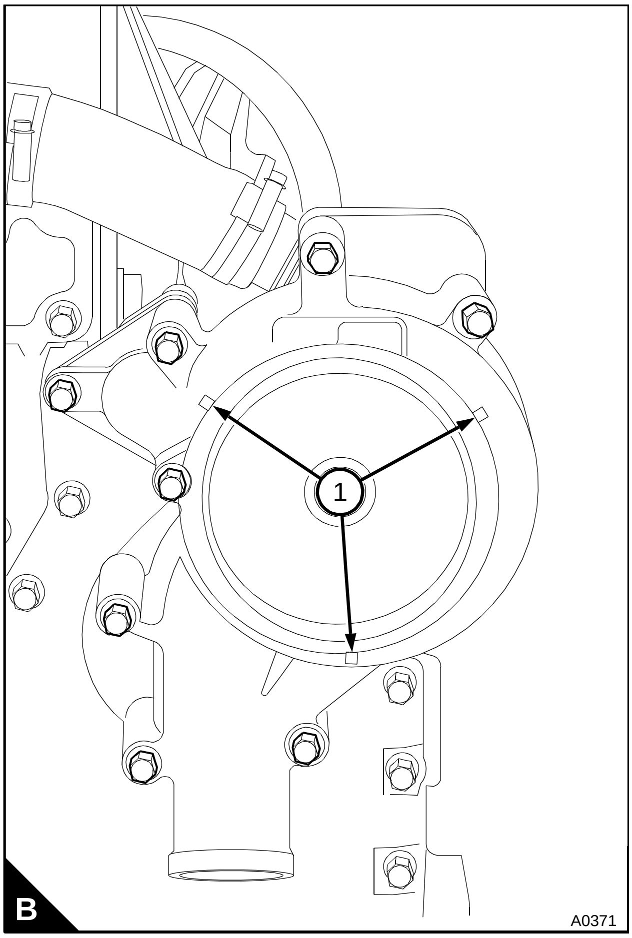

Later coolant pumps have an impeller that has two 8 mm tapped holes. The impeller can be removed by using the basic puller attached to the impeller by two 8 mm setscrews (D1). Tighten the centre setscrew (D2) of the puller until the impeller is removed. Discard the impeller.

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 carbon 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.

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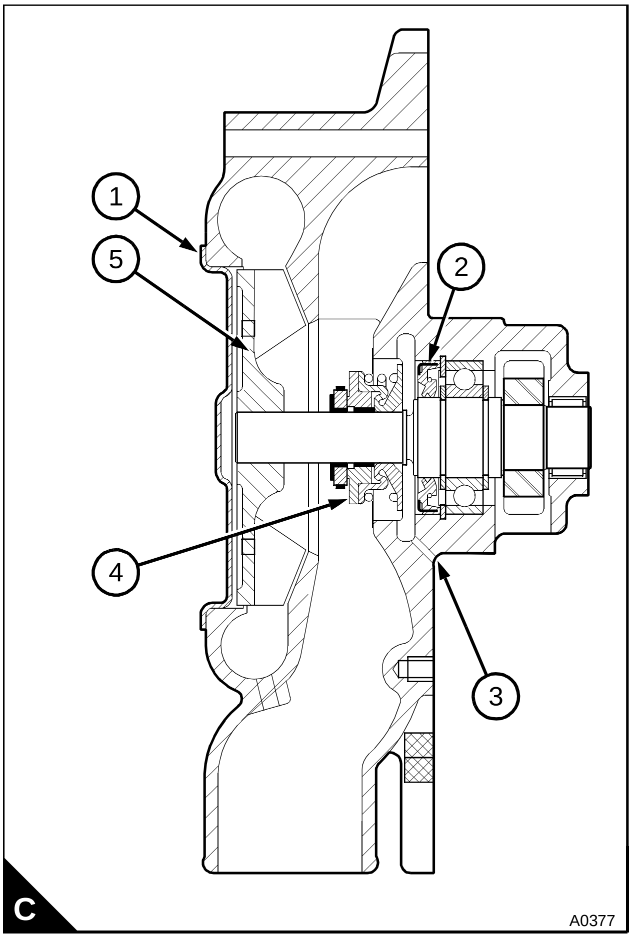
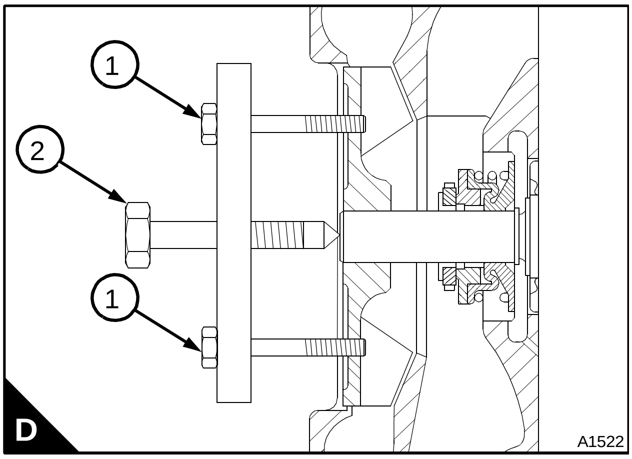




Caution: *Do not damage the sealing face of the oil seal housing during removal of the seal.*

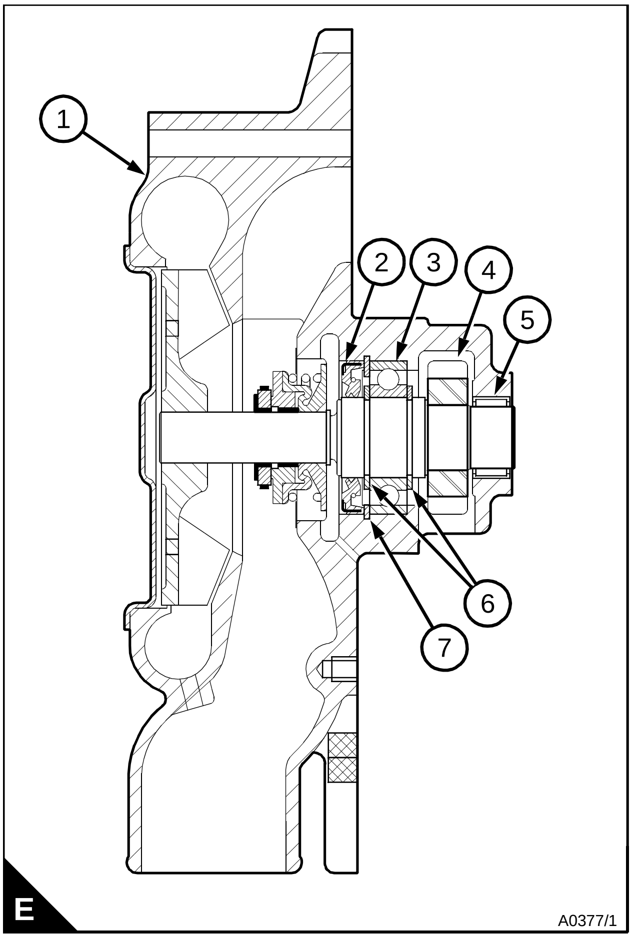
5 Drill a 3.175 mm (0.125 in) hole through the top of the oil seal and fit a 25.4 mm (1.00 in) self-tapping screw. Insert a suitable lever through the coolant inlet of the pump body and apply the lever under the head of the self-tapping screw to remove the oil seal (E2). Discard the oil seal.

6 Remove and discard the circlip (E7).

7 Put the impeller end of the pump body (E1) face down on a suitable press. Press the drive gear end of the shaft through the gear (E4) and the pump body until the shaft and ball bearing assembly (E3) are released from the pump. Discard the bearing, the shaft and the two circlips (E6). The gear will also be released.

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

9 Put the impeller end of the pump body face down onto a press. Use a suitable mandrel to engage the outer race of the needle roller bearing (E5). Press out the bearing and discard it.



To assemble **Operation 12-12**

Special requirements

Special tools		Consumable products	
Description	**Part number**	**Description**	**Part number**
Coolant pump, oil seal replacer tool	27610031	POWERPART Retainer (high strength)	21820638
		POWERPART Gasket and flange sealant	21820518

Caution: *It is important that all of the components in the kit for the coolant pump are used. The kit includes the latest components which may be of a different design to the original components fitted to the engine.*

1 Clean thoroughly the inside of the pump body especially the bearing bores and the counterbore for the coolant seal. These bores and their chamfers must be clean and free of corrosion.

2 Fit a new circlip (A7) onto the gear end of the shaft (A6). Put the drive gear end of the pump body face down on a suitable press. Put the drive gear (A4) into position in the housing. If the original gear is to be used, POWERPART Retainer (high strength) must be applied to the bore of the gear. fit the shaft into the housing. Ensure that the shaft and gear are aligned. Press the impeller end of the shaft until the gear is against the shoulder of the shaft.

3 Apply a thin layer of POWERPART Retainer (high strength) to the outer surface of the bearing, but keep the retainer away from the ends of the bearing. Put the cover end of the pump body (A1) face down on a suitable press. Press the needle roller bearing (A5) 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.

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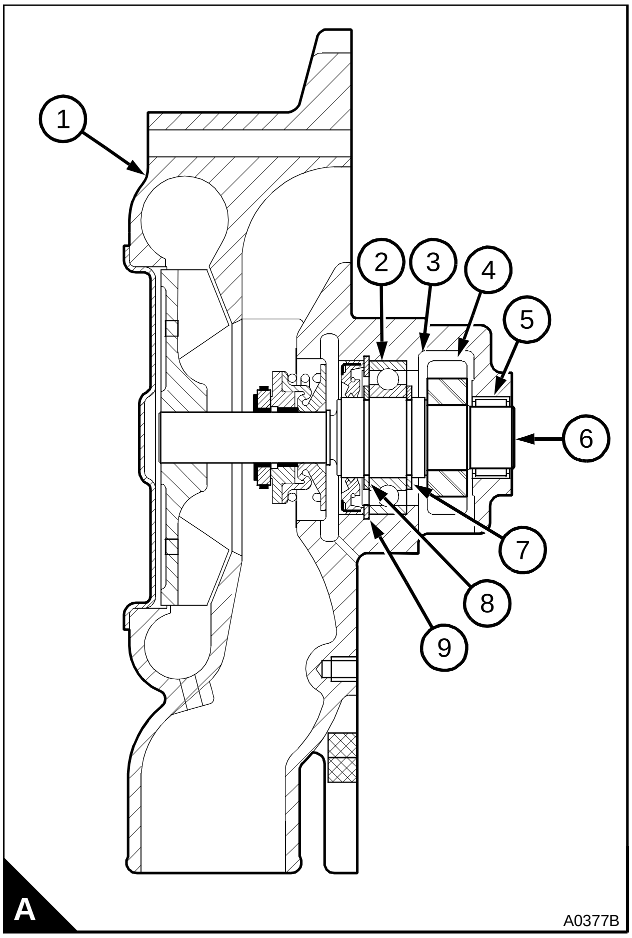

4 Apply a thin layer of POWERPART Retainer (high strength) to the outer surface of the ball bearing (B2), but keep the retainer away from the ends of the bearing. Use a suitable spacer to support the drive gear end of the shaft. Ensure that the drive gear is against face (B3).

Use a suitable adaptor to press the new ball bearing onto the shaft until the inner race is in contact the circlip. Ensure that the adaptor is pressed onto the inner race and outer race of the bearing as it enters the bearing housing. Lubricate the ball bearing and the needle roller bearings with clean engine oil.

Remove the spacer from the gear end of the shaft and support the body of the pump at the gear end. Continue to press the bearing fully into the end of the bearing housing, fit the second circlip (B8) on to the shaft. Clean all POWERPART Retainer (high strength) from the ends of the bearings and the drive gear.

5 Fit the new circlip (B9), with the bevel edge towards the oil seal, to retain the bearing and shaft assembly in the body of the pump.

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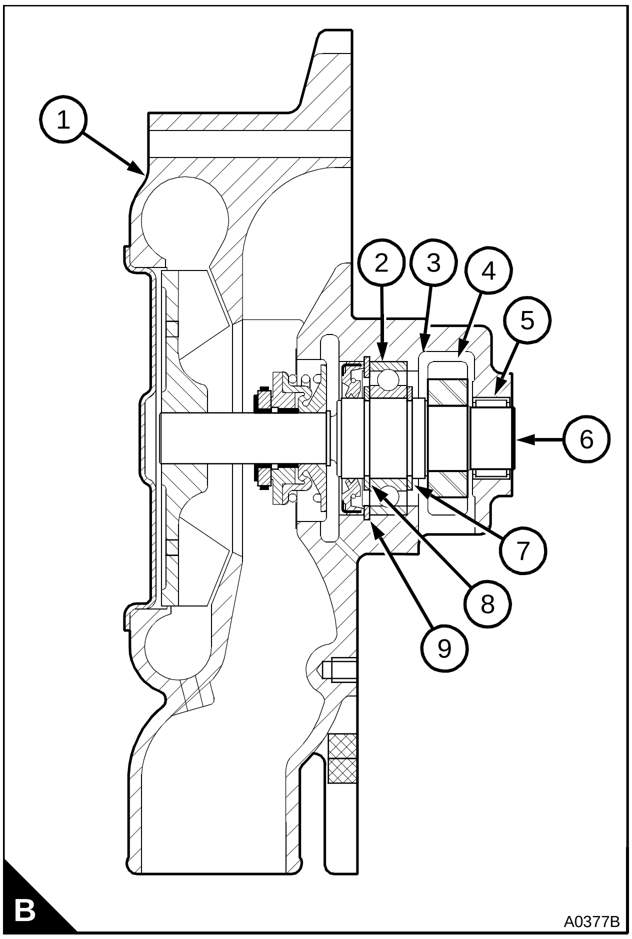

6 Lightly lubricate the oil seal (C2) with clean engine lubricating oil. Put the tapered tool 27610031 onto the drive shaft with the tapered end towards the bearing. The tapered tool ensures that the lip of the oil seal is correctly fitted when the seal is pressed into position.

Lubricate the oil seal with clean engine oil. Push the oil seal over the tapered tool and into position in the pump body with the flat face of the seal towards the impeller end.

7 Press the oil seal into the oil seal housing:

A tool (D) can be made to press the new oil seal into position. The tool should be made of steel to the dimensions shown below:

A	40,0 mm (1.57 in)
B	80,0 mm (3.15 in)
C	60,0 mm (2.36 in)
D	42,0 mm (1.65 in)
E	29,0 mm (1.14 in)
F	14,5 mm (0.57 in)
G	12,0 mm (0.47 in)

The dimensions of the tool to fit the oil seal, will ensure that the seal is in the correct position after it is installed. It will also prevent axial distortion of the seal when it is pressed onto the shaft.

Use tool (D) and press the oil seal into the body until the seal is 14,5 mm (0.57 in) from the end of the flange for the coolant seal (C1). When the seal is in position, continue to apply force for approximately ten seconds to ensure that the seal remains in position when the force is released. Clean off excess oil.

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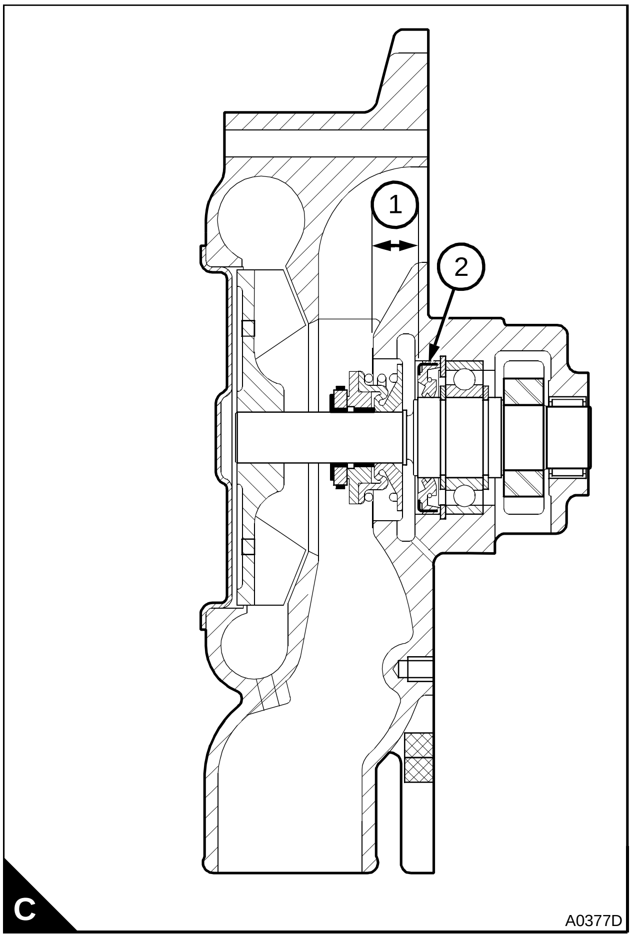
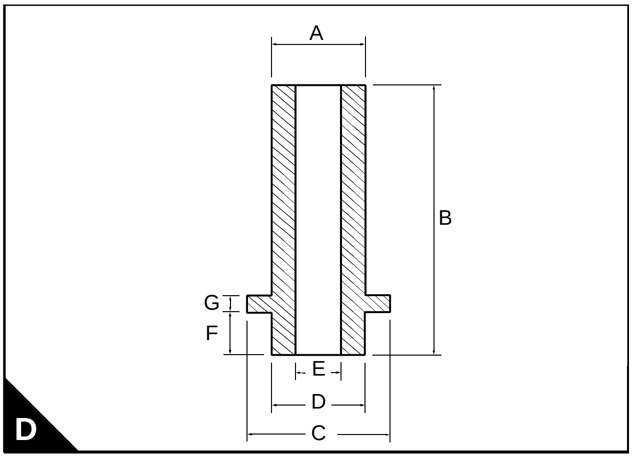




Caution: *Do not lubricate the coolant seal (E4). It is important that it is not contaminated with oil or grease and, if it is held in the hand, it should be held by the edge of the outside flange. Do not damage the ring of green sealant applied to the body of the coolant seal just behind the flange.*

8 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 press the seal into the counterbore, with a suitable adaptor, until the outer flange is in contact with the pump body. The adaptor must apply force only to the outer flange of the seal. Continue to apply force for approximately ten seconds to ensure that the seal remains in position.

A tool (F) can be made to press the new seal into position. The tool should be made of a suitable material to the dimensions shown below:

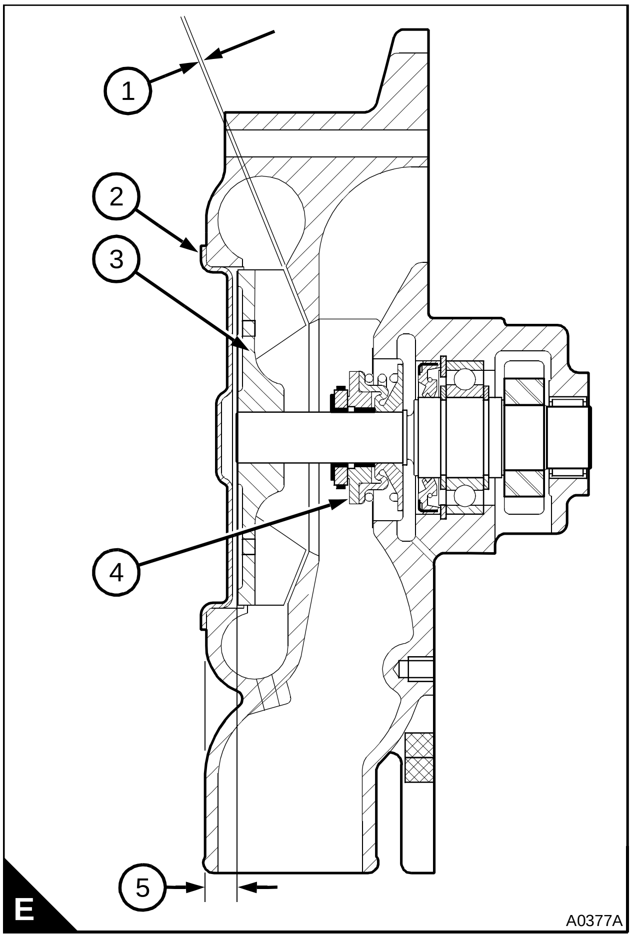
A	44,0 mm (1.73 in)	**E**	16,1 mm (0.63 in)
B	40,0 mm (1.57 in)	**F**	1,00 mm (0.04 in) at 45°
C	12,2 mm (0.48 in)	**G**	2,00 mm (0.08 in) at 45°
D	35,8 mm (1.41 in)		

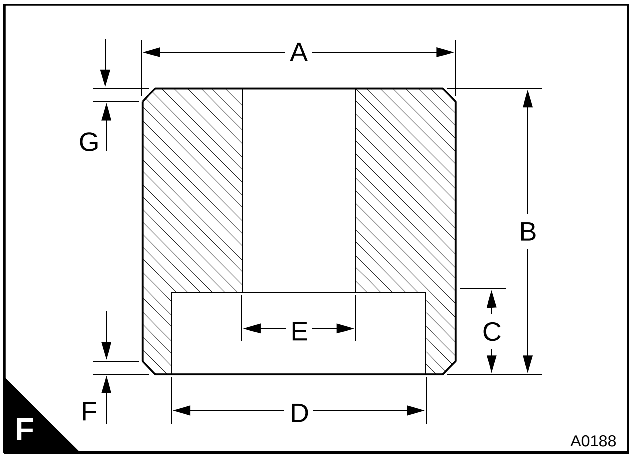
The dimensions of the tool to fit the coolant seal, will ensure that the seal is the correct length after it is installed. It will also prevent axial distortion of the seal when it is pressed onto the shaft.

9 Ensure that the drive end of the shaft has support. Use a suitable distance piece and a flat bar to press the impeller (E3) onto the shaft until the front face of the impeller is 10,35/10,48 mm (0.41/0.40 in) from the front face of the pump body (E5). This dimension will ensure an impeller clearance (E1) of 0,44/1,06 (0.017/0.042in). Rotate the impeller to ensure free movement.

10 Put a bead of POWERPART Gasket and flange sealant on the contact surface of the pressed steel cover (E2). Ensure that the cover is square with the body of the pump and use a suitable adaptor to press the cover until the edge of the cover is fully onto the flange of the coolant pump body.

11 Fit the two studs to the pump.





Coolant pump - belt driven

Note: A small amount of leakage of coolant across the surface of the face seal in the coolant pump is normal. It's purpose is to provide lubrication for the seal. There is a hole in the coolant pump body to allow coolant to drain. Small amounts of coolant might be seen to leak intermittently from the drain hole during the engine operation cycle.

Signs of a small leakage through the drain hole are not an indication that the pump is faulty. Coolant stains or intermittent drops of coolant from the hole, indicate normal operation of the pump.

To remove **Operation 12-13**

Special requirements

Special tools	
Description	**Part number**
Gear puller	21825565

1 Remove the fan, see Operation 12-19.

2 Remove the fan belt, see Operation 14-3.

3 Drain the coolant system and remove the hose connections to the coolant pump.

4 Remove the nut, spring washer and plain washer from the pump pulley. It may be necessary to use extractor 21825565 to remove the pulley from the pump shaft (A).

5 If the pump is to be dismantled, remove the key from the keyway of the pump shaft.

6 Remove the four setscrews which secure the coolant pump to the rear body of the pump.

7 Remove the coolant pump (B1) and discard the joint (B2).

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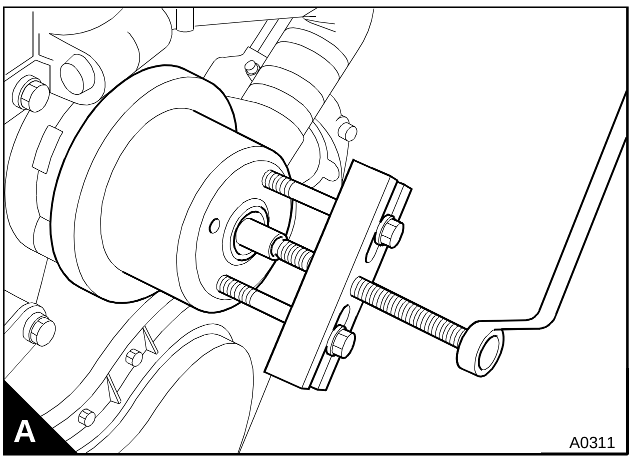
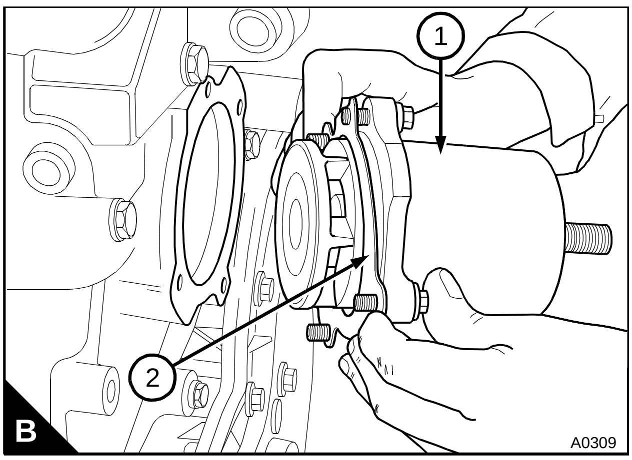
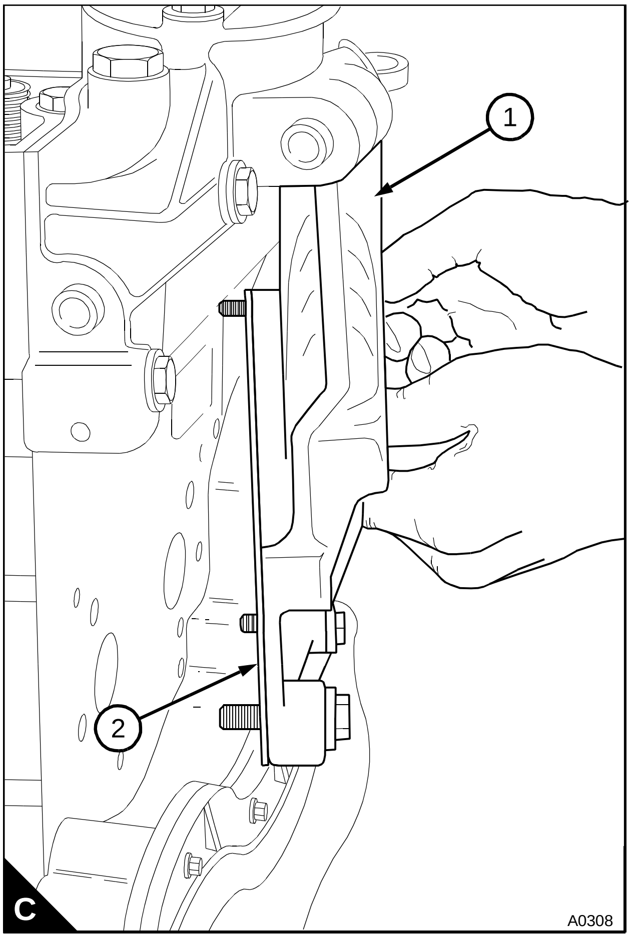




8 If it is necessary to remove the rear body (C1) of the pump from the cylinder block: Remove the setscrew for the alternator adjustment linkage and the spacer. Remove the four other setscrews and remove the rear body from the cylinder block. Discard the joint (C2).



To fit **Operation 12-14**

Note: The joints are fitted without jointing compound.

1 If the rear body of the pump (A1) was removed from the cylinder block: Thoroughly clean the joint faces of the cylinder block and pump rear body. Fit a new joint (A2) between the rear body of the pump and the cylinder block.

2 Fit the rear body of the pump and the joint to the cylinder block. Fit the spacer and adjustment linkage for the alternator. Tighten the M10 setscrews to 44 Nm (33 lbf ft) 4,5 kgf m and the M12 setscrews to 75 Nm (55 lbf ft) 7,6 kgf m.

3 Thoroughly clean the joint faces of the pump rear body and coolant pump (B2). Fit a new joint (B4) to the coolant the pump.

4 Fit the coolant pump and joint to the rear pump body and tighten the four M10 setscrews (B3) to 44 Nm (33 lbf ft) 4,5 kgf m.

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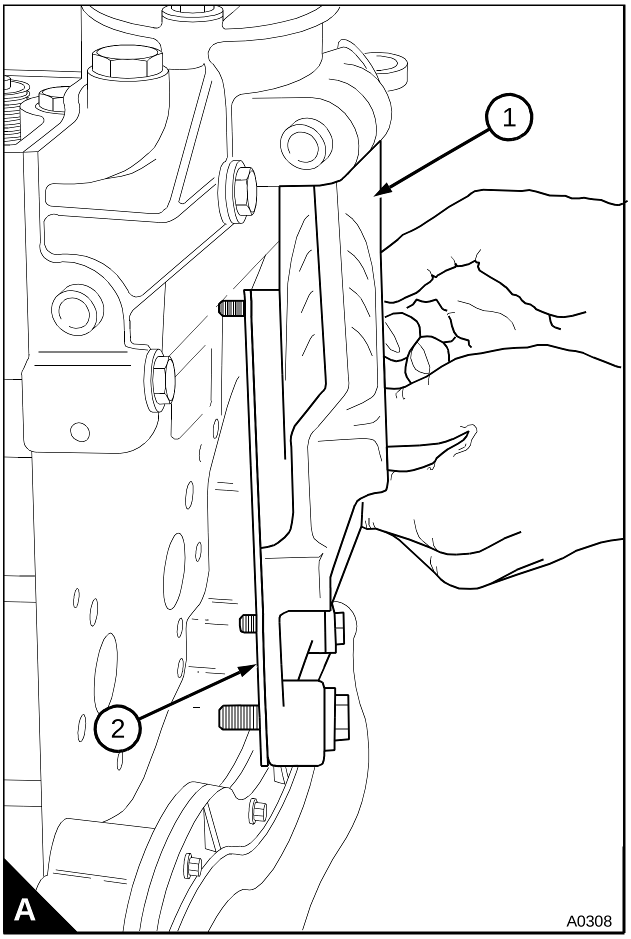

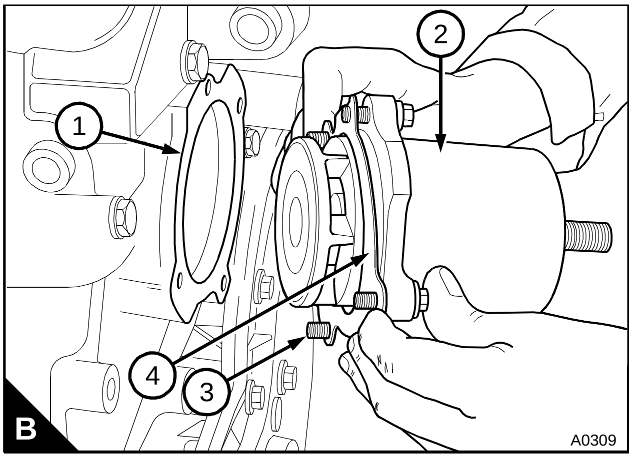

5 Fit the key to the keyway and put the pulley onto the pump shaft. Put the plain washer and the spring washer in position onto the pulley. Fit the nut and tighten it to 77 Nm (57 lbf ft) 7,9 kgf m.

Note: It may be necessary to fit two setscrews into the holes for the fan to enable a lever to be used to prevent rotation of the coolant pump shaft when the nut for the pulley is tightened.

6 Connect the hoses to the coolant pump and tighten the clips.

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

8 Fit the fan, see Operation 12-19.

9 Fill the cooling system.

To remove high position pump **Operation 12-15**

Special requirements

Special tools	
Description	**Part number**
Gear puller	21825565

Note: A small amount of leakage of coolant across the surface of the face seal in the coolant pump is normal. It’s purpose is to provide lubrication for the seal. There is a hole in the coolant pump body to allow coolant to drain. Small amounts of coolant might be seen to leak intermittently from the drain hole during the engine operation cycle.

Signs of a small leakage through the drain hole are not an indication that the pump is faulty. Coolant stains or intermittent drops of coolant from the hole, indicate normal operation of the pump.

To remove

Some engines are fitted with a coolant pump in a high position (A5), these are identified by the thermostat housing (A1) which is part of the pump rear body.

The pump rear body has a connection (A4) to a coolant transfer plate (A3), which allows coolant from the pump impeller to pass into the cylinder block (A2).

1 Remove the fan, see Operation 12-19.

2 Remove the fan belt, see Operation 14-3.

3 Drain the coolant system and remove the hose connections to the coolant pump.

4 Remove the nut, spring washer and plain washer from the pump pulley. It may be necessary to use extractor part number 21825565 to remove the pulley from the pump shaft (B).

5 If the pump is to be dismantled, remove the key from the keyway of the pump shaft.

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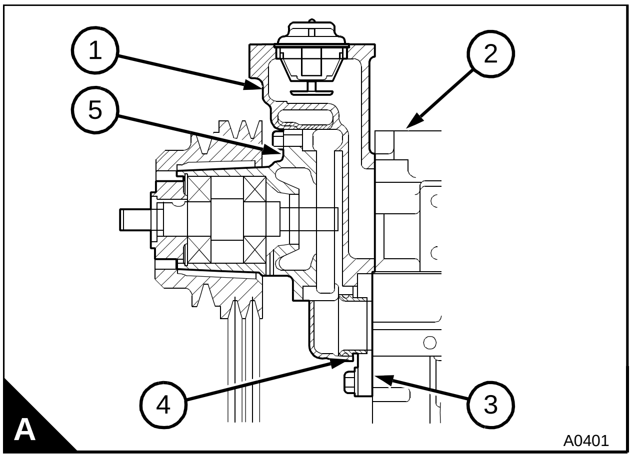
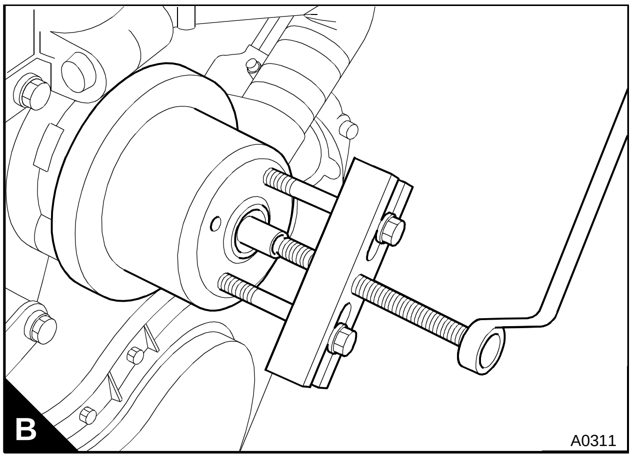


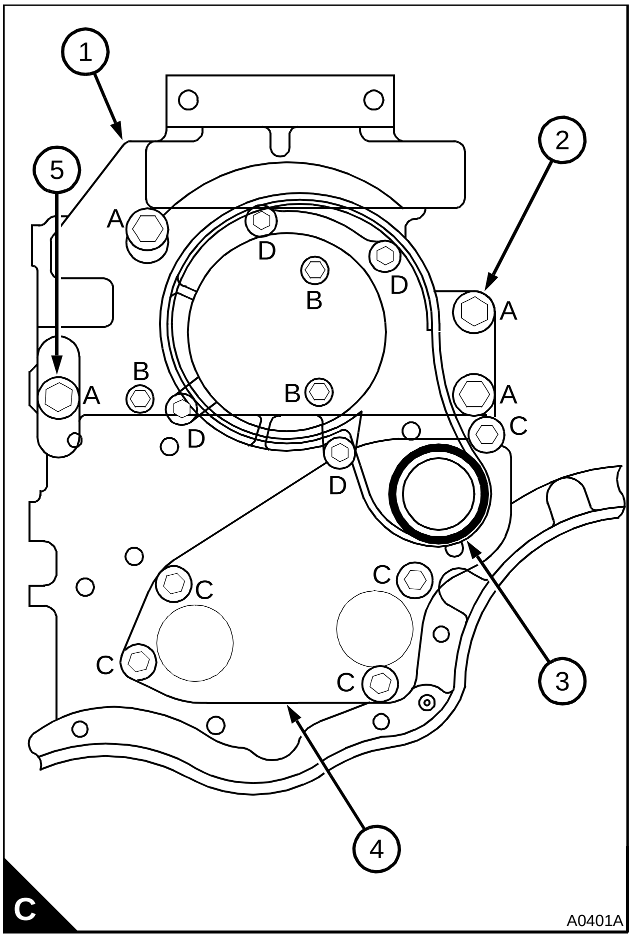


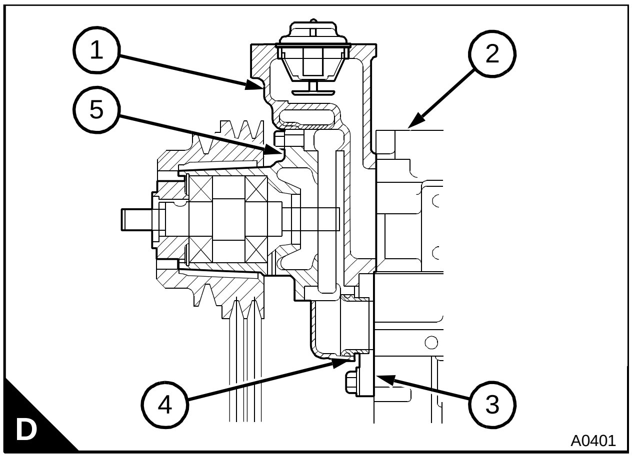
6 Remove the four setscrews "D", in illustration (C), which secure the coolant pump to the rear body of the pump (C1).

7 Remove the coolant pump (D5) and discard the joint.

8 If it is necessary to remove the rear body of the pump from the cylinder block: Remove the setscrew for the alternator adjustment linkage and the spacer. Remove the four setscrews "A" and the other three setscrews or Allen screws "B", in illustration (C) and carefully remove the rear body from the cylinder block and the transfer plate connection. Discard the joint, and the "O" ring (C3).

9 If it is necessary to remove the transfer plate (C4) remove the five setscrews, "C" in illustration (C), and discard the joint.





To fit high position pump **Operation 12-16**

Note: The joints are fitted without jointing compound.

1 If the transfer plate (A4) was removed from the cylinder block: Thoroughly clean the joint faces of the cylinder block and transfer plate. Fit a new joint between the transfer plate and the cylinder block. Fit the transfer plate and tighten the five setscrews "C" in illustration (A) finger-tight only.

2 If the rear body of the pump (A1) was removed from the cylinder block: Thoroughly clean the joint faces of the cylinder block and pump rear body. Fit a new "O" ring to the transfer plate connection (A3) and lubricate the "O" ring with a suitable fluid or grease.

Fit two suitable M10 guide studs in positions (A2 and A5). Fit a new joint onto the guide studs. Put the rear body of the pump into position, with the outlet connection fitted over the "O" ring of the transfer plate. Fit the M8 setscrews or Allen screws, "B" in illustration (A), and remove the two guide studs. Fit the other four M10 setscrews, "A" in illustration (A). Tighten the setscrews "A" to 44 Nm (33 lbf ft) 4,5 kgf m and the setscrews or Allen screws "B" in illustration (A) to 22 Nm (16 lbf ft) 2,2 kgf m. Fit the setscrew for the alternator adjustment linkage and the spacer.

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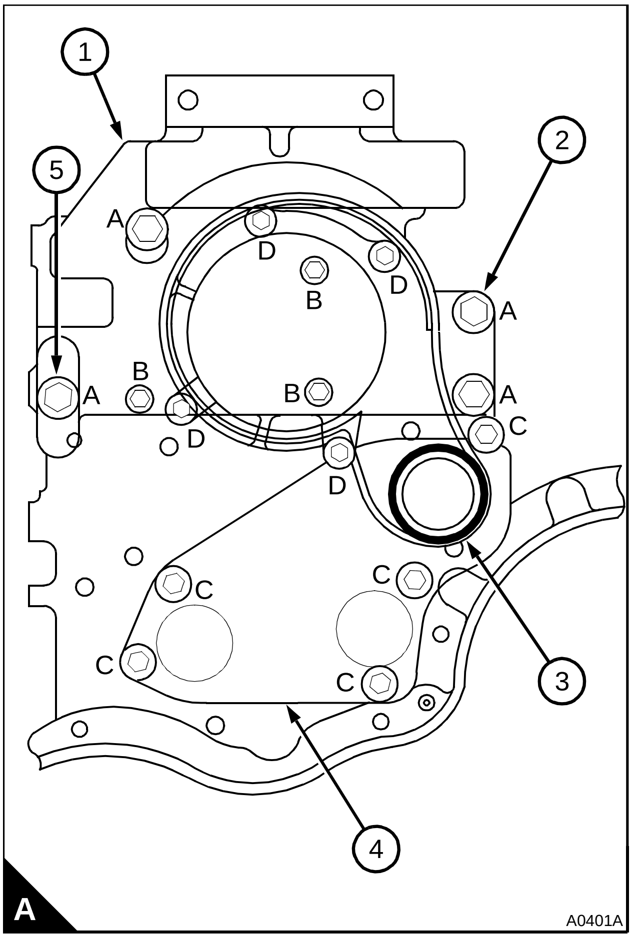
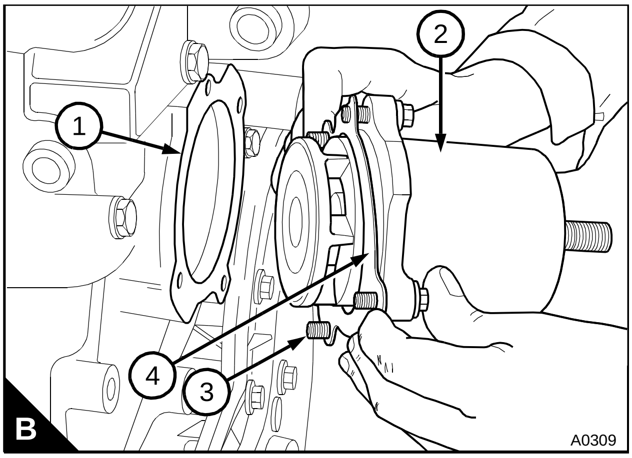




3 Tighten the five setscrews “C” in illustration (C) to 22 Nm (16 lbf ft) 2,2 kgf m

4 Fit the coolant pump (D2) and joint (D4) to the rear pump body (D1) and tighten the four M8 setscrews (D3) to 29 Nm (21 lbf ft) 2,9 kgf m.

5 Fit the key to the keyway and put the pulley onto the pump shaft. Put the plain washer and the spring washer in position onto the pulley. Fit the nut and tighten it to 77 Nm (57 lbf ft) 7,9 kgf m.

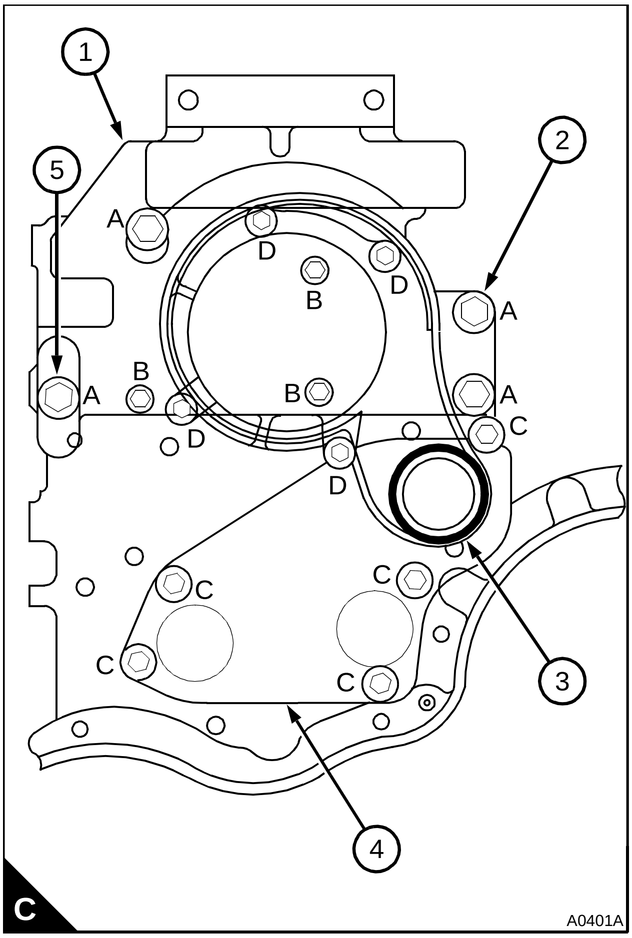
Note: It may be necessary to fit two setscrews into the holes for the fan to enable a lever to be used to prevent rotation of the coolant pump shaft when the nut for the pulley is tightened.

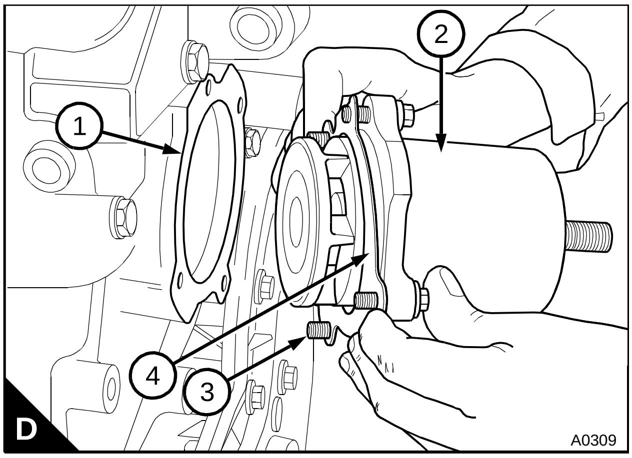
6 Connect the hoses to the coolant pump and tighten the clips.

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

8 Fit the fan, see Operation 12-19.

9 Fill the cooling system.





To dismantle **Operation 12-17**

1 Remove the coolant pump (A) from the engine, see Operation 12-13 or Operation 12-15.

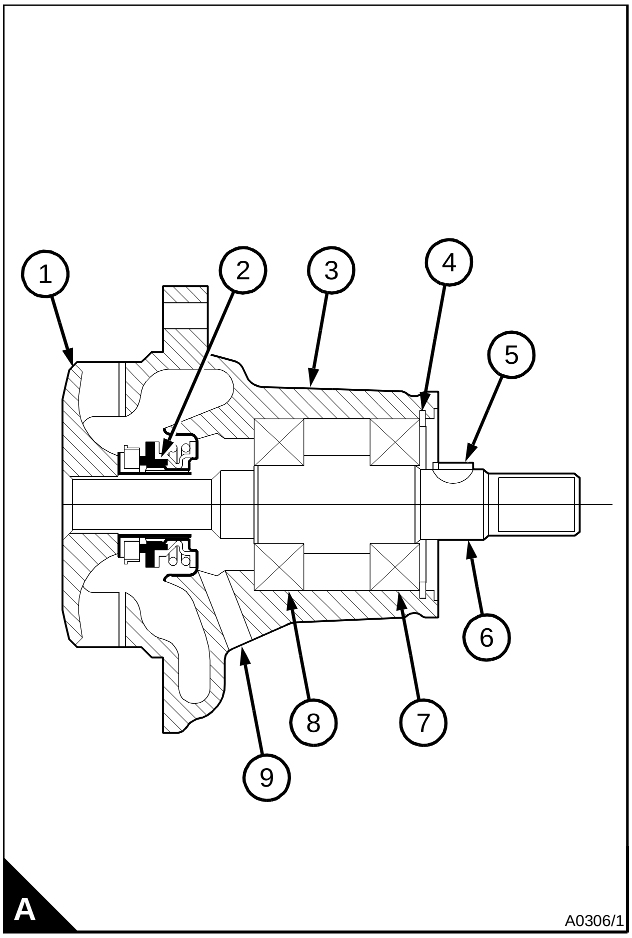
2 Remove the circlip (A4) for the bearing housing (A3).

3 Support the pulley end of the pump and press the shaft (A6) through the impeller (A1) and coolant seal (A2). This will also remove the bearing (A7). Discard the bearing and the shaft.

4 Remove and discard the impeller. Discard the coolant seal.

5 Support the pulley end of the pump and press out the bearing (A8). Discard the bearing.

6 Clean the body of the pump in a suitable safe cleaning fluid. Inspect the pump body for cracks.



To assemble **Operation 12-18**

Special requirements

Special tools		Consumable products	
Description	**Part number**	**Description**	**Part number**
Standard bench press		POWERPART Retainer (oil tolerant)	21820603

The service kit for the pump contains two bearings, the shaft, a circlip, a key, a joint and a coolant seal. Each bearing is filled with grease and sealed by the bearing manufacturer. The bearings will not need attention during service.

1 Support the impeller end of the pump body. Apply a narrow ring of POWERPART Retainer (oil tolerant) to the face of the outer race of each bearing. Put the bearing (A5) into position on the pump housing. Use a suitable adaptor on the outer race and press the bearing fully into the back of the bearing housing.

2 Support the inner race of the bearing just fitted from the impeller end of the pump body. Use a suitable adaptor which will allow the shaft (A3) to pass through it. Press the new shaft into the bearing until the shoulder of the shaft is fully against the inner race of the bearing. Put the bearing (A4) into position on the pump housing and shaft. Use a suitable adaptor on the inner and outer race to ensure the pressure is applied evenly. Press the bearing onto the shaft and housing until the inner race of the bearing is against the shoulder of the shaft. Remove excess retainer and fit the new circlip (A2).

3 Fit a new coolant seal (A1) using the following procedure.

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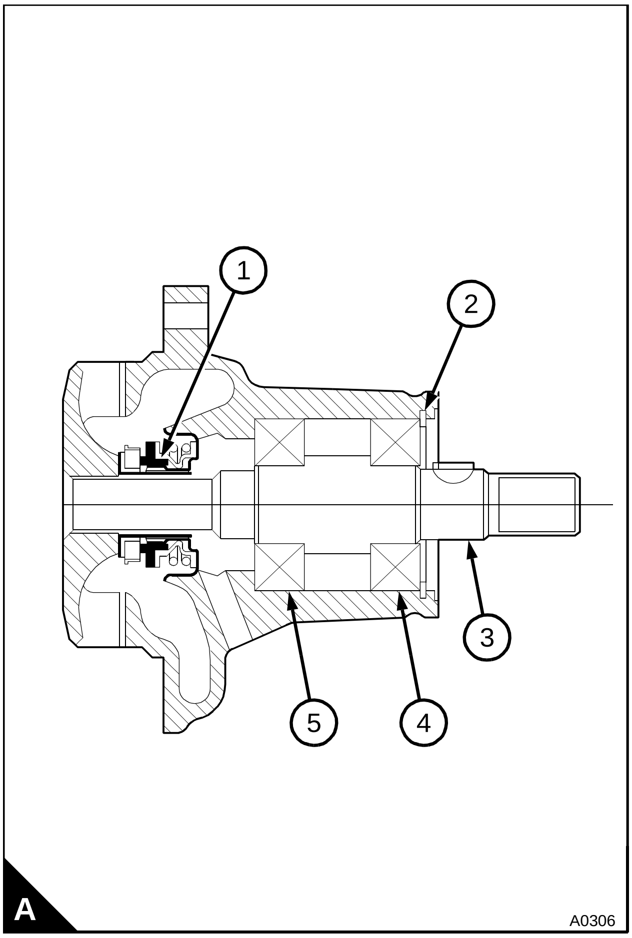

Caution: *It is important that only the tool, shown in (B), is used to fit the new coolant seal.*

The coolant seal is an interference fit on the shaft and a tool will be necessary to fit the seal correctly.

The tool should be made of mild steel bar to the dimensions shown in (B), as follows:

A	44,0 mm (1.73 in)
B	40,0 mm (1.57 in)
C	10,7 mm (0.42 in)
D	37,3 mm (1.47 in)
E	16,1 mm (0.63 in)
F	1,00 mm (0.04 in) at 45°
G	2,00 mm (0.08 in) at 45°

The dimensions of the tool to fit the coolant seal, will ensure that the seal is the correct length after it is installed. It will also prevent axial distortion of the seal when it is pressed onto the shaft.

Caution: *Do not lubricate the seal. It is important that the seal is not contaminated by oil or grease and if it is held in the hand, it should be held by the edge of the flange. Do not damage the ring of green sealant applied to the body of the coolant seal just behind the flange of the seal.*

Support the pulley end of the shaft, ensure that there are no sharp edges on the edge of the shaft and put the seal into position on the end of the shaft. Ensure that the ring of sealant is towards the bearings. Use the tool to press the seal onto the shaft until the bottom of the seal flange is in complete contact with the pump body. Continue to apply force for approximately ten seconds to ensure that the seal remains in position when the force is released.

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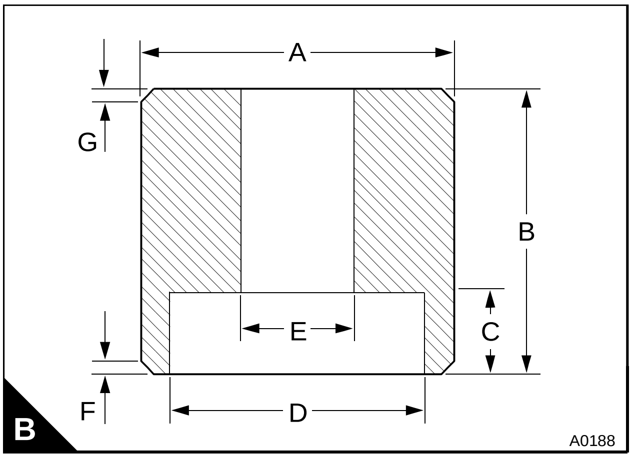
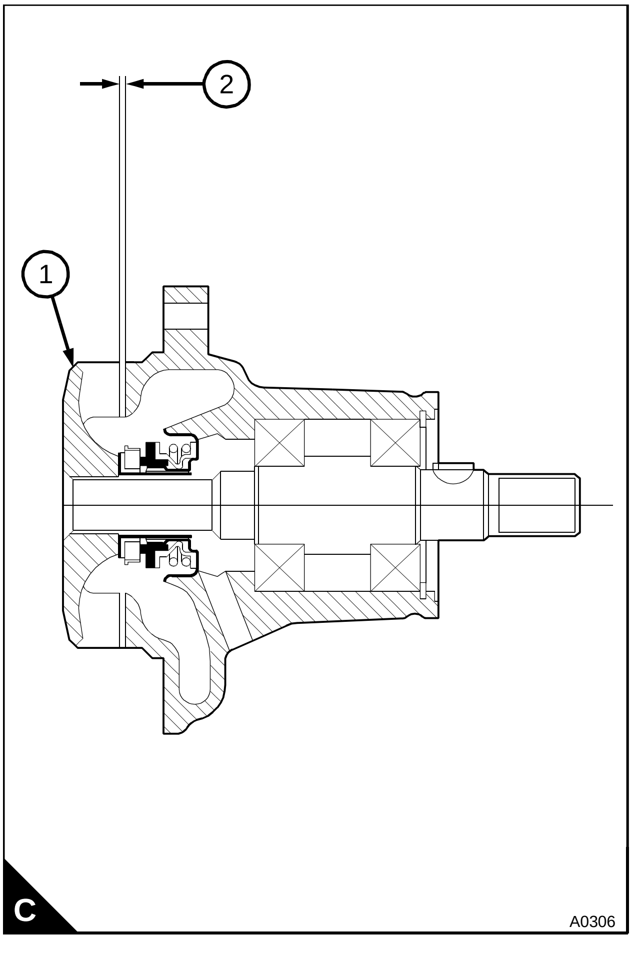
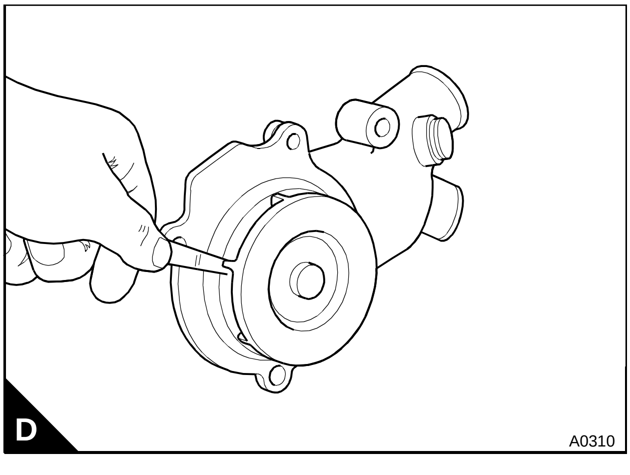


4 Support the pulley end of the shaft and press the new impeller (C1) onto the shaft until the clearance (C2) between the impeller blades and the pump body is 0,69/0,89 mm (0.027/0.035 in). For engine type AS the impeller blade clearance is 0,20/0,60 mm (0.008/0.024 in).

The clearance can be checked with a feeler gauge (D). The minimum clearance with end-float is 0,19 mm (0.007 in). Rotate the shaft to ensure that the impeller is free.

5 Fit the coolant pump to the engine, see Operation 12-14 or Operation 12-15.





Fan

To remove and to fit **Operation 12-19**

To remove

Release the setscrews and remove the fan. If necessary, fit the setscrews to retain the fan extension and the pulley to the hub.

To fit

Clean thoroughly the rear of the fan where it fits onto the fan extension. Also ensure that all paint is removed from this area. Put the pulley into position on the hub and the fan extension onto the pulley. Clean the front face of the fan extension. Fit the fan, refer to the Data and dimensions for "Special torques for setscrews and nuts" on page 37.

Fan drive (engines with gear driven coolant pumps)

To remove and to fit **Operation 12-20**

To remove

1 Loosen the pivot fasteners of the alternator and the fasteners of the adjustment link. Remove the drive belt(s).

2 Release the setscrews and remove the fan. 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 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 12-19.

3 Fit the belt(s) and adjust the tension, see Operation 14-2.

Lubricating oil cooler

To remove (four cylinder turbocharged engines) **Operation 12-21**

1 Drain the cooling system.

2 Release the support bracket at the cooler (A3).

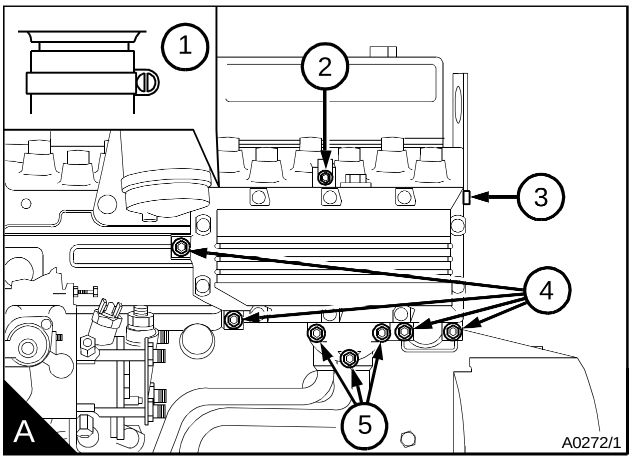
3 Release the setscrew and nut (A2) which fasten the low-pressure fuel pipes to the top of the cooler.

4 Release the hose clip at the top rear of the cooler (A1).

5 Place a suitable container under the oil cooler.

6 Release the three setscrews (A5) that retain the oil cooler pipe flange to the oil cooler.

7 Release the setscrews (A4) and remove the oil cooler.



To fit (four cylinder turbocharged engines) **Operation 12-22**

1 Renew the "O" rings on the inlet connection for the coolant (A3) and the outlet flange for the coolant (A5). Ensure that the joint faces are clean. Renew the joint (A4) for the oil pipe flange.

2 Lightly lubricate the bore of the vent connection (A2) and the "O" ring on the coolant inlet connection with clean engine lubricating oil.

3 Loosely fit the hose clip to the vent connection.

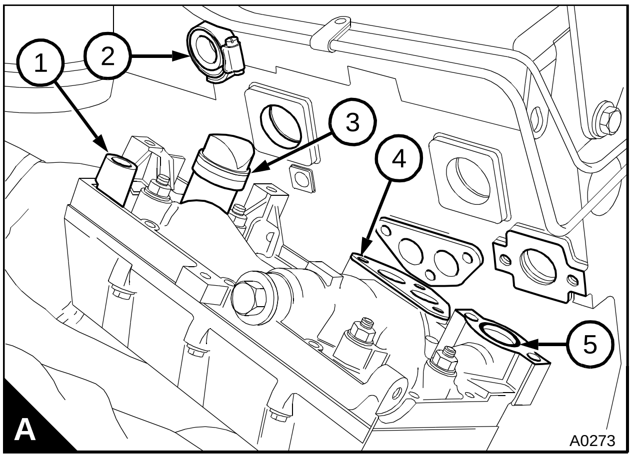
4 Fit the cooler to the engine with the vent (A1) fitted correctly in its connection. Tighten the setscrews and the hose clip of the vent connection.

5 Fit and tighten the setscrew of the support bracket.

6 Fit the setscrew and nut which fasten the low-pressure fuel pipes to the top of the oil cooler.

7 Fill the coolant system.

8 Operate the engine and check for leakage of coolant or oil.



To dismantle and to assemble (four cylinder engines) **Operation 12-23**

To dismantle

1 Remove the oil cooler from the cylinder block, see Operation 12-21.

2 Release the setscrews and remove the cover.

3 Release the self-locking nuts at the back of the oil cooler and remove the cooler element.

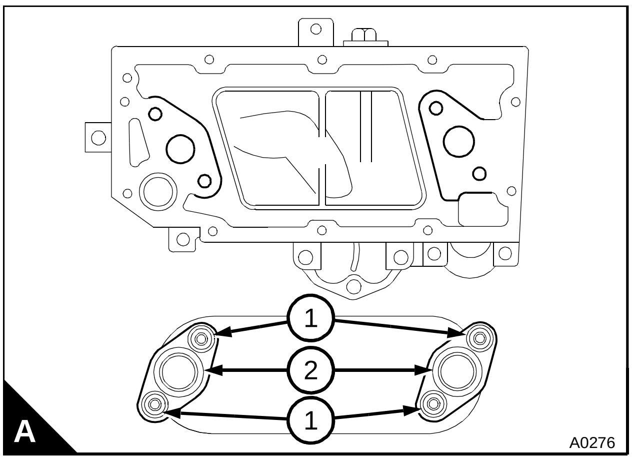
4 Clean the element and check for cracks. If a solution is used to clean the outside of the element, ensure that this does not enter the element. Check that there is nothing to restrict the flow of lubricating oil through the element of the oil cooler. If the inside of the element needs to be cleaned, 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 "O" rings (A1 and A2) on the flanges of the element and the self-locking nuts for the studs.

2 Fit the element to the backplate and tighten the self-locking nuts to 22 Nm (16 lbf ft) 2,2 kgf m.

3 Fit the cover and a new joint to the cooler backplate and tighten the setscrews to 11 Nm (8 lbf ft) 1,1 kgf m.



To remove (six cylinder turbocharged engines) **Operation 12-24**

Early lubricating oil coolers fitted to six cylinder engines have an aluminium cover, the cooler element may have a baffle (A3) to control coolant flow. The cooler element must be fitted with the baffle toward the front of the engine (A1).

Later lubricating oil coolers fitted to six cylinder engines have a pressed steel cover, the cooler element may have a baffle (A3) to control coolant flow. If the cooler element has a baffle, it must be fitted with the baffle towards the front of the engine (A1).

To remove an early type lubricating oil cooler

1 Drain the cooling system.

Warning! *The engine oil may be hot, allow the engine temperature to cool down before the oil pipes are released.*

2 Put a suitable container under the oil cooler and remove the lubricating oil pipes from the oil cooler, see Operation 10-15.

3 Release the setscrews and nuts of the cover of the oil cooler and remove the cover together with the element (A2). Thoroughly clean the flange face of the cover and the cylinder block.

4 If an overhaul of the oil cooler is necessary, see Operation 12-26.

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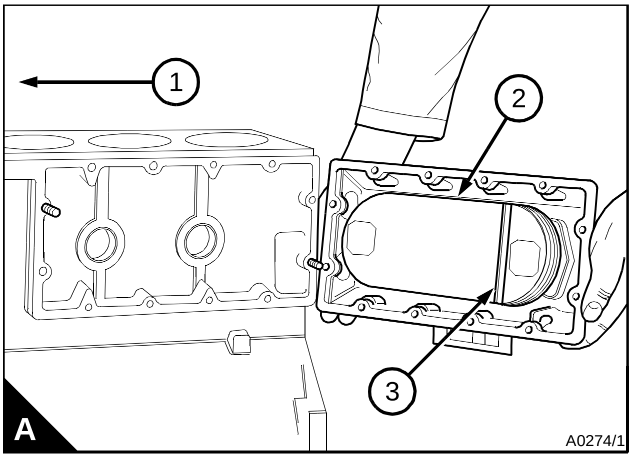


To remove a later type lubricating oil cooler

1 Drain the cooling system.

Warning! *The engine oil may be hot, allow the engine temperature to cool down before the oil pipes are released.*

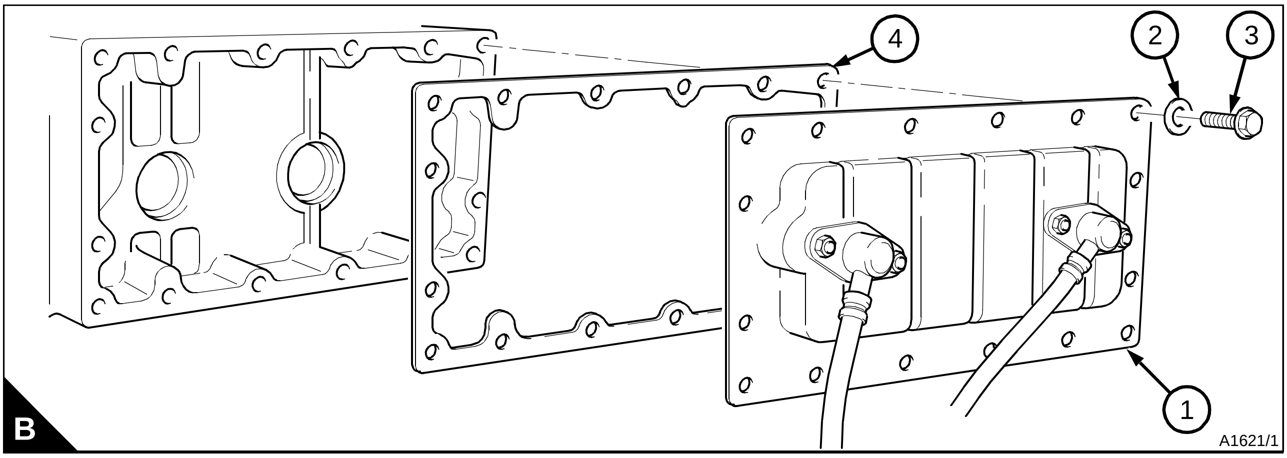
Caution: *Do not remove both of the oil pipes at the same time.*

2 Put a suitable container under the oil cooler and remove the lubricating oil pipes from the oil cooler, see Operation 10-15.

3 Release the setscrews and nuts (A3) of the cover of the oil cooler and remove the cover (A1) together with the element. Thoroughly clean the flange face of the cover and the cylinder block.

Note: A liquid joint may have been used in the factory, this must be removed and a new joint fitted in its place.

4 If an overhaul of the oil cooler is necessary, see Operation 12-26.



To fit (six cylinder turbocharged engines) **Operation 12-25**

To fit an early type lubricating oil cooler or blanking plate

Special requirements

Consumable products	
Description	**Part number**
POWERPART Silicone rubber sealant	1861108

Early lubricating oil coolers fitted to six cylinder engines have an aluminium cover, the cooler element may have a baffle (A3) to control coolant flow. The cooler element must be fitted with the baffle toward the front of the engine (A1).

1 Thoroughly clean the joint faces of the lubricating oil cooler housing and the cylinder block.

2 Fit a new joint (C2) to the cylinder block (sealant must not be used on the joint).

3 Fit the lubricating oil cooler (C1) to the cylinder block.

4 Tighten the setscrews or nuts in sequence (B) to 28 Nm (20 lbf ft) 2.8 kgf m.

Note: Do not fit sealing washers to the setscrews.

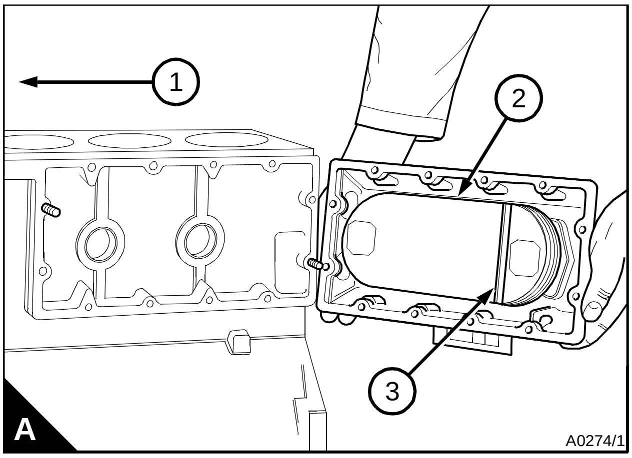
5 Fit the lubricating oil pipes to the cover, see Operation 10-16.

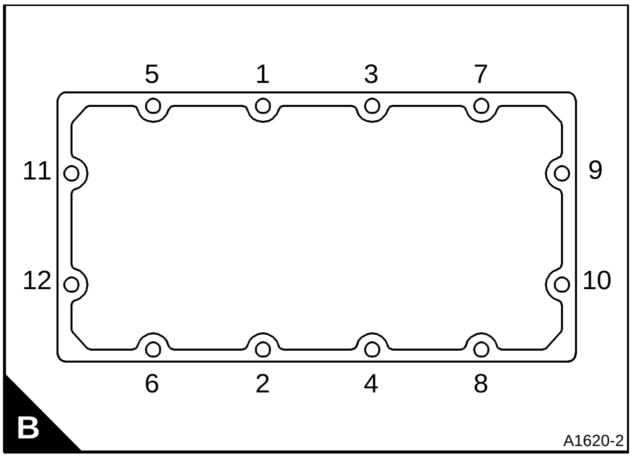
6 Fill the cooling system.

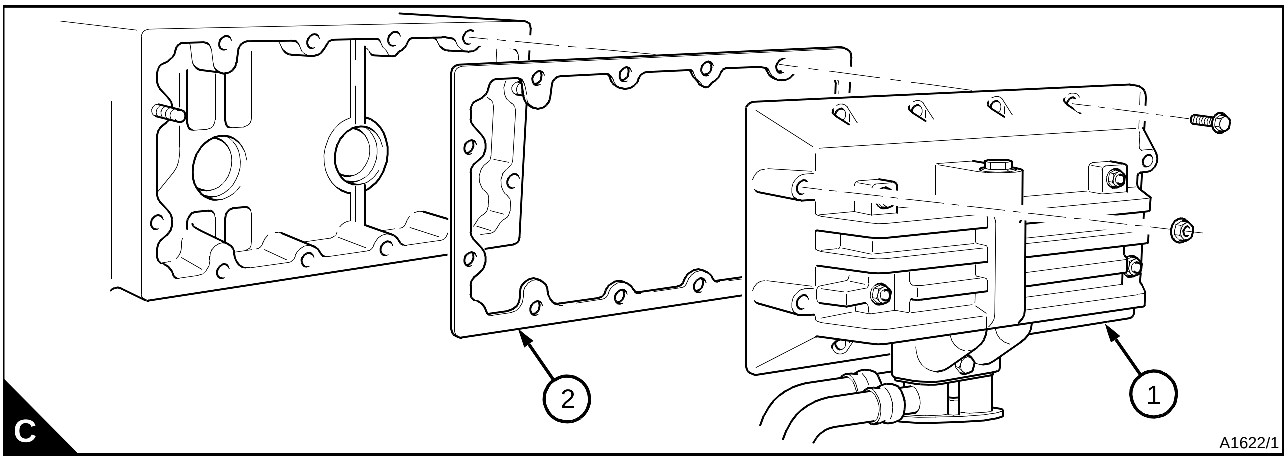
7 Operate the engine and check for oil or coolant leakage.

To fit an aluminium blanking plate

To fit an aluminium blanking plate use the same procedure as above.







To fit a later type lubricating oil cooler or blanking plate

Later lubricating oil coolers fitted to six cylinder engines have a pressed steel cover.

1 Thoroughly clean the joint faces of the lubricating oil cooler housing and the cylinder block. Thoroughly clean the seating area around the holes for the setscrews on the front face of the lubricating oil cooler.

Note: If damage is found on the seating area around the holes for the setscrews on the front face of the lubricating oil cooler housing, the lubricating oil cooler housing must be renewed.

2 Thoroughly clean the seating face of the heads on all setscrews.

3 Remove any studs from positions 10,11 and 16 on the tightening sequence (D). MEAS coated setscrews must be fitted in these positions to ensure that coolant does not leak. If the setscrews are to be re-used the male and female threads must be cleaned and POWERPART Silicone rubber sealant applied to the first 13 mm (0.5 in) of the setscrews before they are fitted.

4 Fit a new joint (E4) to the cylinder block (sealant must not be used on the joint).

5 Fit the lubricating oil cooler (E1) to the cylinder block, ensure that sealing washers (E2) part number 2415D022 are used on all setscrews (E3).

Note: Sealing washers must not be fitted on any additional studs or spacers.

6 Tighten the setscrews in sequence (D) to 28 Nm (20 lbf ft) 2.8 kgf m.

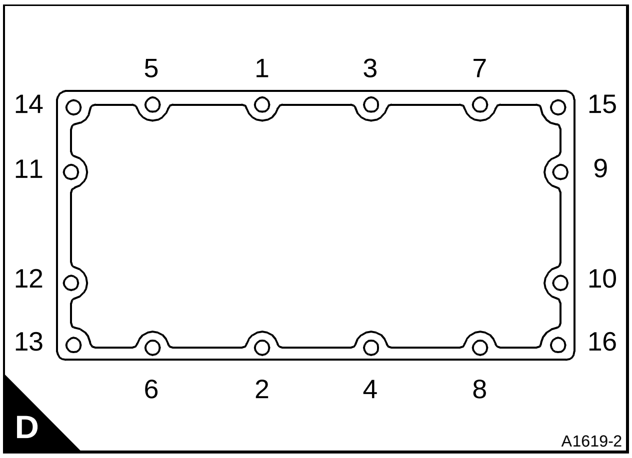
7 Fit the lubricating oil pipes to the cover, see Operation 10-16.

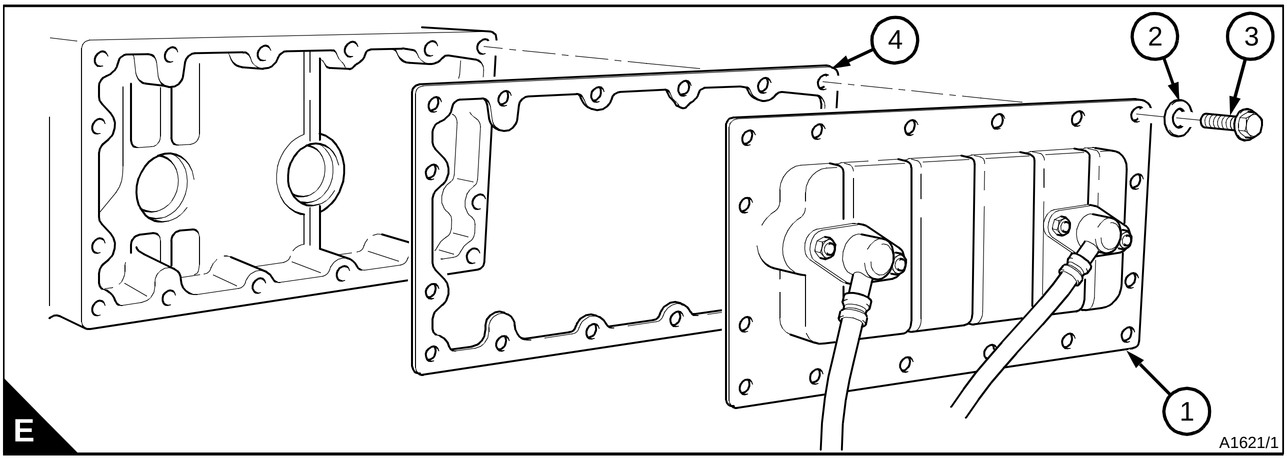
8 Fill the cooling system.

9 Operate the engine and check for oil or coolant leakage.

To fit a steel blanking plate

To fit a steel blanking plate use the same procedure as above.





To dismantle and to assemble (six cylinder engines) **Operation 12-26**

To dismantle an early type lubricating oil cooler

1 Remove the lubricating oil cooler, see Operation 12-24.

2 Release the nuts on the front of the cover and remove the element of the oil cooler (A).

Warning! *Do not allow compressed air to contact your skin. If compressed air enters your skin, obtain medical help immediately.*

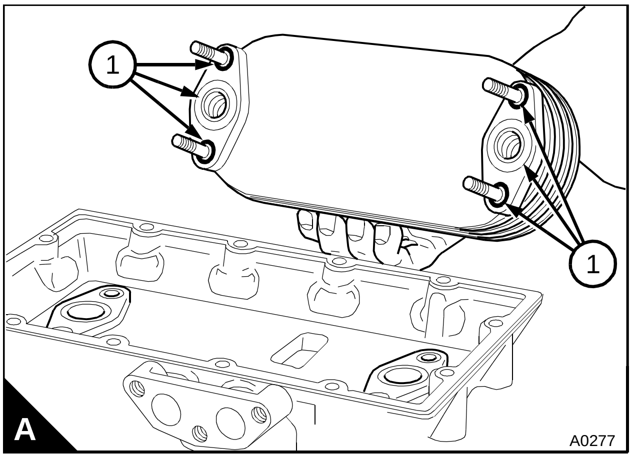
3 Clean the element and check for cracks. If a solution is used to clean the outside of the element, ensure that this does not enter the element. Check that there is nothing to restrict the flow of lubricating oil through the element of the oil cooler. If the inside of the element needs to be cleaned, 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 an early type lubricating oil cooler

1 Renew the "O" rings (A1) on the flanges of the element.

Caution: *Some oil coolers fitted to six cylinder engines have a baffle to control coolant flow. The cooler element must be fitted with the baffle towards the front of the engine.*

2 Fit the element of the oil cooler to the cover and tighten the nuts to 22 Nm (16 lbf ft) 2,2 kgf m.



To dismantle a later type lubricating oil cooler

1 Remove the oil cooler from the cylinder block, see Operation 12-25.

2 Put the oil cooler assembly on a clean work surface. Release the four nuts that retain the flanges for the lubricating oil pipes. The pipe flanges are in two pieces.

3 Remove the cover (B1) from the four studs (B2) of the oil cooler element (B3).

Warning! *Do not allow compressed air to contact your skin. If compressed air enters your skin, obtain medical help immediately.*

4 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 is nothing to restrict 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.

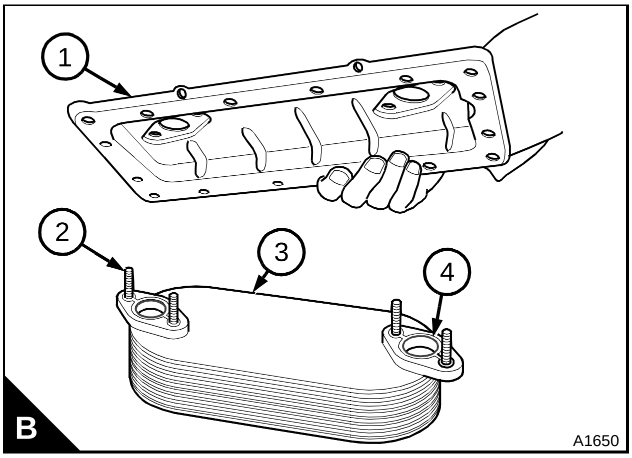
To assemble a later type lubricating oil cooler

Clean the flange face and the seats for the three-piece “O” rings.

1 Fit new "O" rings (B4).

2 Fit the cover of the oil cooler (B1) to the element.

3 Fit the two-piece flanges onto the studs (B2). Loosely tighten the nuts to retain the element when the oil cooler assembly is fitted to the engine.



To remove and to fit (canister type) **Operation 12-27**

To remove

1 Drain the cooling system.

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

To fit

1 Clean the joint face of the filter head (A2).

2 Check the washer (A4) and the seals (A7 and A8) for damage. Renew the washer and the seals if they are damaged or worn. Lightly lubricate the seals with clean lubricating oil.

3 Push the hose connections for the coolant pipes onto the lubricating oil cooler. Hold the oil cooler in position against the filter head and fit the threaded adaptor. Tighten the threaded adaptor to 57 Nm (42 lbf ft) 5,8 kgf m. Ensure that the hose connections are fitted correctly and tighten the hose clips.

4 Fill the cooling system.

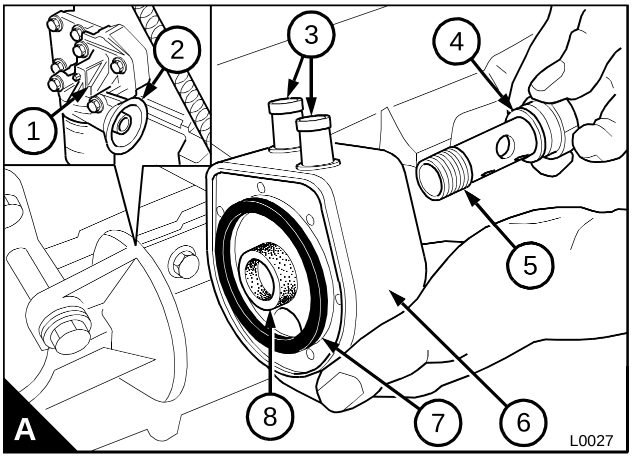
5 Operate the engine and check for leakage of coolant or oil.

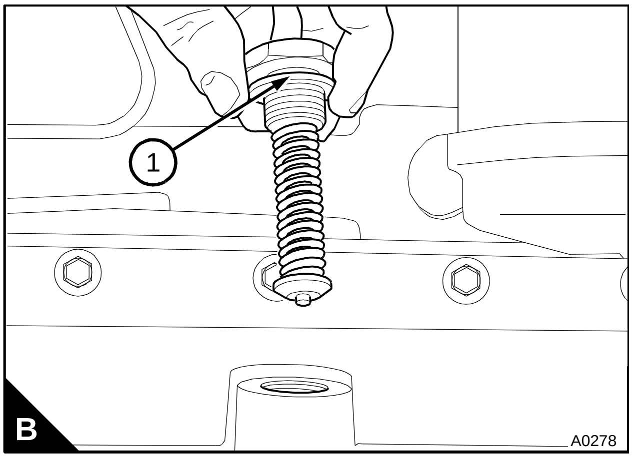
To remove and to fit cooler bypass valve **Operation 12-28**

1 Release the hexagonal cap and remove the bypass valve (B).

2 Check the valve spring and the seat for damage and renew the complete assembly, as necessary.

3 Renew the aluminium washer (B1). Fit the bypass valve into the oil cooler and tighten the cap to 50 Nm (37 lbf ft) 5,1 kgf m.



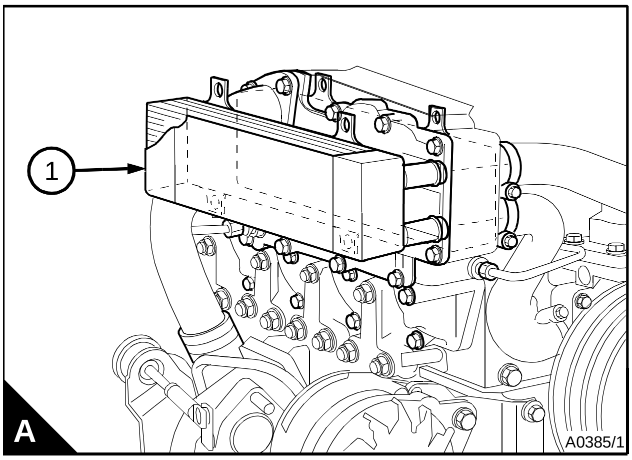


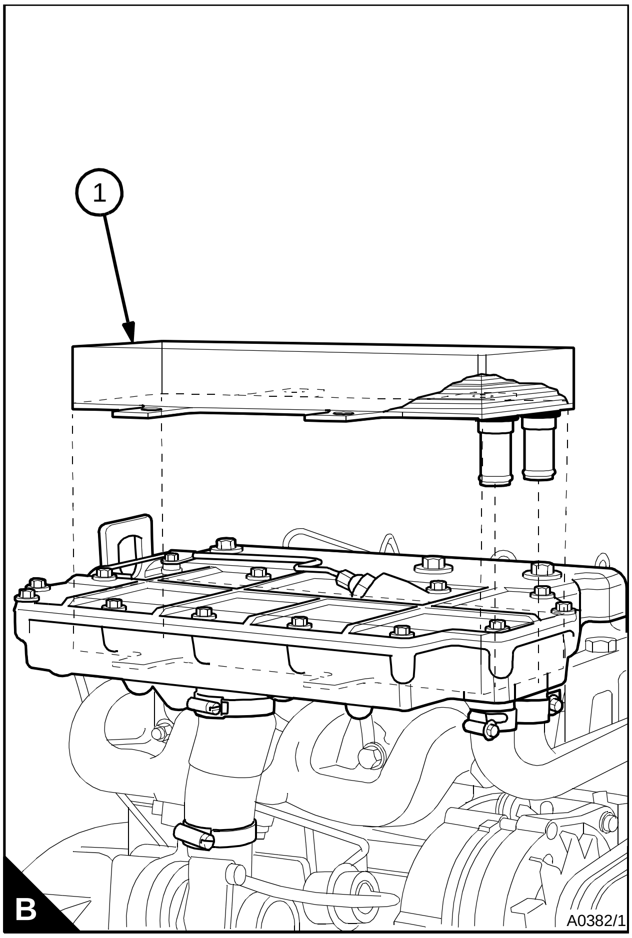
Intercoolers

A water-to-air intercooler assembly is fitted to the induction manifold of some four and six cylinder high-rated engines to cool the air between the turbocharger and the combustion chamber. Hot air from the turbocharger passes through the casing of the intercooler and over the fins on the integral tube stack (A1) or (B1) before it enters the combustion chamber. The air is cooled by the coolant which passes through the tubes of the tube stack. Coolant is circulated through the tube stack by the engine coolant pump and is returned to the thermostat housing.

The tube stack can be removed from the induction manifold, and if necessary renewed.

The intercooler assembly may be mounted either horizontally or vertically.





Horizontally mounted intercooler

To remove **Operation 12-29**

1 Release the hose clips (A9) which fasten the air hose from the turbocharger to the intercooler. Slide the hose away from the intercooler air inlet pipe.

Warning! *Do not drain the coolant while the engine is still hot and the system is under pressure because dangerous hot coolant can be discharged.*

2 Drain the coolant system. Release the hose clips (A5) which fasten the hoses to the coolant inlet and the outlet connections of the tube stack. Remove the hoses.

3 If a fuelled starting aid (A4) is fitted to the intercooler top cover (A6), remove the electrical connection and the fuel pipe.

Caution: *Do not use a lever between the flange faces to separate the intercooler top cover from the induction manifold.*

4 Release the setscrews (A8) which retain the intercooler top cover to the induction manifold (A7); work from the outside of the flange to the centre. Remove the top cover and discard the joint.

Caution: *Be careful with the tubestack (A1) when it is removed and fitted, be especially careful not to damage the fins.*

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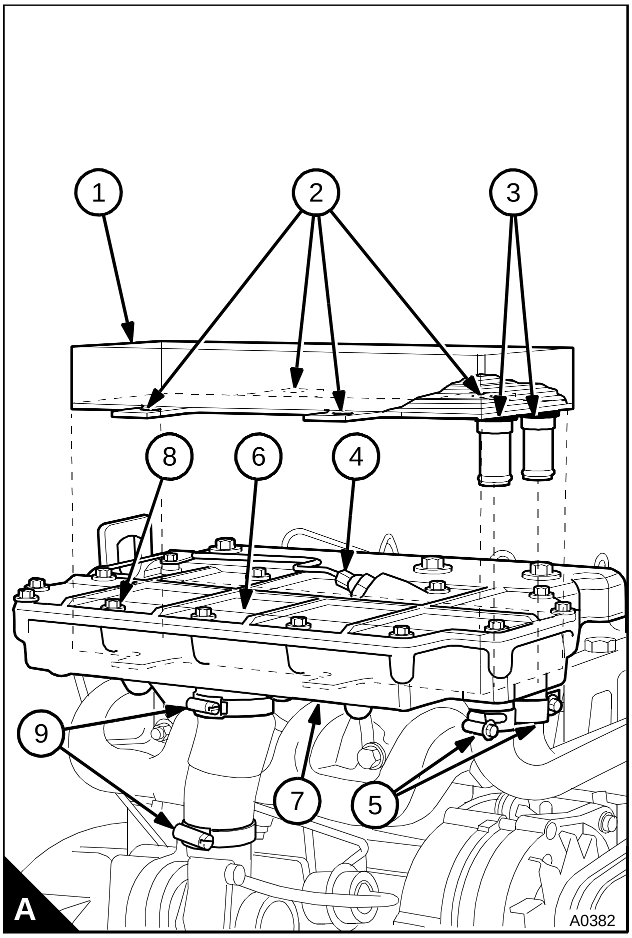
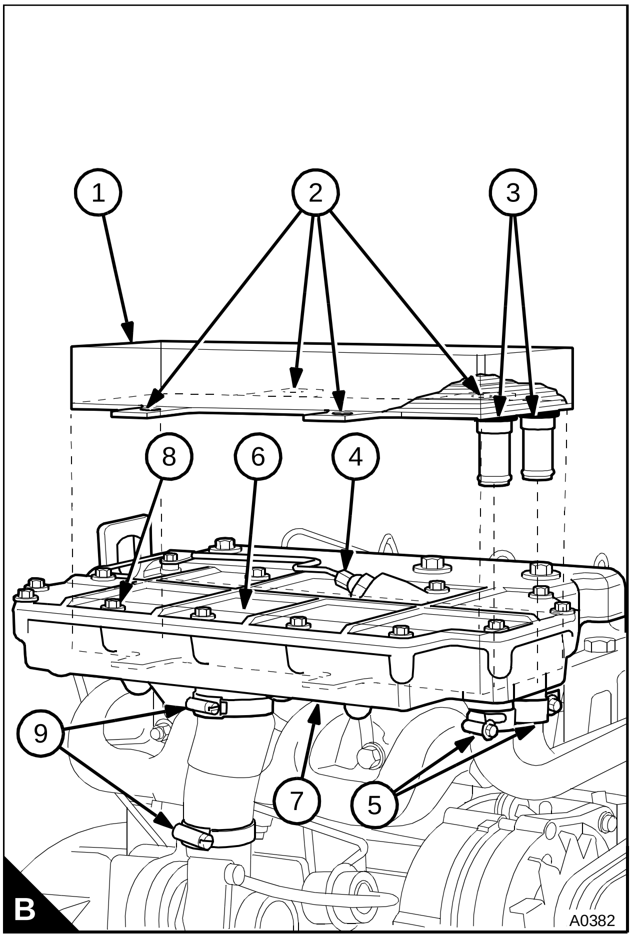


5 Remove the four setscrews (B2); six cylinder engines have six setscrews, that secure the tubestack to the induction manifold.

6 Carefully lift the tubestack from the induction manifold, Do not use force. It may be necessary to push the inlet and outlet connections from the outside of the manifold to fully release the tubestack. Remove and discard the "O" rings (B3) for the inlet and outlet connections.

7 Clean and inspect the intercooler assembly, see Operation 12-33.



To fit **Operation 12-30**

Special requirements

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

Adhesive sealing strips are fitted to the intercooler top cover and the induction manifold to seal the external surfaces of the tubestack. This is necessary to ensure that all of the air which enters the intercooler passes through the fins of the tubestack.

1 Renew the adhesive sealing strips (A1) that are fitted to the bottom of the induction manifold and the intercooler top cover:

Remove the tape from the adhesive strip. Ensure that the sealing strip is fitted in a straight line, onto the flat machined surface on the cover and the cast surface of the manifold. Ensure that the ends are aligned with the vertical machined surface (A3) on each side of the manifold.

Note: Be careful with the tubestack when it is removed and fitted, be especially careful not to damage the fins.

2 Put the "O" rings (A2) into position against the large shoulder, on the inlet and outlet connections of the tubestack. Apply a bead of sealant (B2) POWERPART Silicone rubber sealant to the “O” rings (B1). Carefully position the tubestack in the induction manifold, ensure that the inlet and outlet connections are centred as they enter the holes in the manifold.

The tubestack will be in contact with the bottom of the manifold, if the "O" rings are fitted correctly.

Note: The setscrews for securing the tube stack 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.

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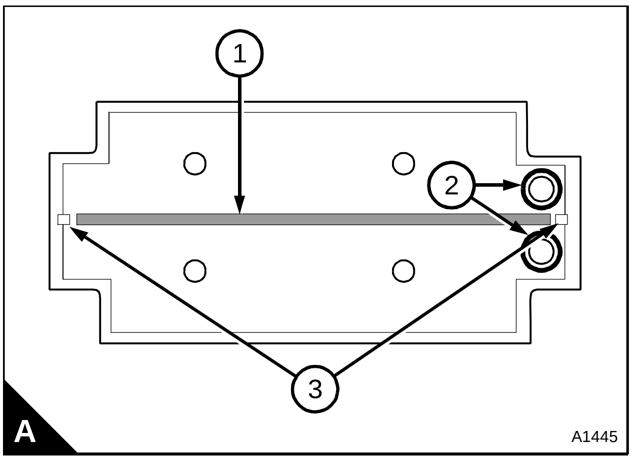
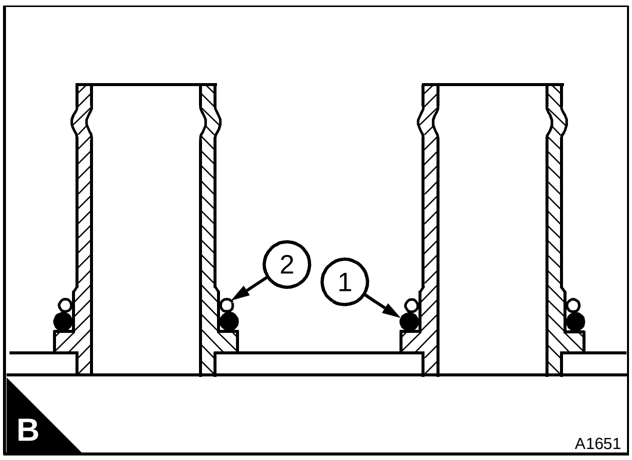




3 Fit the setscrews which retain the tubestack to the induction manifold and tighten them gradually and evenly to 22 Nm (16 lb ft) 2,2 kgf m.

4 Renew the joint between the flange face of the intercooler top cover and induction manifold. The joint is fitted without sealant.

5 Put the intercooler top cover into position and fit the setscrews which retain the intercooler top cover to the induction manifold and tighten them gradually and evenly to 22 Nm (16 lb ft) 2,2 kgf m. Work from the centre of the flange to the outside.

6 Connect the fuel pipe to the connection of the fuelled starting aid and fit the electrical connection. Eliminate air from the fuelled starting aid, see Operation 14-11.

7 Fit the hoses and the hose clips to the coolant inlet and the outlet connections of the tube stack and tighten the clips. Fill the coolant system.

8 Fit the air hose from the turbocharger to the intercooler assembly and tighten the hose clips.

Note: If a hose that has a heat shield is renewed, ensure that the new part is of the correct type and it is fitted in the correct position.

9 Operate the engine and check for coolant and air leaks.

Vertically mounted intercooler

To remove **Operation 12-31**

1 Release the hose clips (A7) which fasten the air hose from the turbocharger to the intercooler. Slide the hose away from the intercooler air inlet pipe.

Warning! *Do not drain the coolant while the engine is still hot and the system is under pressure because dangerous hot coolant can be discharged.*

2 Drain the coolant system and release the hose clips (A5) which fasten the hoses to the coolant inlet and the outlet connections of the tube stack. Remove the hoses.

3 If a fuelled starting aid (A8) is fitted to the intercooler top cover (A4), remove the electrical connection and the fuel pipe.

Caution: *Do not use a lever between the flange faces to separate the intercooler top cover from the induction manifold.*

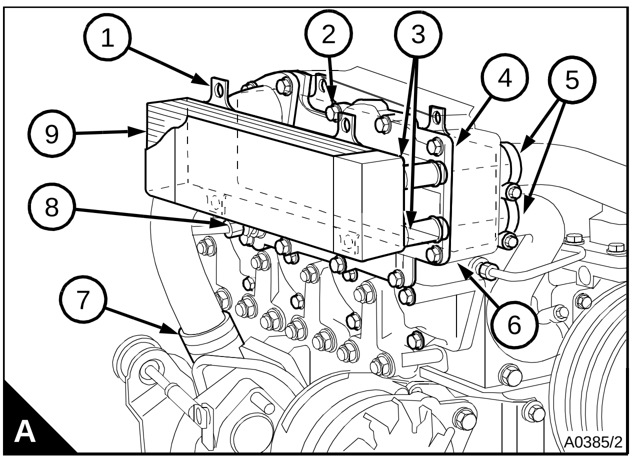
4 Release the setscrews (A2) which retain the intercooler top cover to the induction manifold (A6); work from the outside of the flange to the centre. Remove the top cover and discard the joint.

Caution: *Be careful with the tubestack (A9) when it is removed and fitted, be especially careful not to damage the fins.*

5 Remove the four setscrews (A1), six cylinder engines have six setscrews, that secure the tubestack to the induction manifold.

6 Carefully lift the tubestack from the induction manifold, Do not use force. It may be necessary to push the inlet and outlet connections from the outside of the manifold to fully release the tubestack. Remove and discard the "O" rings (A3) for the inlet and outlet connections.

7 Clean and inspect the intercooler assembly, see Operation 12-33.



To fit **Operation 12-32**

Special requirements

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

Adhesive sealing strips are fitted to the top cover and the induction manifold to seal the external surfaces of the tubestack. This is necessary to ensure that all of the air which enters the intercooler passes through the fins of the tubestack.

1 Renew the adhesive sealing strips (A1) that are fitted to the bottom of the induction manifold and the top cover:

Remove the tape from the adhesive strip. Ensure that the sealing strip is fitted in a straight line, onto the flat machined surface on the cover and the cast surface of the manifold. Ensure that the ends are aligned with the vertical machined surface (A3) on each side of the manifold.

Note: Be careful with the tubestack when it is removed and fitted, be especially careful not to damage the fins.

2 Put the "O" rings (A2) into position against the large shoulder, on the inlet and outlet connections of the tubestack. Apply a bead of sealant (B2) POWERPART Silicone rubber sealant to the “O” rings (B1). Carefully position the tubestack in the induction manifold, ensure that the inlet and outlet connections are centred as they enter the holes in the manifold.

The tubestack will be in contact with the bottom of the manifold, if the "O" rings are fitted correctly.

Note: The setscrews for securing the tube stack 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.

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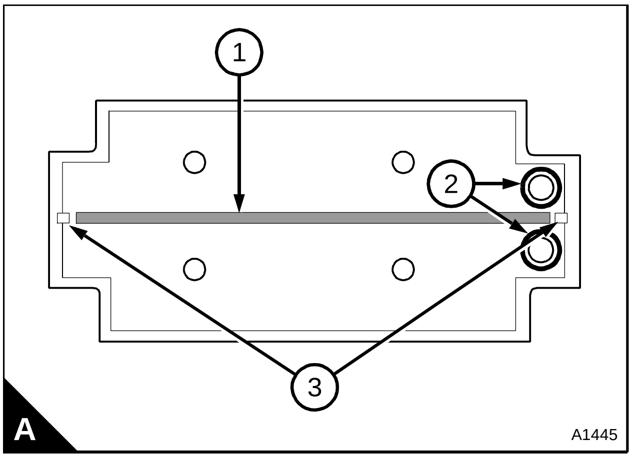

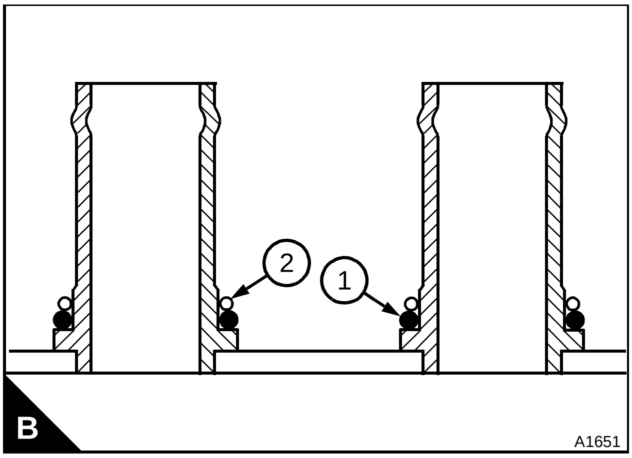

3 Fit the setscrews which retain the tubestack to the induction manifold and tighten them gradually and evenly to 22 Nm (16 lb ft) 2,2 kgf m.

4 Renew the joint between the flange face of the intercooler top cover and induction manifold. The joint is fitted without sealant.

5 Put the intercooler top cover into position and fit the setscrews which retain the intercooler top cover to the induction manifold and tighten them gradually and evenly to 22 Nm (16 lb ft) 2,2 kgf m. Work from the centre of the flange to the outside.

6 Connect the fuel pipe to the connection of the fuelled starting aid and fit the electrical connection. Eliminate air from the fuelled starting aid, see Operation 14-11.

7 Fit the hoses and the hose clips to the coolant inlet and the outlet connections of the tube stack and tighten the clips. Fill the coolant system.

8 Fit the air hose from the turbocharger to the intercooler assembly and tighten the hose clips.

Note: If a hose that has a heat shield is renewed, ensure that the new part is of the correct type and it is fitted in the correct position.

9 Operate the engine and check for coolant and air leaks.

To clean and to inspect **Operation 12-33**

To clean

1 Thoroughly clean the flange face of the intercooler top cover and the induction manifold with an approved detergent solution.

Warning! *Do not allow compressed air to contact your skin, if compressed air enters your skin obtain medical help immediately.*

Caution: *Do not clean the tube stack in a caustic solution.*

2 Soak the fins of the tube stack in an approved detergent degreasing fluid. Allow the excess fluid to drain off and dry the fins with low pressure compressed air.

3 Flush the tube stack through the outlet connection, in the opposite direction of coolant flow, with clean water.

4 Thoroughly clean the internal and external surfaces of the intercooler casing, with an approved detergent solution. It is important that the seats for the "O" rings are thoroughly cleaned.

To inspect

1 Check the casing of the intercooler for cracks or distortion, especially the flange faces which must be flat to prevent leakage.

2 Check the tube stack for signs of leakage, cracks, damaged fins or damaged hose connections. If the tube stack is damaged or the tubes are restricted the tube stack must be renewed.

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13

Flywheel and housing

General description

The steel flywheel is fitted with a hardened starter ring. Generally the starter rings have 126 or 115 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 and fit temporarily two guide studs to ensure safety when the flywheel is removed and fitted.

2 Remove the remainder of the setscrews and washers and remove the flywheel.

3 Check the flywheel and ring gear for damage and renew, if necessary.

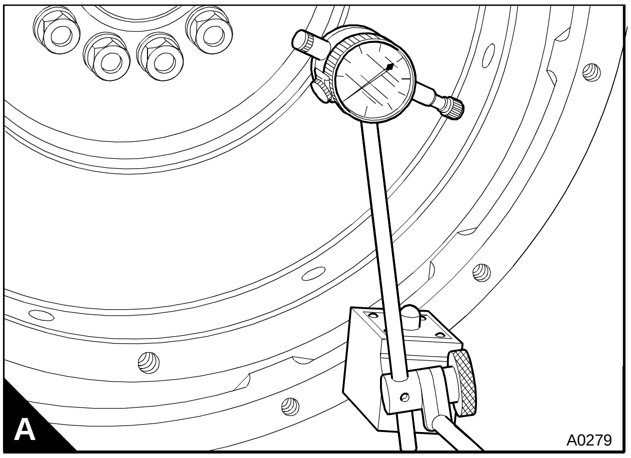
To fit

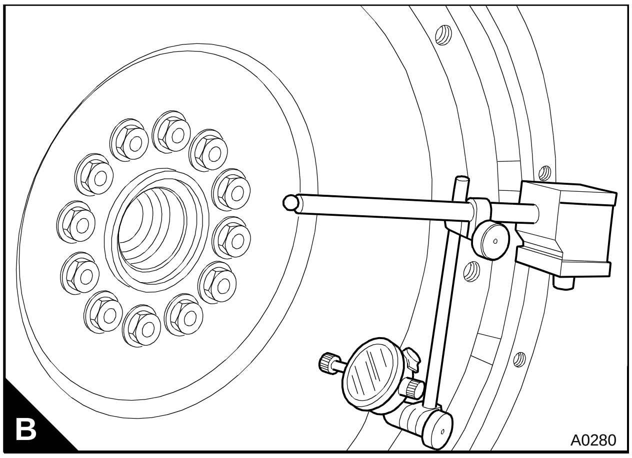
1 Ensure that the location faces of the crankshaft and the flywheel are clean and free from damage.

2 Fit the flywheel over the guide studs. Fit four setscrews and their washers. Remove the guide studs and fit the remainder of the setscrews and the washers. Tighten the setscrews to 105 Nm (77 lbf ft) 10,7 kgf m.

3 Check the flywheel run-out with a dial test indicator (A). This must be less than 0,30 mm (0.012 in) total indicator reading.

4 Check the alignment of the flywheel face (B). The error in alignment must not be more than 0,03 mm (0.001 in) total indicator reading for every 25 mm (1.0 in) of the flywheel radius from the crankshaft axis to the indicator plunger. During this check, keep the crankshaft pressed toward the front to remove the effect of crankshaft end-float.





Ring gear

To remove and to fit **Operation 13-2**

To remove

Warning! *Wear eye protection during this operation.*

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

To fit

The ring gear is heated onto the flywheel. When a new gear is to be fitted, ensure that it is not heated to more than 250 °C (480 °F). Ensure that the chamfer on the teeth of the gear is in the correct direction.

Flywheel housing

To remove and to fit **Operation 13-3**

Warning! *The flywheel housing is heavy, use lift equipment or get 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.

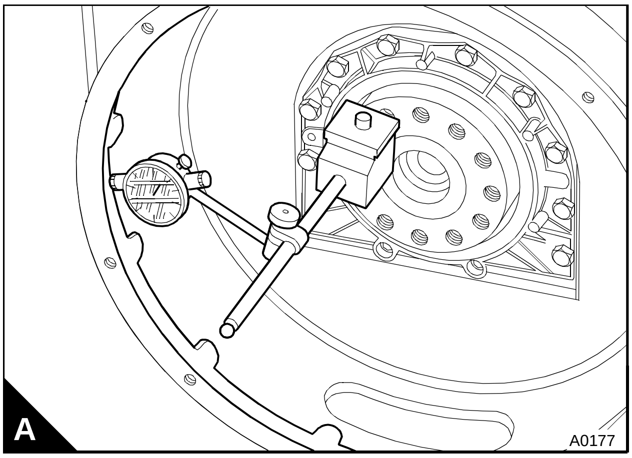
2 Fit the housing onto the dowels and tighten lightly the setscrews.

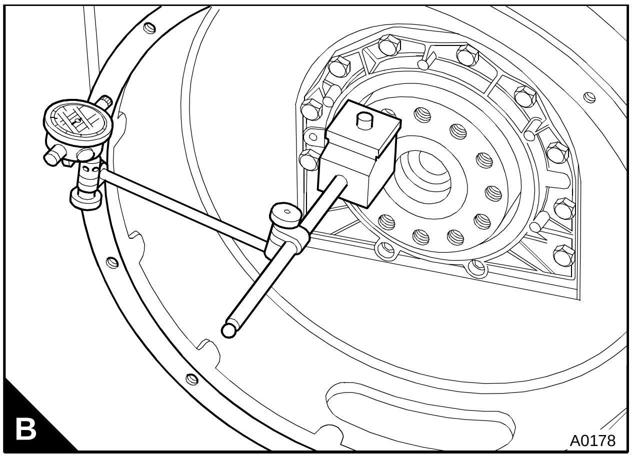
3 Check the housing concentricity with a dial test indicator (A). Refer to the Data and dimensions for "Limits for flywheel housing run-out and alignment (total indicator reading)" on page 33. If any adjustment is necessary, it must be made on the housing and the concentricity checked again.

4 Tighten the setscrews, refer to the Data and dimensions for "Specific torque tensions" on page 37.

5 Check the housing alignment (B). Refer to the Data and dimensions for "Limits for flywheel housing run-out and alignment (total indicator reading)" on page 33. 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

Alternators

General description

The alternator is driven from the crankshaft pulley by single or double belt(s).

The Lucas/Delphi AC5RS, Magneti Marelli A127 and the Bosch KI 12 volt and NI 24 volt alternators have solid state regulators fitted at the rear. The regulator of the Magneti Marelli A127 alternator includes the brush box as a part of the unit. The regulators of both alternators are sealed and repair is not possible.

Precautions

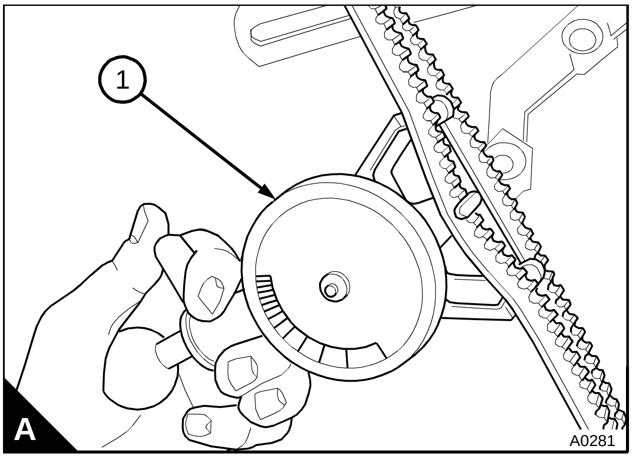
To prevent damage to the diodes and to the resistors, the precautions given below must be followed:

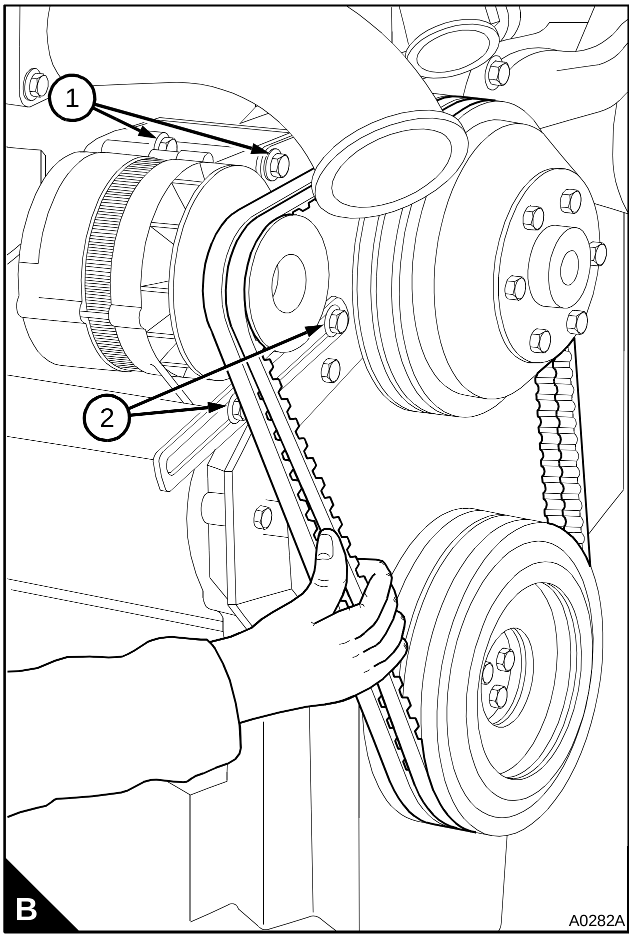
- Do not disconnect the battery while the engine is in operation. This will cause a voltage surge in the alternator charge system which will immediately cause damage to the diodes or to the transistors.
- Do not disconnect an electrical wire before the engine is stopped and all electrical switches are in the "off" position.
- Do not cause a short circuit by the connection of electrical wires to the wrong terminals. The correct electrical wire must be connected to the correct terminal. A short circuit or wrong connection which gives reverse polarity will immediately cause permanent damage to the diodes and to the transistors.
- Do not connect a battery into the system until it has been checked for correct polarity and voltage.
- Do not check for current flow with a spark contact as damage can be caused to the transistors.

To check the drive belts **Operation 14-1**

1 Check the belt(s) for wear and damage and renew the belt(s), if necessary. If twin belts are fitted, they should both be renewed.

2 Check the belt tension. If twin belts are fitted, check/adjust the tension on the tighter belt. 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 355 N (80 lbf) 36 kgf. If the tension is equal to or less than 220 N (50 lbf) 22 kgf, adjust it to 355 N (80 lbf) 36 kgf, see Operation 14-2. If no gauge is available, press down the belt with the thumb at the centre of the longest free length and check the deflection (B). With moderate thumb pressure, 45 N (10 lbf) 4,5 kgf, the correct belt deflection is 10 mm ($^3/_8$ in).



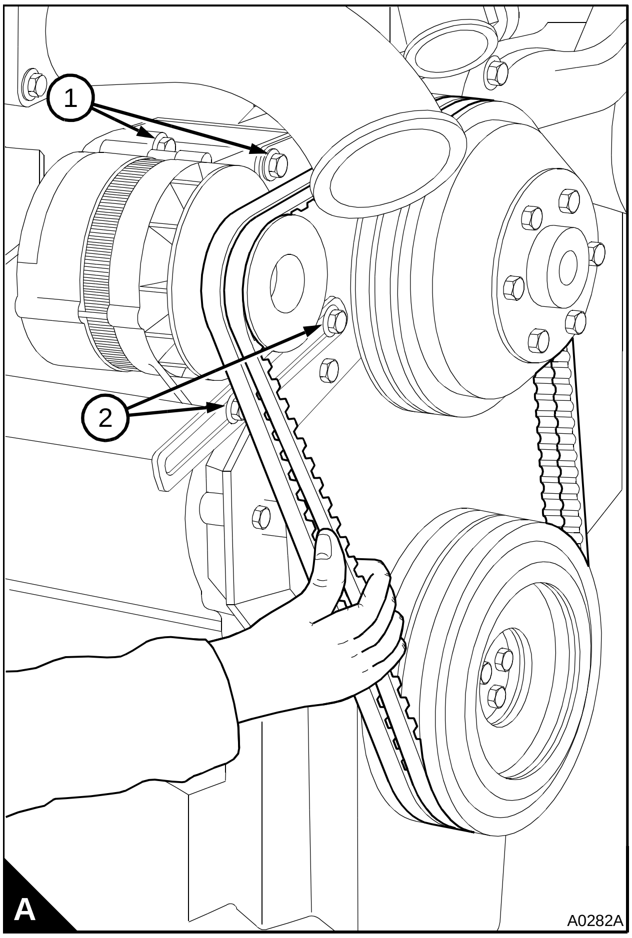


To adjust drive belt tension **Operation 14-2**

1 Loosen the pivot fasteners (A1) of the alternator and the fasteners of the adjustment link (A2).

2 Change the position of the alternator to give the correct tension. Tighten the adjustment link fasteners, refer to the Data and dimensions for "Special torques for setscrews and nuts" on page 37 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.



To remove and to fit the drive belts

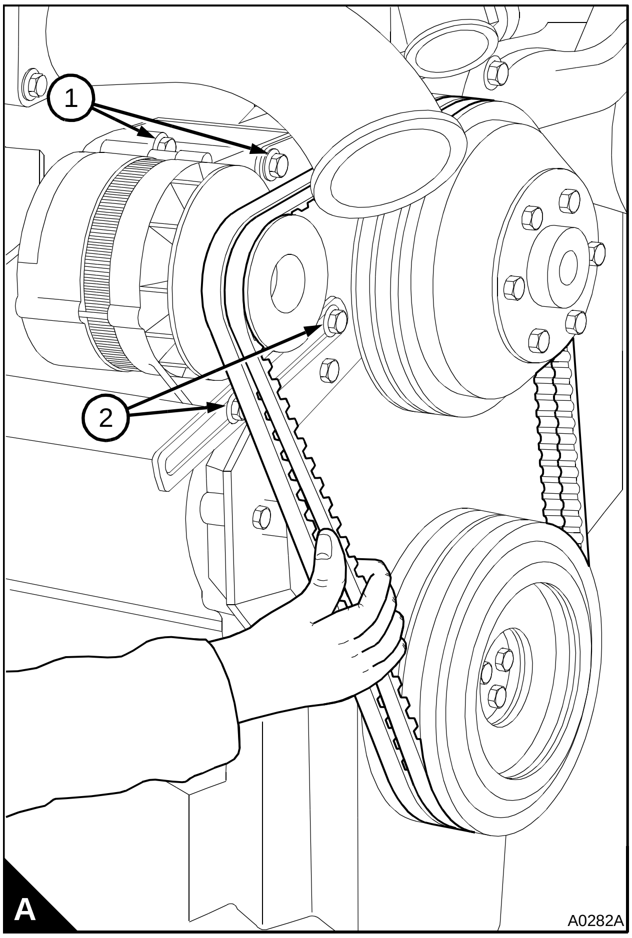
Operation 14-3

Where twin belts are fitted, they are supplied as a set and must be renewed as a set.

1 Loosen the pivot fasteners (A1) of the alternator and the adjustment link fasteners (A2).

2 Release all of the tension from the belt(s) and remove the belt(s).

3 Fit the new belt(s) 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

1 Disconnect the electrical connection.

2 Loosen the pivot fasteners of the alternator and the fasteners of the adjustment link.

3 Release all the belt tension and remove the belt(s).

4 Remove the adjustment link from the alternator and remove the pivot bolt(s). 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 ± 2,4 mm (3/32 in).

2 Fit the drive belt(s) and adjust the drive belt tension, see Operation 14-2. Tighten the fasteners and check the tension again.

3 Connect the electrical connection.

To maintain **Operation 14-5**

1 Ensure that the drive belts are not worn and that the belt tension is correct.

2 Keep the alternator clean. To clean the alternator, use a material which is damp with kerosene or a special fluid used for this purpose. Ensure that the fluid does not enter the cover of the alternator.

3 Ensure that air can pass easily over the casing to keep it cool.

Fault diagnosis **Operation 14-6**

The alternator is designed in such a way that a flow of current (indicated by no light at the warning light or a reading shown on an ammeter) shows that the system is in correct operation. If the system is in correct operation, no open circuit, voltage or current output checks need to be done on the installation unless:

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

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

1 Ensure that the battery is fully charged.

2 Connect a moving-coil voltmeter of good quality, with a range of 0-50 volts, across the positive and negative terminals of the alternator. If an ammeter is not fitted in the electrical circuit, fit a moving-coil ammeter of good quality, with a range of 0-100 ampere, in the wire between the alternator and the positive terminal of the battery.

3 Turn the warning light switch to the "ON" position (main switch on instrument panel); the warning light should be illuminated.

4 Switch on a 10-15 ampere load, for example, lights, fans, etc.

5 Start the engine and operate it at a fast idle speed; either the warning light should be extinguished or the ammeter indicates a small change in the current in relationship to the engine speed.

6 Increase the engine speed for a moment to near maximum speed, when the charge current should be approximately equal to the rating for the alternator, refer to the Data and dimensions for "Alternators" on page 34.

7 Operate the alternator at approximately half speed (engine speed approximately 1500 rev/min) and remove the electrical load. The voltage should go up to 14 volts for a 12 volt system or 28 volts for a 24 volt system and then remain constant. At the same time the current reading should show a reduction.

Any change in the above data can indicate a fault and the procedure that follows should be used before any components are disconnected. This procedure is not suitable for A127 alternators and, if a fault is found, the alternator should be removed for test by a specialist.

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

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

Check the bulb. If no fault:

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

If no fault:

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

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

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

Continued

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

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

If no fault:

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

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

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

If the warning light continues to show when the alternator is in operation and the ammeter shows a reduced output with maximum output only at maximum engine speed or, if the warning light does not show, but there is a reduced output from the alternator with maximum output only at maximum engine speed:

There is a fault in the alternator.

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

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

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

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

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

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

Starter motors

General description

The Magneti Marelli M127 starter motor is operated by a solenoid and has a six roller clutch. The solenoid engages the starter drive in two operations to ensure that the motor gets its maximum torque only when the starter motor is engaged fully with the flywheel. The clutch prevents rotation of the armature at high speed if the starter is held in the engaged position.

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

To remove and to fit

Operation 14-7

Special requirements

Consumable products	
Description	**Part number**
POWERPART Silicone rubber sealant	1861108

Warning! *Always disconnect the battery terminals before the removal of any component of the electrical system.*

To remove

If the engine has a flywheel housing which is oil filled, drain the flywheel housing before the starter motor is removed.

1 Disconnect the battery.

2 Disconnect the starter motor cables.

3 Release the fasteners and remove the starter motor and the distance piece, if one is fitted.

To fit

Note: Some starter motors may have an “O” ring fitted to the starter motor flange. If an “O” ring is fitted ensure that a new “O” ring is fitted.

1 Clean the flange face of the starter motor, the distance piece, if one is fitted, and the face of the flywheel housing.

If the engine has a flywheel housing which is oil filled, the starter motor must be sealed before it is fitted. Apply a 2,0 mm (0.080 in) continuous bead of POWERPART Silicone rubber sealant to the flange face of the starter motor (A2) and to the flywheel housing (A3).

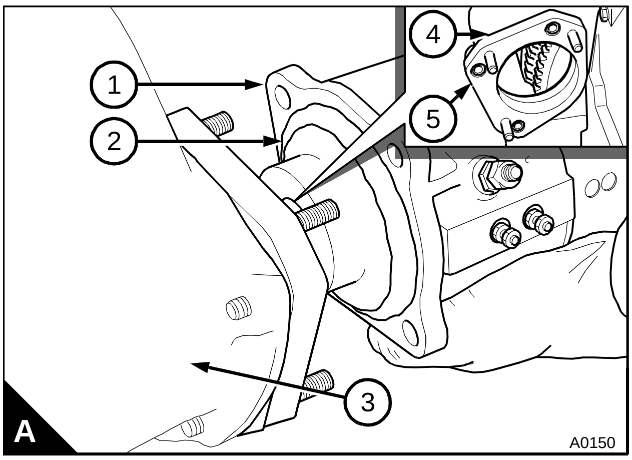
Caution: *For engines fitted with a distance piece: Do not fit the starter motor without the distance piece.*

2 If one is fitted, ensure that the distance piece (A4) is fitted in position, with its location lip to the flywheel housing, and that the cap screws (A5) are tight.

3 Fit the starter motor and tighten the fasteners.

4 Connect the starter motor cables.

5 Connect the battery.



To maintain the brush gear and the commutator **Operation 14-8**

S115 starter motors

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

Ensure that the brushes are fitted in their original positions to keep the original wear seat. The brushes must have good seats which conform to the shape of the commutator. If the brush seat is not correct, put a piece of very fine carborundum paper or similar material tight around the commutator with the rough face to the outside. With the brush in position, turn the armature by hand, in the normal direction of rotation, until the brush has the correct shape. If the brushes are worn and the springs do not give enough pressure, they must be renewed. Check the spring pressure with the hook of a spring balance under the spring lip. The correct tension is 8,34/ 11,00 N (30/40 ozf) 0,85/1,13 kgf.

The new brushes must be the same grade as the original brushes. To ensure that correct brushes are fitted, use only parts from the approved manufacturer. To remove the brushes, remove the four setscrews that hold the brushes, one for each brush. When the new brushes are assembled, connect carefully the field coil and connector wires, held by two of the setscrews. Before the brushes are inserted in their holders, it is advised that the holders are cleaned with compressed air or with a material which is damp with gasolene.

The commutator must be completely clean; dirt or oil must be removed by a piece of clean dry material (with no loose fibres) pressed against it, while the armature is turned by hand. If the commutator is dirty and has a colour other than its natural colour, lift the brushes and put a strip of fine carborundum paper or similar material around the commutator, with the rough surface to the inside. Turn the armature by hand until the surface has returned to its natural colour. Clean the commutator with a material which is damp with gasolene.

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

M127 Starter motor

Repair of this starter motor is more difficult. If necessary, remove the starter motor for specialist repair.

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.

Failure to engage smoothly between the starter and the flywheel can be caused, on some types of starter motor, by dirt on the helical grooves of the starter motor drive, which can prevent free pinion movement. Clean the shaft thoroughly with gasolene, or a fluid made especially for the purpose, and apply a small quantity of Aero Shell 6B or its equal.

Engine shows symptoms of a faulty starter motor

On initial start, some AR engines fitted with Lucas/Delphi injection pumps show symptoms similar to a low battery voltage or a faulty starter motor. The fault could be due to the amount of start advance and not the battery or the starter motor. To correct this problem, Lucas/Delphi now fit a start advance pin that gives 3° of start advance instead of 5°. The change will enable an engine to start easily and to run evenly. However, if an engine operates in ambient temperatures of 0°C (32° F) or less and uses fuel with a cetane number of 40 or less, the engine could be difficult to start and produce white smoke and misfire after the initial start. Perkins recommends that fuel with a minimum cetane number of 45 is used. The fuel injection pumps currently fitted with this pin are listed in the table below:

Perkins part number	Engine build list
2644G741	AR81148
2644G741	AR50741
2644G742	AR81027
2644G565	AR50690

The table below shows fuel pumps, fitted to engines earlier than AR*****U124289G, that can be modified. The fuel pump to be modified must be removed from the engine and sent to a Lucas/Delphi Diesel Systems distributor to ensure that the pump is correctly tested and has the correct information on the data plate:

Lucus/Delphi number	Pump code	Perkins part number	New Lucas/ Delphi number	New pump code	New Perkins part number
8920A492G	RG	U2644G021	8925A000G	FP	2644G031
8920A972G	RG	U2644G022	8925A010G	FP	2644G032
8920A072G	RG	U2644G023	8925A020G	FP	2644G033
8923A112G	YG	2644G541	8925A030G	HP	2644G561
8923A121G	YG	2644G544	8925A040G	HP	2644G564
8923A131G	YG	2644G545	8925A050G	HP	2644G565
8923A131H	YG	2644G550	8925A050H	HP	2644G570
8923A301G	YG	2644G551	8925A060G	HP	2644G571
8932A960G	YG	2644G542	8925A070G	HP	2644G562
8932A191G	ZG	2644G731	8925A080G	JP	2644G741
8923A201G	ZG	2644G732	8925A090G	JP	2644G742
8923A431E	ZG	2644G736	8925A199E	JP	2644G746

Starting aids

General description

There are two types of electrical starting aid in use: The fuelled starting aid and the port heater.

The fuelled starting aid (B1) is a device which is operated electrically and ignites a controlled amount of diesel fuel in the induction manifold to heat the induction air. A heater coil in the body expands a valve holder to allow fuel to flow into the device. The fuel is ignited by the hot coil and heats the air which passes through the induction manifold when the starter motor is operated.

The port heater has an electrically heated coil that heats the air as it enters the induction manifold. Port heaters are used in a group of two or three.

To remove and to fit a fuelled starting aid **Operation 14-11**

To remove

1 Disconnect the fuel pipe (A2) and the electrical connection (A3).

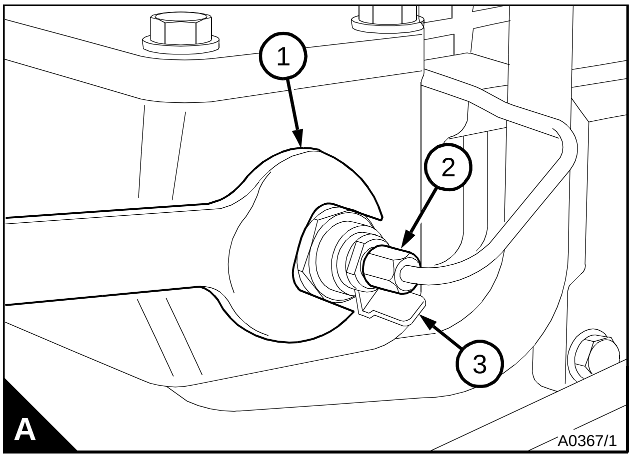
2 Turn the spanner (A1) counter-clockwise and remove the starting aid.

To fit

1 Ensure that the contact faces of the manifold and the starting aid are clean. Put the sealing washer into position and fit the starting aid. Tighten the starting aid to 31 Nm (23 lbf ft) 3,2 kgf m.

2 Check the fuel pipe and, if it is still full of fuel, connect it to the starting aid. If the fuel has drained from the pipe, eliminate the air from the pipe, see Operation 11-20.

3 Connect the electrical connection (A3).



To remove and to fit a twin-fuelled starting aid **Operation 14-12**

Some engines which have water-to-air intercoolers are fitted with twin fuelled starting aids (A3). These starting aids are in a recess on top of the induction manifold. In this situation, access to the electrical terminals (A2) can be restricted if the starting aids are not fitted correctly.

The correct procedure to remove and to fit twin fuelled starting aids is as follows:

To remove

1 Disconnect the fuel connections and the electrical connections.

2 Remove the starting aids.

To fit

1 Ensure that the seat faces of the manifold and the fuelled starting aids are free of dirt.

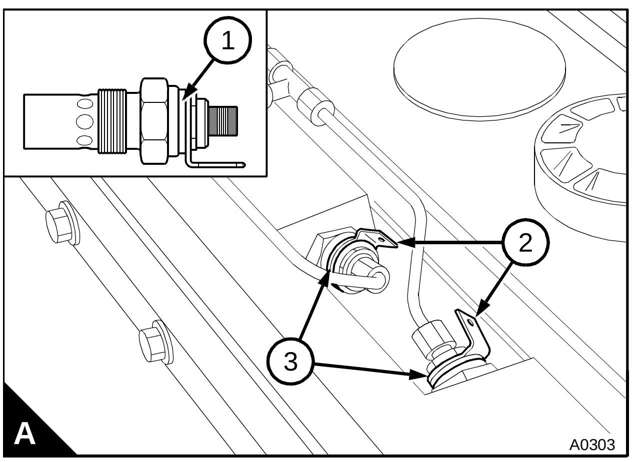
2 Fit the nylon spacer(s) (A3) over the threads of the starting aid. Screw the fuel starting aid into the manifold and tighten to 31 Nm (23 lbf ft) 3,1 kgf m. Ensure that the electrical connector(s) (A2) are in the correct position. It is not necessary to use sealant.

Caution: *To prevent electrical contact when the circuit is on and for easy removal during maintenance, It is important that the electrical terminals face away from the casing.*

3 When the fuelled starting aids are tightened fully into the manifold. If necessary, rotate them back, no more than half of one complete turn, until the electrical terminals face away from the casing.

4 Check the fuel pipes and if they are still full of fuel, connect them to the starting aids. If the fuel has drained from the pipes, eliminate the air from the pipes.

5 Connect the electrical connections.



To check the fuelled starting aid **Operation 14-13**

If the inside of the induction manifold is wet, check that there is not a fuel leak from the fuelled starting aid.

1 Disconnect the fuel pipe and the electrical connection at the starting aid. Remove the starting aid from the manifold and fit a suitable plug in the manifold.

2 Connect the fuel pipe to the starting aid, but leave the connection loose. Do not fit the electrical connection, but ensure that the connector has a suitable insulator fitted. Operate the priming lever of the fuel lift pump until fuel free of air comes from the connection. Tighten the connection.

3 Start the engine and operate it at low speed. Check that there is no fuel leakage from the valve of the starting aid.

4 If there is no leakage, remove the plug from the induction manifold and fit the starting aid. Connect the fuel pipe to the starting aid and remove the air from the pipe, see Operation 11-20. Connect the electrical connection.

If there is a leak from the valve of the starting aid, fit a new starting aid.

To remove and to fit a port heater **Operation 14-14**

To remove

1 Disconnect the electrical connection.

2 Remove the port heater from the induction manifold or from the elbow.

To fit

1 Fit the port heater and tighten it to 60 Nm (44 lbf ft) 6,1 kgf m.

2 Connect the electrical connection.

15

Auxiliary equipment

Compressors

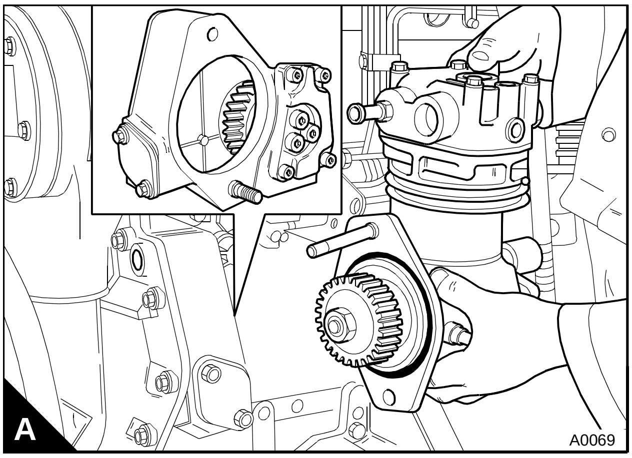
General description

The engines can be fitted with either a Bendix or a Knorr-Bremse compressor. The compressor is fitted on the left side of the engine directly onto the rear face of the timing case. The compressor is driven from the main idler gear through an idler gear for the compressor.

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

Operation

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



To remove

Operation 15-1

1 Drain the engine cooling system.

2 Release the air pressure in the air system. Disconnect the air pipes and the coolant pipes (A1) to and from the cylinder head of the compressor.

3 Remove the lubricating oil pipe (A6) which is fitted between the compressor and the engine cylinder block.

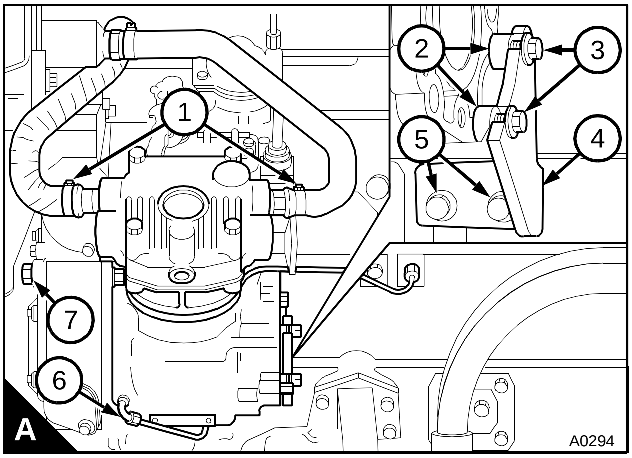
4 If necessary, remove the steering pump from the rear of the compressor.

5 Loosen the two setscrews (A3) of the support bracket (A4) at the rear end of the compressor. Remove the two fasteners (A5) which fasten the support bracket to the cylinder block or filter head and remove the bracket.

Note: Spacers (A2) are used between the bracket of the 1W150R compressor and the compressor body.

Remove the nut from the stud at the bottom of the compressor flange. Remove the nut (A7) from the stud at the front of the timing case and remove the compressor from the engine.

If it is necessary to remove the idler gear of the compressor, see Operation 6-8.



To fit **Operation 15-2**

1 Set the piston of number 1 cylinder to TDC, see Operation 8-1 or Operation 8-2.

2 Fit a new "O" ring (A5) in its recess in the drive housing. Lubricate the "O" ring with clean engine lubricating oil.

3 Rotate the crankshaft of the compressor until the mark (B1) or (C1) on the rear face of the crankshaft aligns with the 6A line (six cylinder engines) or the 4A line (four cylinder engines) on the label on the rear face of the compressor.

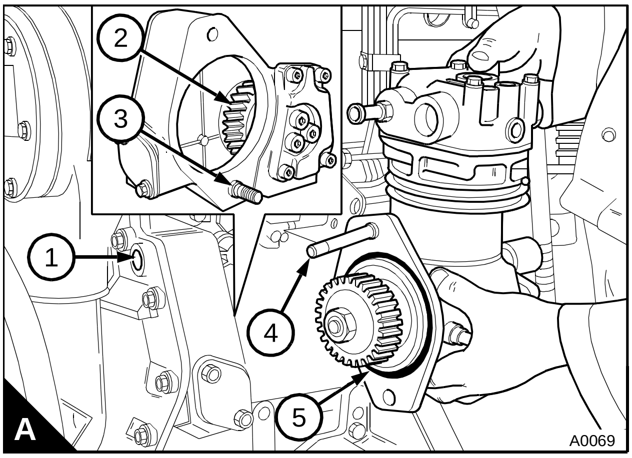
4 Push the shortest thread of the stud (A4) through the hole at the top of the compressor flange and fit the nut fully onto the thread. Engage the stud in the hole (A1) in the timing case. Slide the compressor onto the stud (A3) for the bottom of the flange.

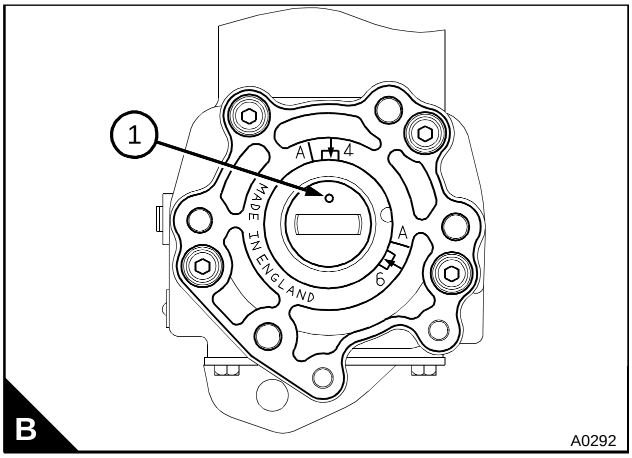
5 Slide the compressor forward until the teeth of the drive gear are against the teeth of the idler gear (A2). Slowly rotate the crankshaft of the compressor clockwise (from the rear) until the drive gear and the idler gear are in mesh.

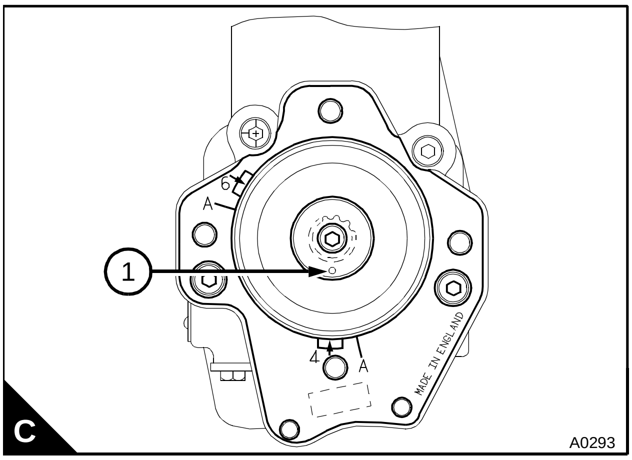
6 Carefully push the compressor forward until the spigot on the compressor is fully fitted in the timing case. In this position, the mark on the rear of the crankshaft should align with the dark area on the timing label marked 6 (six cylinder engines) or 4 (four cylinder engines).

7 If the alignment is not correct, pull the compressor out of engagement and move the crankshaft of the compressor in the relevant direction to mesh with the next gear tooth. Carefully push the compressor assembly into position. Check that the mark on the rear of the crankshaft is in the correct position. Fit the nuts to the stud (A4) which passes through the timing case (A1) and to the stud at the bottom of the flange. Tighten the two nuts to 75 Nm (55 lbf ft) 7,6 kgf m.

Continued







Caution: *If the support bracket is mounted on the oil filter head, check that the nuts for the filter head are tightened correctly before the compressor support bracket is fitted.*

8 Put the support bracket (E4) in position between the cylinder block or the filter head and the compressor. Loosely fit the fasteners (E5) the spacer (E2), if fitted, and the setscrews (E3). Adjust the support bracket to ensure that there will be no tension on the compressor. Tighten the two setscrews to 22 Nm (16 lbf ft) 2,2 kgf m for the setscrews (E3) and 44 Nm (33 lbf ft) 4,5 kgf m for the fasteners (D5).

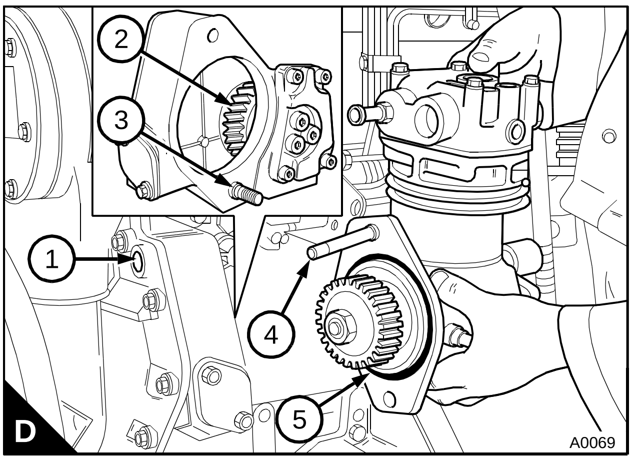
Note: Spacers (D2) are used between the bracket and the body of the 1W150R compressor.

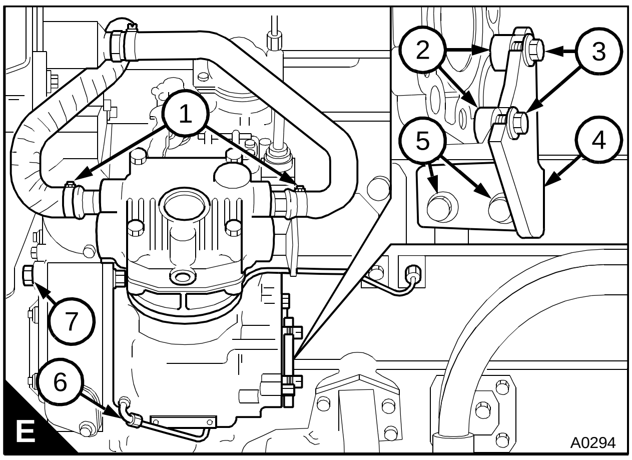
9 Check that the "O" ring in the cover for the rear of the compressor is not damaged. Fit the cover and tighten the setscrews.

10 Ensure that there is no restriction in the oil pipe (E6) between the engine and the compressor. Before the oil pipe is connected to the compressor, ensure that the engine stop solenoid is disconnected or that the engine stop control is in the ’stop’ position. Operate the starter motor until a free flow of oil comes from the oil pipe. Connect the oil pipe. Connect the engine stop solenoid.

11 Connect the compressor coolant pipes (E1) and the air pipes to the compressor.

12 Fill the engine cooling system. Operate the engine and check for leakage of oil, coolant and air from the compressor.





Knorr-Bremse compressor

To remove **Operation 15-3**

Note: Illustration (A) shows a compressor with a top unloader valve, and DIN drive. Illustration (B) shows a compressor that has a line unloader valve (line unloader valve not illustrated) and SAE drive.

1 Drain the engine cooling system.

2 Release the air pressure in the air system.

Warnings!

- *Never apply compressed air to any part of the body or clothing, severe injury can occur*
- *Wear safety goggles/mask, and use correct shielding to protect others.*

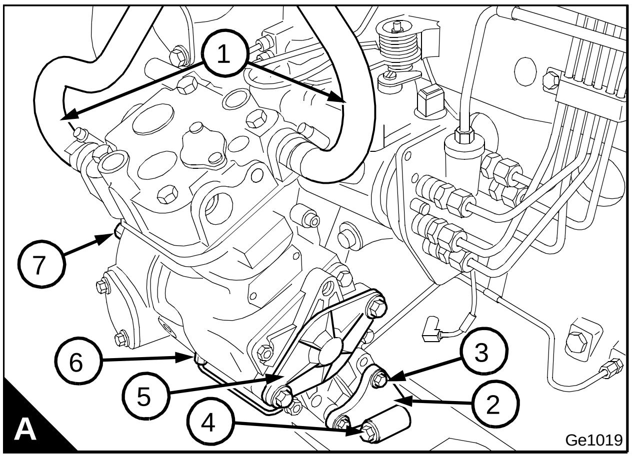
3 Disconnect the air pipes and the coolant pipes (A1/B1) to and from the cylinder head of the compressor.

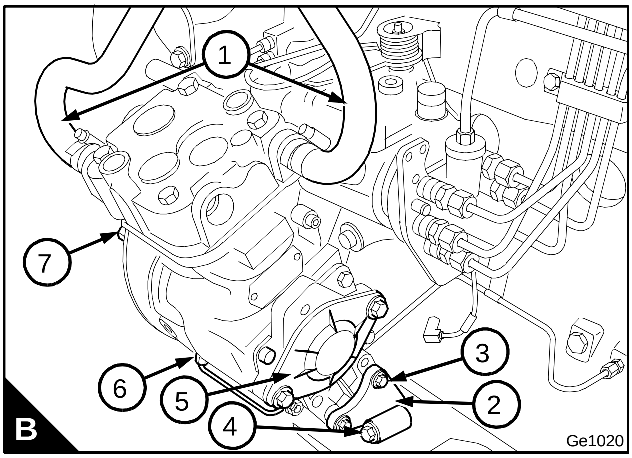
4 Remove the lubricating oil pipe (A6/B6) which is fitted between the compressor and the engine cylinder block.

5 If fitted, remove the hydraulic pump from the rear of the compressor.

6 Remove the two setscrews (A3/B3) at the rear end of the compressor. Remove the two setscrew (s) (A4/B4) which fasten the support bracket (A2/B2) to the cylinder block or filter head and remove the bracket.

7 Remove the nut from the stud at the bottom of the compressor to the timing case flange. Remove the nut (A7/B7) from the stud at the front of the timing case and remove the compressor from the engine. it may be necessary to support the compressor during this operation.





To fit

Operation 15-4

1 Set the piston of number 1 cylinder to TDC, see Operation 8-1 or Operation 8-2.

2 Fit a new "O" ring (A5) in its recess in the drive housing. Lubricate the "O" ring with clean engine lubricating oil.

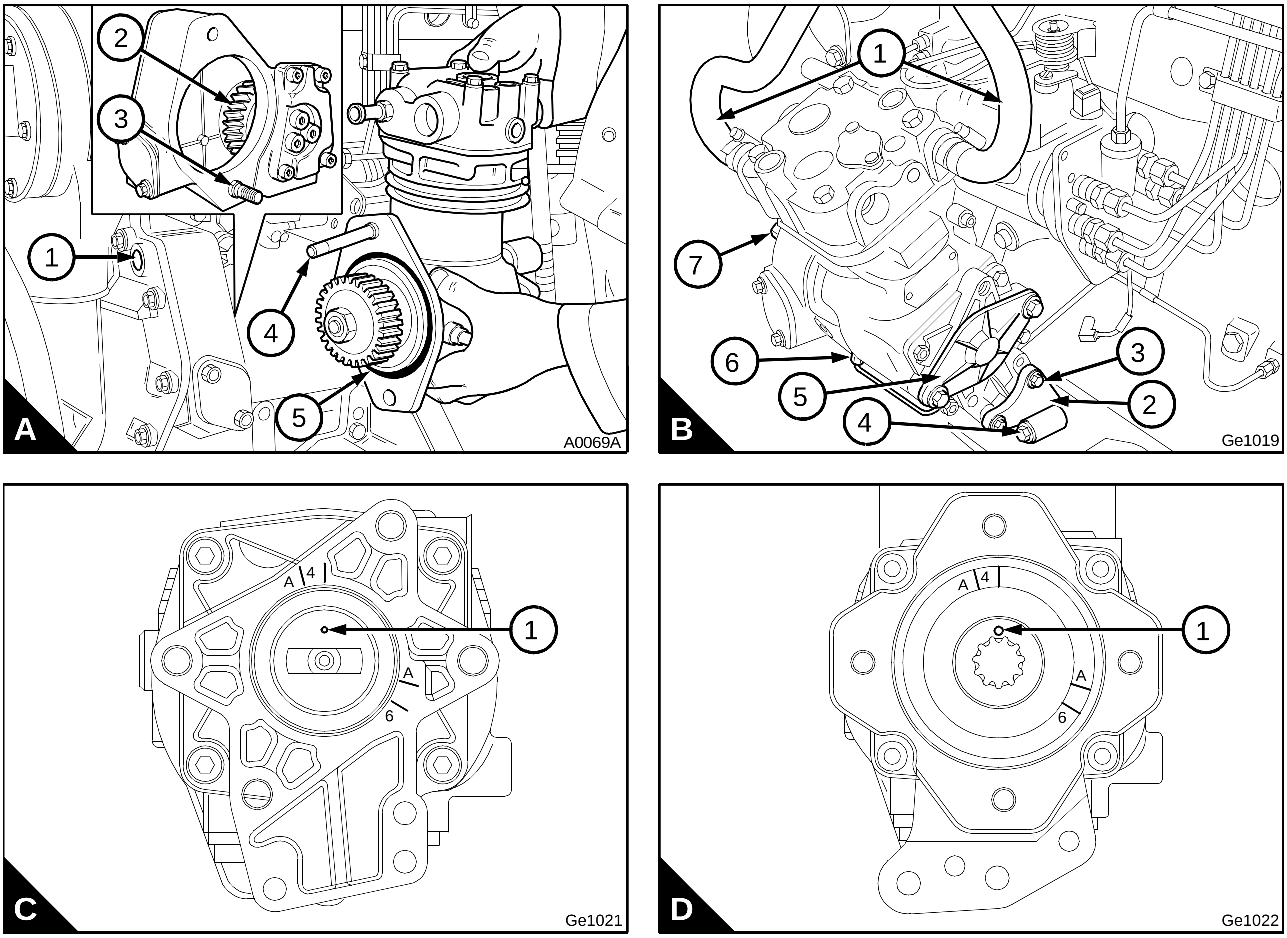
3 With the rear cover plate (B5) (or the hydraulic pump removed), rotate the crankshaft of the compressor until the mark (C1 - DIN crankshafts) or (D1 - SAE crankshafts) on the rear face of the crankshaft aligns with the 6A line (six cylinder engines) or the 4A line (four cylinder engines) on the label on the rear face of the compressor.

4 Push the shortest thread of the stud (A4) through the hole at the top of the compressor flange and fit the nut fully onto the thread. Engage the stud in the hole (A1) in the timing case. Slide the compressor onto the stud (A3) for the bottom of the flange.

5 Slide the compressor forward until the teeth of the drive gear are against the teeth of the idler gear (A2). Slowly rotate the crankshaft of the compressor clockwise (from the rear) until the drive gear and the idler gear are in mesh.

6 Carefully push the compressor forward until the spigot on the compressor is fully fitted in the timing case. In this position, the mark on the rear of the crankshaft should align with the area on the timing label marked 6 (six cylinder engines) or 4 (four cylinder engines) (C/D).

Continued



7 If the alignment is not correct, pull the compressor out of engagement and move the crankshaft of the compressor in the relevant direction to mesh with the next gear tooth. Carefully push the compressor assembly into position. Check that the mark on the rear of the crankshaft is in the correct position. Fit the nuts to the stud (E4) which passes through the timing case and to the stud (E3) at the bottom of the flange. Tighten the two nuts to 75 Nm (55 lbf ft) 7,6 kgf m.

8 Fit the rear cover plate (F5) (or the hydraulic pump) with a new 'O' ring seal lightly lubricated with clean engine lubricating oil. Fit and tighten the setscrews.

9 Fit the support bracket (F2) to the engine side / oil filter head with the setscrew(s) (F4) but do not tighten.

10 Fit the support bracket (F2) to the compressor with the two setscrews (F3).

11 Tighten the setscrews (F3) and (F4) evenly.

12 Disconnect the engine stop solenoid, or ensure the engine stop control is in the 'stop' position. Operate the starter motor until oil flows from the lubricating oil pipe (F6). Connect the lubricating oil pipe (F6) to the compressor. Connect the engine stop solenoid.

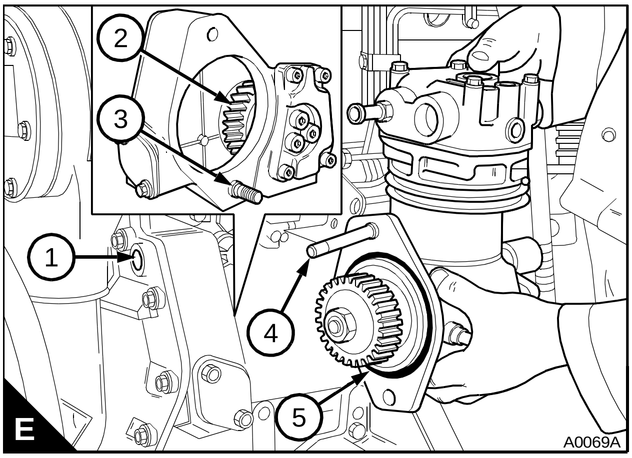
Note: Illustration (F) shows a compressor with top unloader valve, and DIN drive. Illustration (G) shows a compressor that has a line unloader valve (line unloader valve not illustrated) and SAE drive.

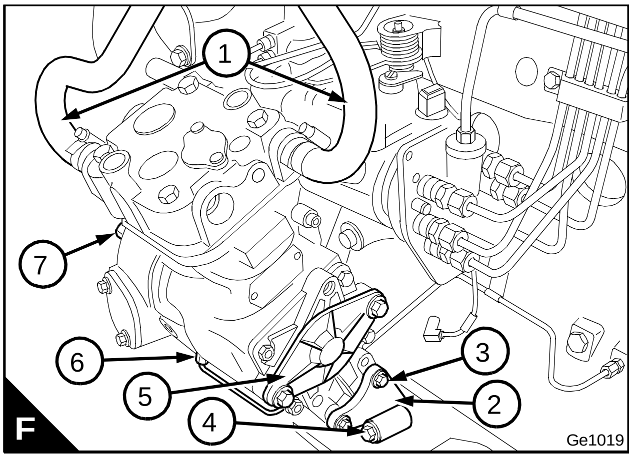
13 Connect the air pipes to the compressor cylinder head.

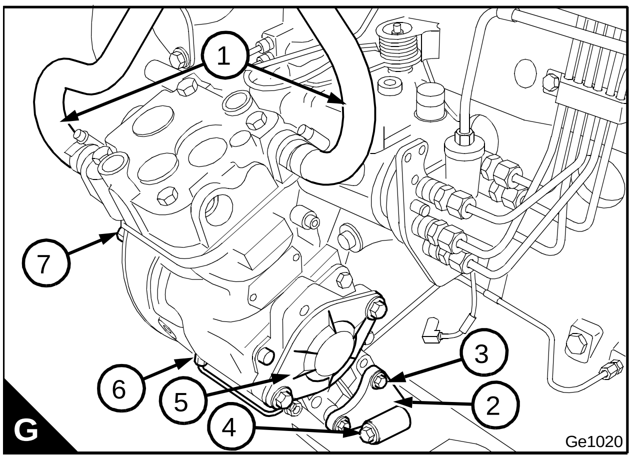
14 Connect the engine coolant pipes (F1) to the compressor cylinder head.

15 Fill the engine cooling system with coolant to the correct level. See the operators' handbook.

16 Operate the engine and check for leakage of oil, coolant and air from the compressor.







To remove the reed valves **Operation 15-5**

Note: To renew compressor cylinder head related components it may not be necessary to remove the compressor from the engine.

1 Drain the engine cooling system.

2 Release the air pressure in the air system.

Warnings!

- *Never apply compressed air to any part of the body or clothing, severe injury can occur.*
- *Wear safety goggles/mask, and use correct shielding to protect others.*

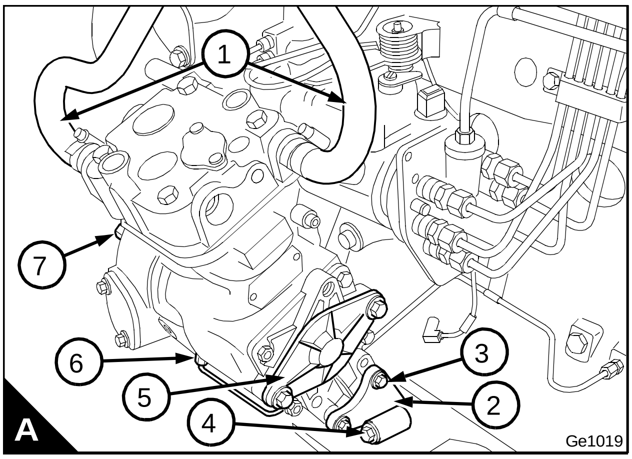
3 Disconnect the air pipes and the coolant pipes (A1) from the compressor cylinder head.

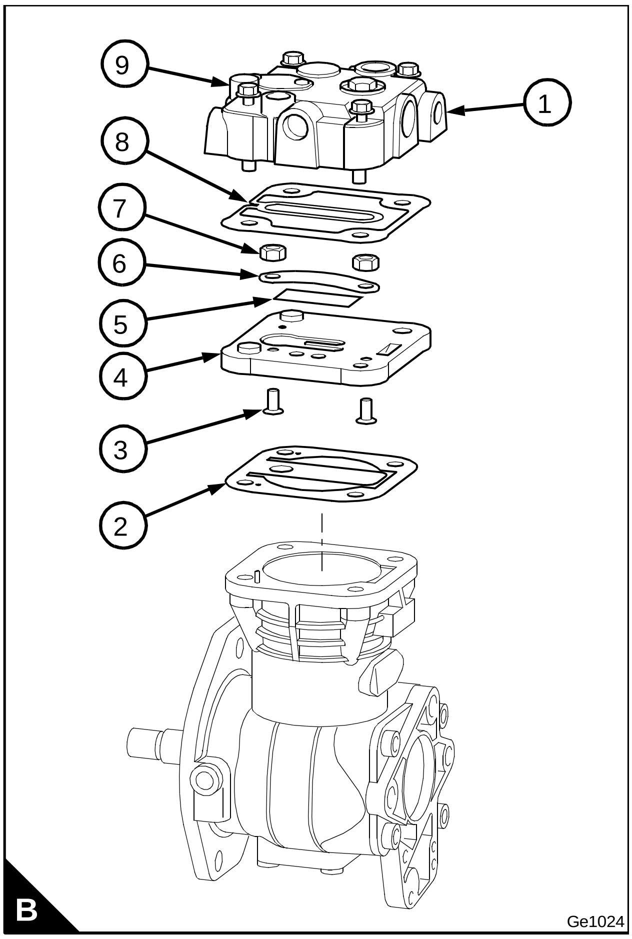
4 Remove the four cylinder head setscrews (B1), and remove the cylinder head (B9).

5 Remove the gasket (B8).

6 Remove the delivery reed plate (B4) and the inlet reed (B2).

7 Remove the delivery reed nuts (B7) and the setscrews (B3), remove the delivery bridge (B5) and remove the delivery reed (B5).





To fit the reed valves **Operation 15-6**

1 Ensure all contact surfaces are clean.

2 Fit and align the new delivery reed (A5) to the delivery reed plate (A4), and secure with the delivery bridge (A6), setscrews (A3) and nuts (A7) tighten to 8,25 Nm (6.08 lbf ft) 8,41 kgf m.

3 Fit and align a new inlet reed (A2).

4 Fit and align the delivery reed plate (A4).

5 Fit and align a new cylinder head gasket (A8).

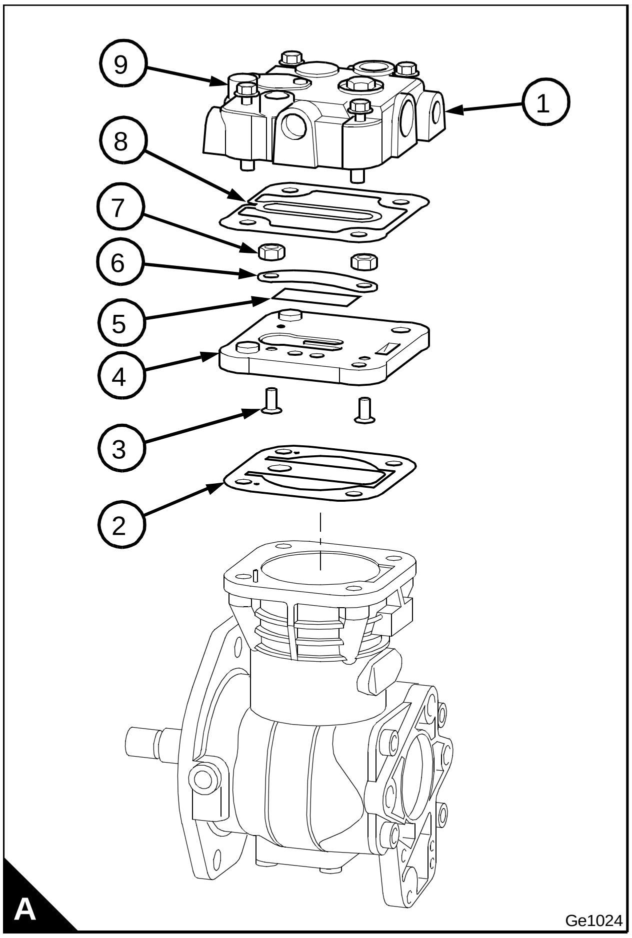
6 Fit and align the cylinder head (A9) and secure with the setscrews (A1) and tighten to 27,50 Nm, (20.28 lbf ft) 28,04 kgf m.

7 Connect the air pipes to the compressor cylinder head.

8 Connect the engine coolant pipes to the compressor cylinder head.

9 Fill the engine cooling system with coolant to the correct level. See the operators' handbook.

10 Operate the engine and check for leakage of oil, coolant and air from the compressor.



To remove the top unloader valve **Operation 15-7**

1 Release the air pressure in the air system.

Warnings!

- *Never apply compressed air to any part of the body or clothing, severe injury can occur.*
- *Wear safety goggles/mask, and use correct shielding to protect others.*

2 Remove the unloader valve setscrews (A1).

3 Remove the unloader valve cap (A9).

4 Remove the joint (A2).

5 Remove the ‘O’ ring (A7).

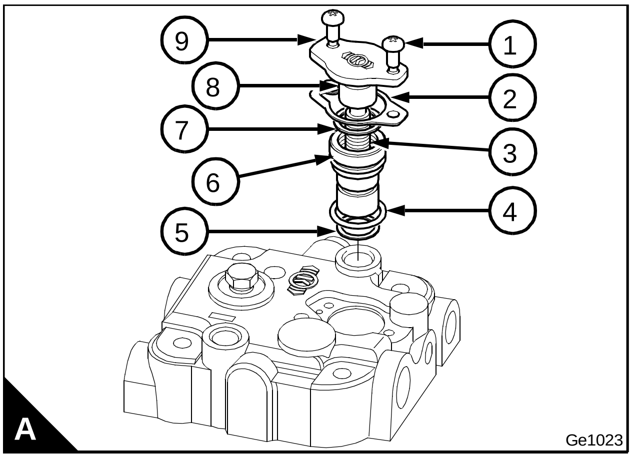
6 Remove the piston (A8).

7 Remove the spring (A3).

8 Remove the balance piston (A6).

9 Remove the ‘O’ ring (A4) from the balance piston (A6).

10 Remove the ‘O’ ring (A5) from the balance piston (A6).



To fit the top unloader valve **Operation 15-8**

Note: Ensure all components are clean.

1 Fit a new 'O' ring (A4) to the balance piston (A6).

2 Fit a new 'O' ring (A5) to the balance piston (A6).

3 Fit the balance piston (A6) to the cylinder head.

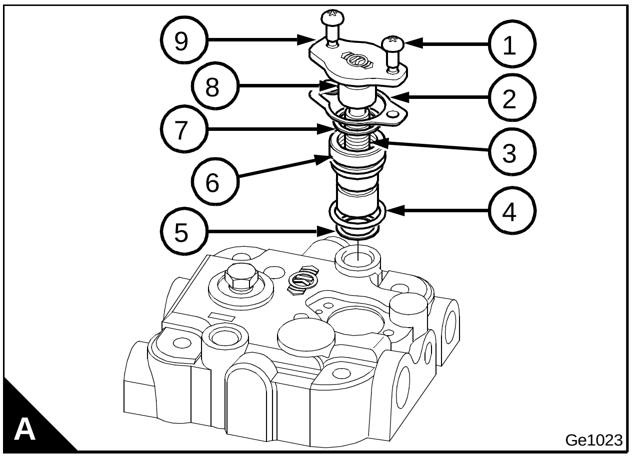
4 Fit the spring (A3).

5 Fit a new 'O' ring (A7).

6 Fit the piston (A8).

7 Fit a new joint (A2).

8 Fit the cap (A9) and secure with the screws (A1) and tighten to 7,0 Nm (5.16 lbf ft) 7,14 kgf m.



To remove the crankshaft / connecting rod / piston / piston rings **Operation 15-9**

1 Remove the compressor from the engine, see Operation 15-3.

2 Remove the compressor drive gear and drive key.

3 Remove the cylinder head, the cylinder head gasket, delivery reed plate, and the inlet reed.

4 Remove the setscrews (A16) and remove the sump plate (A15) together with the sump joint (A14).

5 Remove the connecting rod setscrews (A13) and remove the connecting rod bearing cap (A12).

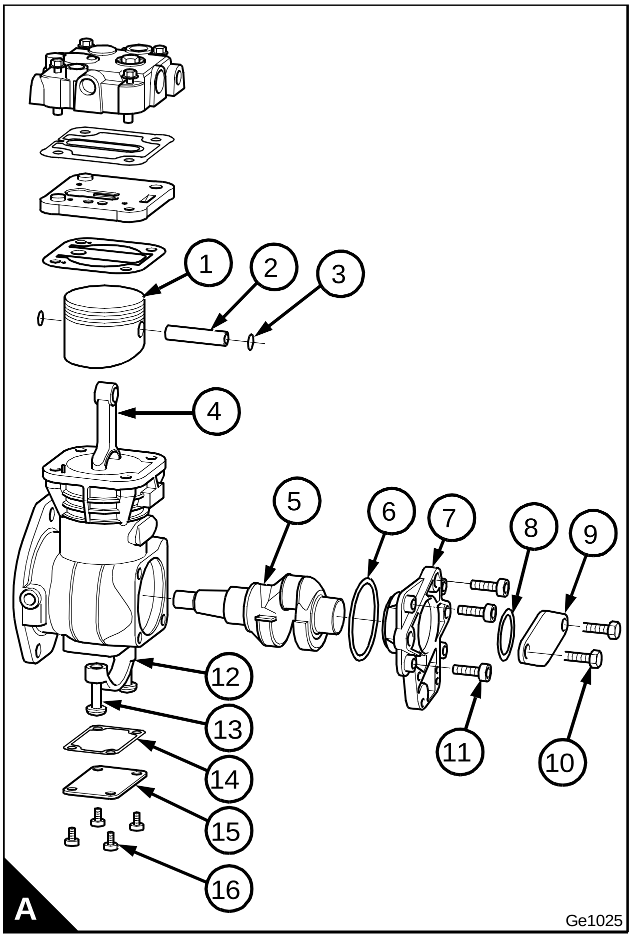
6 The piston and connecting rod assembly can now be pushed up the cylinder and out through the top of the compressor.

7 Remove the circlips (A3) from the piston (A1) and push out the gudgeon pin (A2) to remove the piston from the connecting rod (A4).

8 Remove the setscrews (A10), the cover plate (A9) and the ‘O’ ring (A8).

9 Remove the setscrews (A11) and remove the end plate (A7) and the ‘O’ ring (A6).

10 Remove the crankshaft (A5) through the compressor rear opening.



To fit the crankshaft / connecting rod / piston / piston rings **Operation 15-10**

1 Fit a new crankshaft (A5) into the compressor through the rear opening.

2 Ensure all components are clean. Fit a new ‘O’ ring (A6) in its recess in the end plate (A7). Lubricate the ‘O’ ring with clean engine lubricating oil.

3 Fit and secure the end plate (A7) with the setscrews (A11), and ensure that the crankshaft rotates freely.

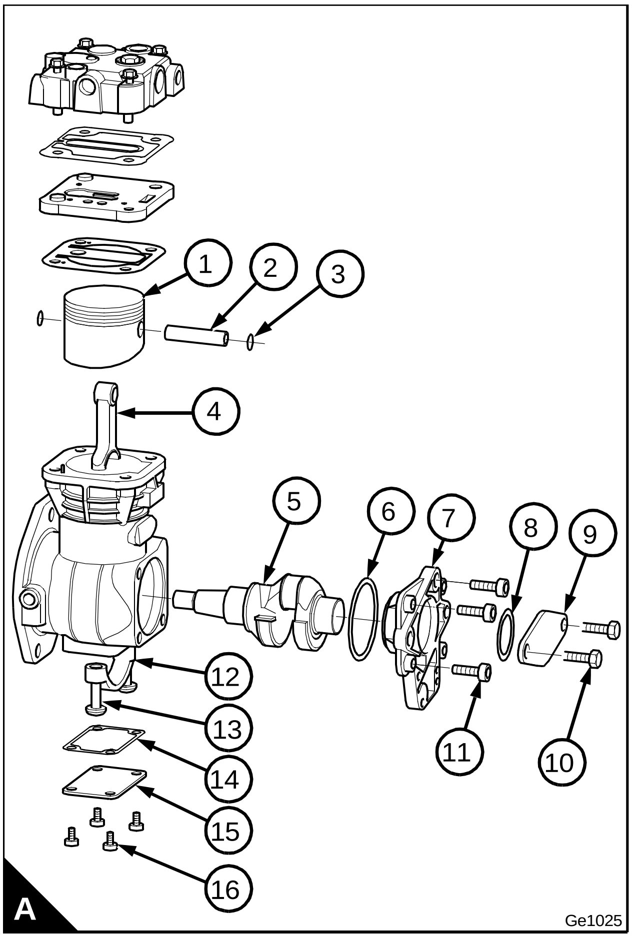
4 Fit the piston (A1) to the connecting rod (A4) with the gudgeon pin (A2) and secure with the circlips (A3).

5 Fit the new piston / connecting rod assembly (without the connecting rod bearing cap) down through the compressor cylinder.

Caution: *Using a suitable piston ring compressor, ensure the piston rings are compressed into the piston grooves.*

6 Lubricate the connecting rod bearing surface and the crank pin with clean engine lubricating oil.

Continued



7 Fit the connecting rod to the crankpin.

8 Lubricate the bearing cap (B12) with clean engine lubricating oil and fit and hold the bearing cap in position to the connecting rod.

9 Fit the two bearing cap retaining setscrews (B13) by hand. If they do not fit freely by hand, fit new setscrews. If the new setscrews do not fit freely by hand, fit a new connecting rod.

10 Tighten the setscrews gradually and evenly to 14,5 Nm (10.69 lbf ft) 14,78 kgf m.

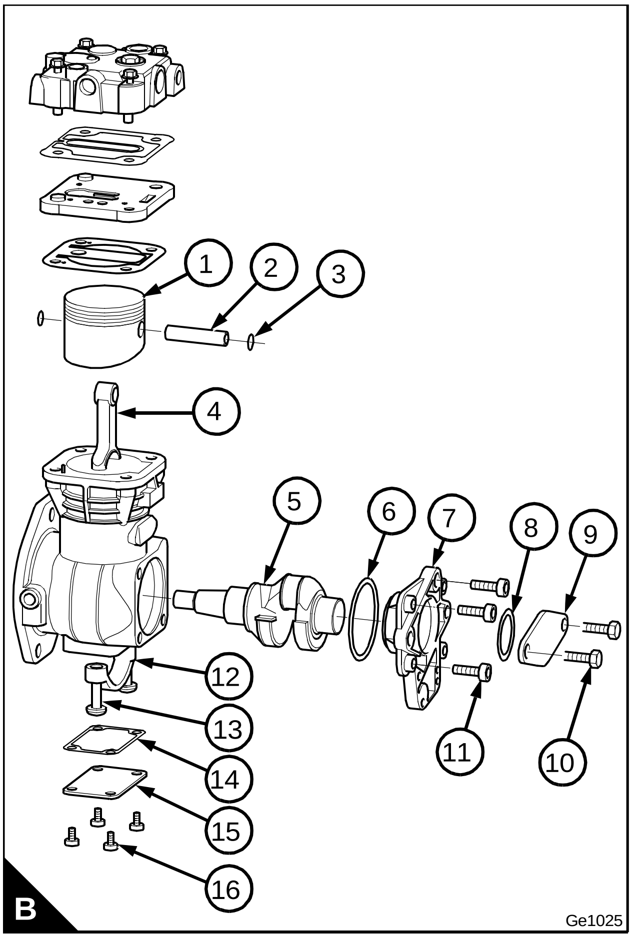
11 Ensure that the crankshaft rotates freely.

12 Fit a new sump joint (B14) and the sump plate (B15) and secure with the setscrews (B16) and tighten to 9 Nm (6.64 lbf ft) 9,17 kgf m.

13 Fit the inlet reed, the delivery reed plate, the cylinder head gasket and the cylinder head and tighten the cylinder head setscrews to 27,5 Nm (20.28 lbf ft) 28,04 kgf m.

14 Fit the drive key and drive gear.

15 Fit the compressor to the engine, see Operation 15-4.



Power steering pump

To remove and to fit **Operation 15-11**

To remove

1 Disconnect the pipe connections at the power steering pump and fit covers to the open ends of the pipes.

2 Release the setscrews and remove the pump. If the pump is fitted to the rear of the compressor, ensure that the drive coupling is not lost.

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 or for damage. Renew it, if necessary.

3 If necessary, fit the drive coupling to the end of the compressor shaft and rotate the pump shaft to align the drive with the coupling. Fit the pump to the compressor and tighten the setscrews.

4 Remove the covers from the open ends of the pipes and connect the connections.

Adaptor for a hydraulic pump or a steering pump with a splined drive

To remove and to fit **Operation 15-12**

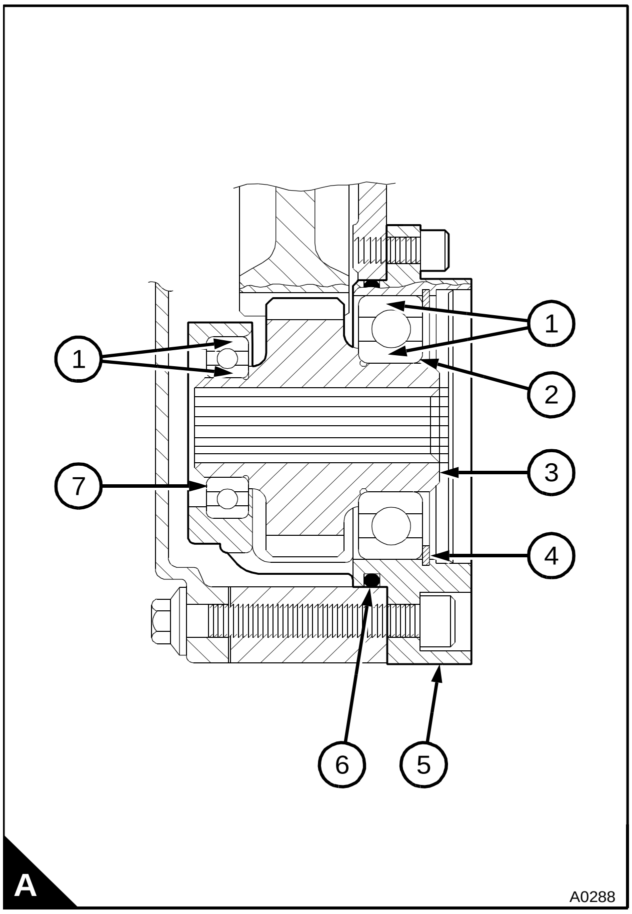
To remove

1 Release the cap screws and remove the adaptor assembly from the rear of the timing case.

2 Check the gear, the spline and the bearings for wear and other damage and renew the components as necessary.

To fit

1 Fit a new "O" ring (A6) in its recess in the housing (A5) and lightly lubricate it with clean engine lubricating oil. Lubricate the bearings (A2) and (A7) with clean engine lubricating oil. Fit the adaptor assembly to the timing case and tighten the cap screws.



To dismantle

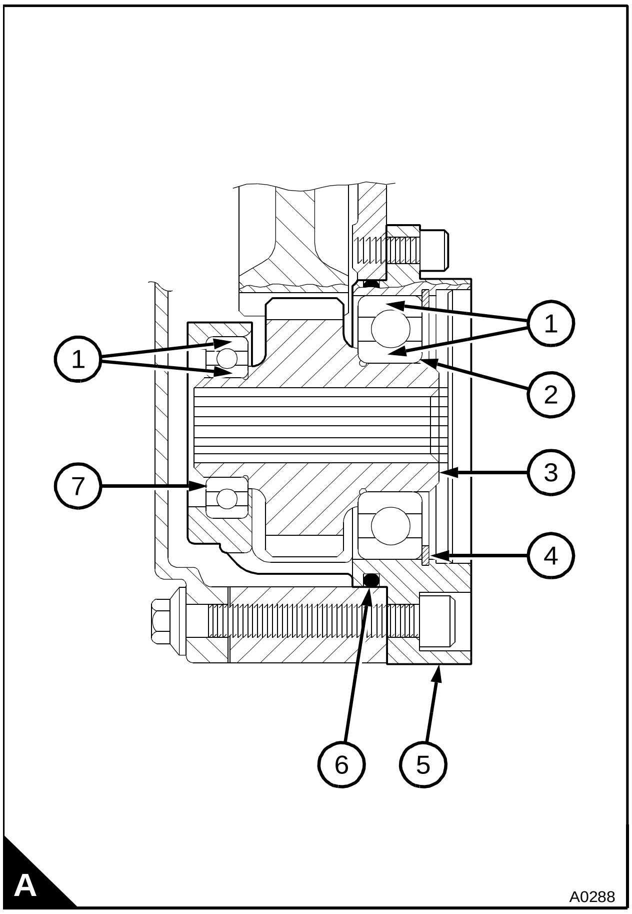
Operation 15-13

1 Remove the hydraulic pump or steering pump.

2 Remove the adaptor assembly, see Operation 15-12.

3 Remove the circlip (A4). Provide a support for the flange face of the housing (A5). Use a suitable adaptor on the front bearing (A7) to press the gear and bearings out of the housing.

4 Remove the bearings from the gear (A3) with a suitable gear puller.



To assemble **Operation 15-14**

Special requirements

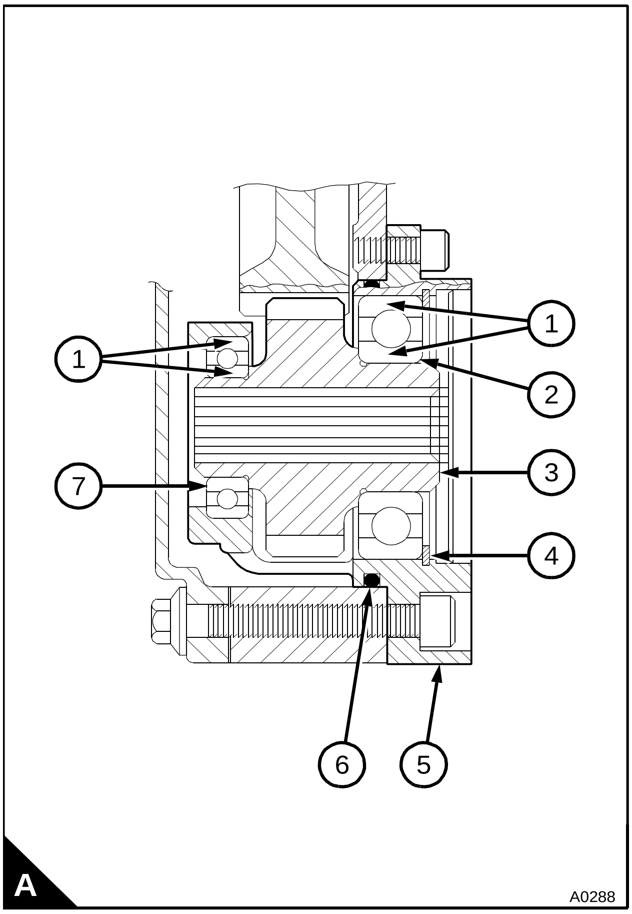
Consumable products	
Description	**Part number**
POWERPART Retainer (oil tolerant)	21820603

1 Apply a narrow ring of POWERPART Retainer (oil tolerant) to the outer face of the front bearing (A7) in the position shown (A1). Provide a support for the front face of the housing. Use a suitable adaptor on the outer ball guide of the bearing to press the front bearing onto the shoulder in the housing. Remove excess retainer (oil tolerant).

2 Apply a narrow ring of POWERPART Retainer (oil tolerant) to the inner face of the front bearing in the position shown (A1). Provide a support for the bearing. With the small diameter of the gear toward the bearing, press the gear into the bearing until the gear is onto its shoulder.

3 Apply a narrow ring of POWERPART Retainer (oil tolerant) to the outer face and to the inner face of the rear bearing (A2) in the positions shown (A1). Ensure that the support is under the front bearing. Use a suitable adaptor on the outer ball guide of the bearing to press the bearing into the housing and onto the shoulder on the gear. Remove excess retainer. Fit the circlip into its groove in the housing.

4 Check the backlash between the power take-off gear and the idler gear: Power take-off gears are identified by the part number stamped on the gear face. The backlash for gears with part numbers 3117C111, 3117C112 or 3117C113, is 0,08 mm (0.003 in) minimum. The backlash for gears with part numbers 3117C114, 3117C115 and 3117C116 is 0,18/0,25 mm (0.007/0.010 in) minimum.



To remove and to fit — Operation 15-15

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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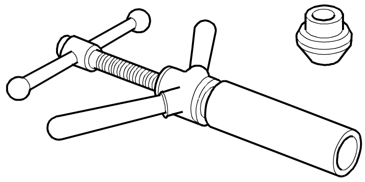
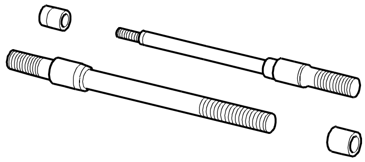
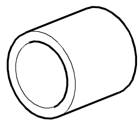
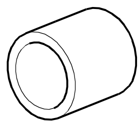
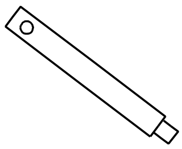
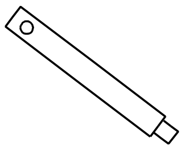
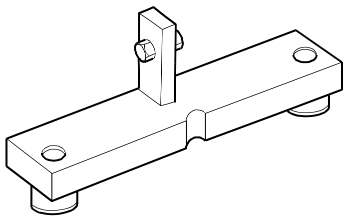
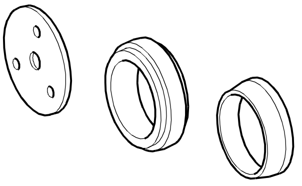
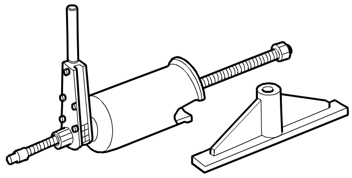
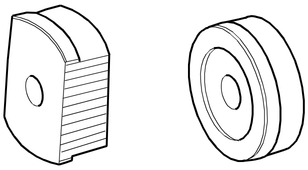
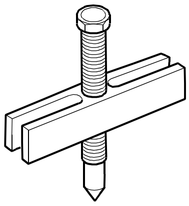
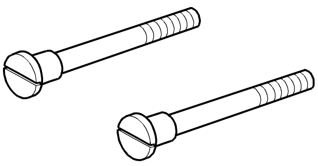
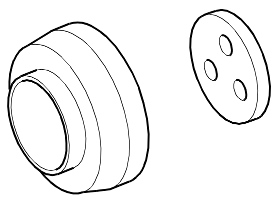
Special tools

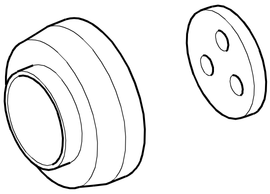
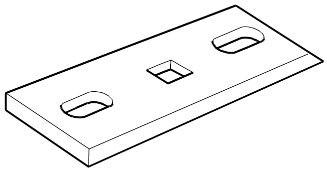
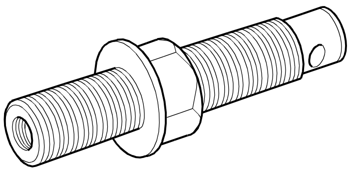
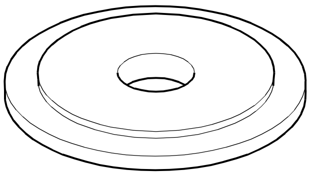
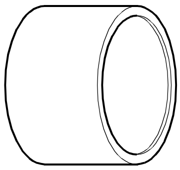
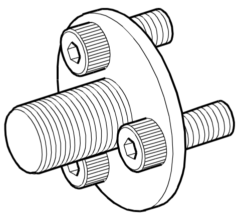
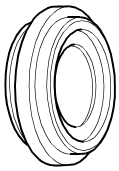
These tools are available through your local Perkins Distributor. If you cannot obtain the correct tool locally contact:

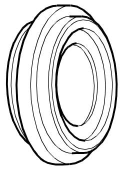
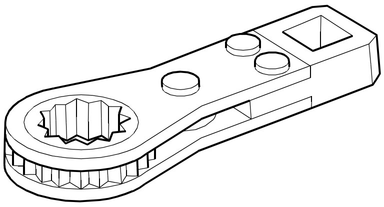
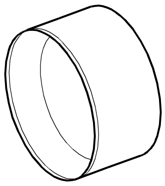
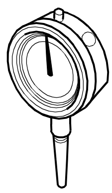
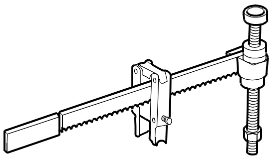
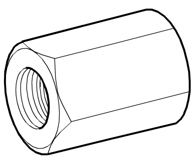
The Perkins Service Department, Peterborough, PE1 5NA, England, UK. Tel 01733 583000, Fax 01733 582240, Telex 32501 PERKEN G.

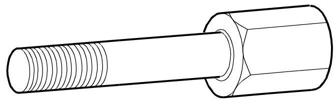
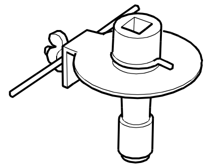
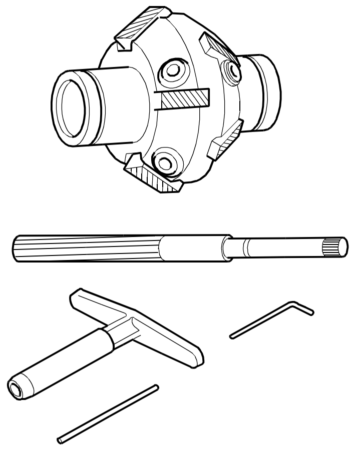
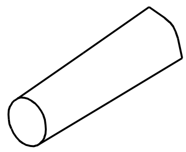
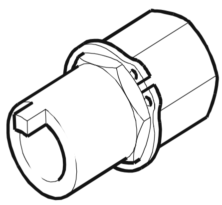
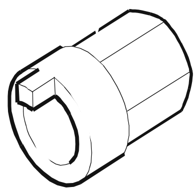
List of special tools

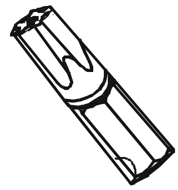
Part number	Description	Illustration
21825478	Remover / replacer for valve guides (main tool). Reference number PD.1D.	
27610019	Adaptor for use with 21825478. Reference number PD.1D-13.	
21825482	Inlet valve guide adaptor for use with 21825478. Reference number PD.1C-6.	
27610029	Exhaust valve guide adaptor for use with 21825478. Reference number PD.248.	
27610032	Timing pin for Bosch fuel injection pumps. Reference number PD.245.	
27610033	Timing pin for Lucas/Delphi and Stanadyne fuel injection pumps. Reference number PD.246.	
21825496	Gauge for piston height, valve depth and cylinder liner flange; for use with 21825617. Reference number PD.41D.	

Part number	Description	Illustration
21825540	Replacer tool for crankshaft rear seal. Reference number PD.145D.	
21825543	Remover / replacer for cylinder liner (main tool). Reference number PD.150B.	
21825563	Adaptors for use with 21825543. Reference number PD.150B-17A.	
21825565	Basic puller for camshaft gear. Reference number PD.155C.	
21825930	Adaptors for use with 21825565. Reference number PD.155B-5.	
21825936	Centralising tool for timing case cover (four cylinder engines). Reference number PD.162B.	

Part number	Description	Illustration
21825574	Centralising tool for timing case cover (Six cylinder engines). Reference number PD.163A.	
21825576	Crankshaft rotation adaptor for use with a 12,7 mm (0.5 in) square drive. Reference number PD.165B.	
21825577	Replacer tool for seal of timing case cover (main tool). Reference number PD.170.	
21825578	Pressure plate for use with 21825577. Reference number PD.170-1.	
21825579	Sleeve for use with 21825577. Reference number PD.170-2.	
21825580	Fastener plate for use with 21825577. Reference number PD.170-3.	
21825581	Adaptor for front seal for use with 21825577. Reference number PD.170-4.	

Part number	Description	Illustration
21825583	Adaptor for water immersion seal for use with 21825577. Reference number PD.170-8.	
21825964	Spanner for flange nuts of the Bosch fuel injection pump. Reference number PD.239.	
21825615	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
21825932	Setscrew adaptor for use with 21825666. Reference number PD.6118-8.	
21825607	Angle gauge to tighten cylinder head setscrews. Reference number PD.198. (MS.1531).	
27610030	Combined reamer/cutters and handle for valve guides and 31°/ 46° valve seat inserts. Reference number PD.242.	
27610031	Coolant pump, oil seal replacer tool. Reference number PD.247.	
27610144	Torque screw locknut wrench.	
27610145	Idle adjustment locknut wrench.	

Part number	Description	Illustration
27610122	Torx drive socket (fuel pump gear models AP, AQ and AS.	

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