Perkins 2300 Series

Model 2306C-E14

WORKSHOP MANUAL

6 cylinder turbocharged diesel engines for industrial applications

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Chapters

The pages which follow contain a detailed table of contents

Contents

1 General information

2 Specifications

3 Cylinder head assembly

4 Pistons and connecting rod assemblies

5 Crankshaft assembly

6 Gear case and drive assembly

7 Crankcase and cylinder liners

8 Engine timing and electronic controls

9 Aspiration system

10 Lubrication system

11 Fuel system

12 Cooling system

13 Flywheel and housing

14 Electrical equipment

15 Auxiliary equipment

16 Special tools

1

General information

Introduction

The 2300 and 2800 Series engines are from Perkins Engines Company Limited, a world leader in the design and manufacture of high-performance diesel engines.

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

This Workshop Manual has been designed to provide assistance in the service and the overhaul of Perkins 2300 and 2800 Series engines. Most of the general information, which is included in the User's Handbook (Chapters 1 to 6), has not been repeated in this Workshop Manual and the two publications should be used together.

To ensure that you use the relevant information for your specific engine type, refer to "Engine identification" on page 6.

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

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

Data and dimensions are included in Chapter 2, Specifications.

Read the "Safety precautions" on page 2 and remember them. They are given for your protection and must be applied at all times.

In addition to the general safety precautions, danger to both operator and engine are highlighted by the following conventions:

Warning! *This indicates that there is a possible danger to the person (or the person and engine).*

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.

Safety precautions

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

- Always refer to the text of this handbook for specific warnings and cautions.
- 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 make adjustments that you do not understand.
- Do not allow the engine to stand on its sump.
- Do not smoke when you put fuel in the tank.
- Clean away fuel which has been spilt. Material which has been contaminated by fuel must be moved to a safe place.
- Do not put fuel in the tank while the engine runs (unless it is absolutely necessary).
- Do not clean, add lubricating oil, or adjust the engine while it runs (unless you have had the correct training; even then extreme caution must be used to prevent injury).
- Ensure that the engine does not run in a location where it can cause a concentration of toxic emissions.
- Other persons must be kept at a safe distance while the engine or auxiliary equipment is in operation.
- Do not permit loose clothing or long hair near moving parts.

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

- Do not operate the engine if a safety guard has been removed.
- Do not remove the filler cap or any component of the coolant 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. Always disconnect the negative terminal first.
- Only one person must control the engine.
- Ensure that the engine is operated only from the control panel or from the operator’s position.
- If your skin comes into contact with high-pressure fuel, obtain medical assistance immediately.
- Diesel fuel and lubricating oil (especially used lubricating oil) can damage the skin of certain persons. Protect your hands with gloves or a special solution to protect the skin.
- Do not wear clothing which is contaminated by lubricating oil. Do not put material which is contaminated with oil into the pockets.
- Discard used lubricating oil and coolant in accordance with local regulations to prevent contamination.
- 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.

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 debris away from the inlet and outlet ports of the turbocharger and prevent contact with hot surfaces.
- Some components are not waterproof and should not be washed with a high-pressure water jet or steam.
- Fit only genuine Perkins parts.

Viton seals

Some seals used in engines and in components fitted to engines are made from Viton (fluorocarbon).

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 a calcium hydroxide solution and then with clean water.
- Disposal of gloves and components 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 a calcium hydroxide solution for 15-60 minutes. Obtain immediate medical attention.

Welding

Welding can cause damage to the electronic components fitted to the engine. If welding is necessary, the precautions which follow must be undertaken before and during the welding operation.

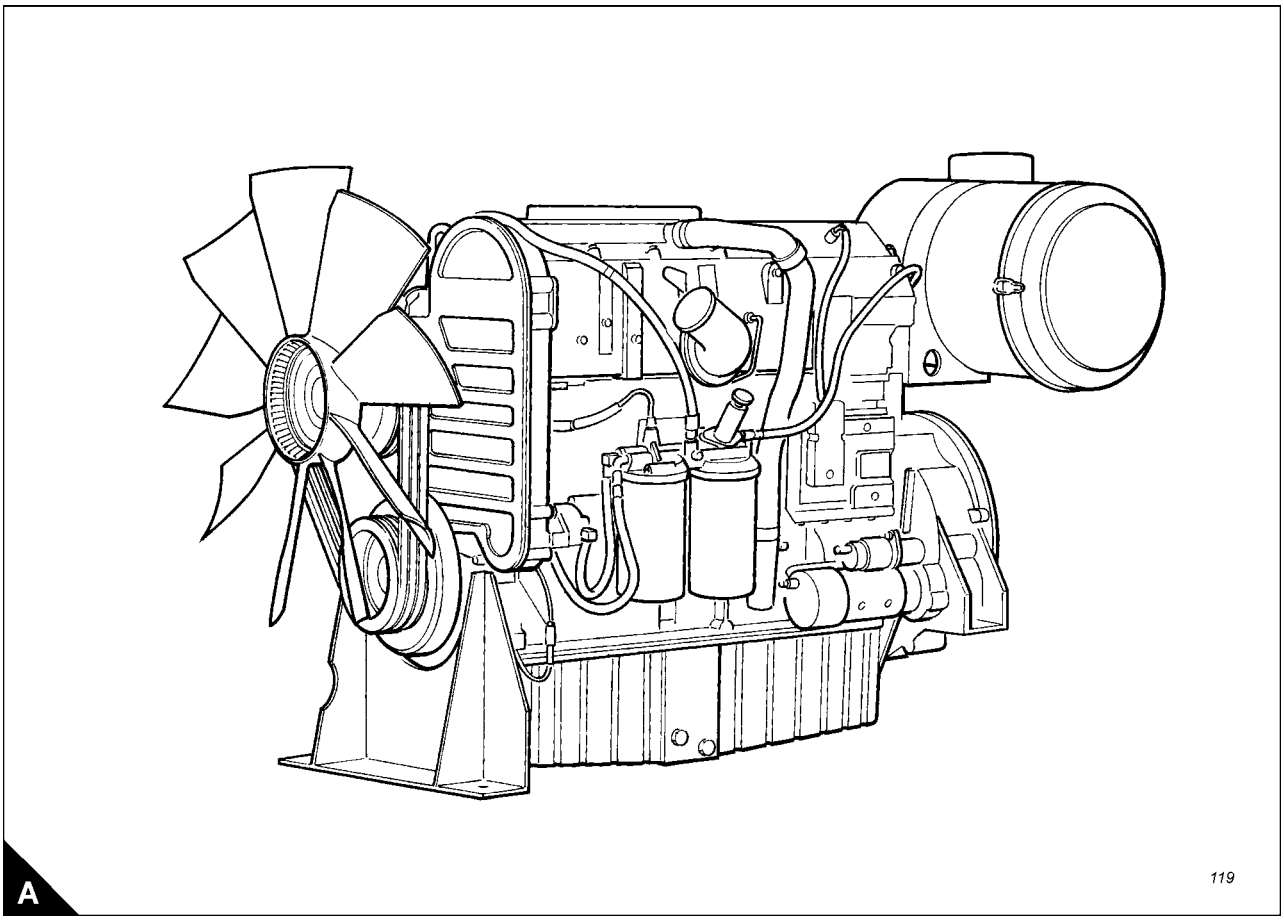
***Cautions*:**

- *Switch off the engine.*
- *Disconnect the cable from the negative terminal of the battery. If the machine is fitted with a battery disconnect the switch then open the switch.*
- *If welding to the engine, remove the ECM (electronic control module).*
- *If welding onto the machine chassis, ensure that the earth clamp is attached as close to the welding point as possible and NOT near to the ECM.*
- *If it is necessary to weld near to the ECM, remove the ECM from the engine.*

Environmental protection

There is legislation to protect the environment from the incorrect disposal of used lubricating oil. To ensure that the environment is protected, consult your Local Authority who can give advice.

Engine views



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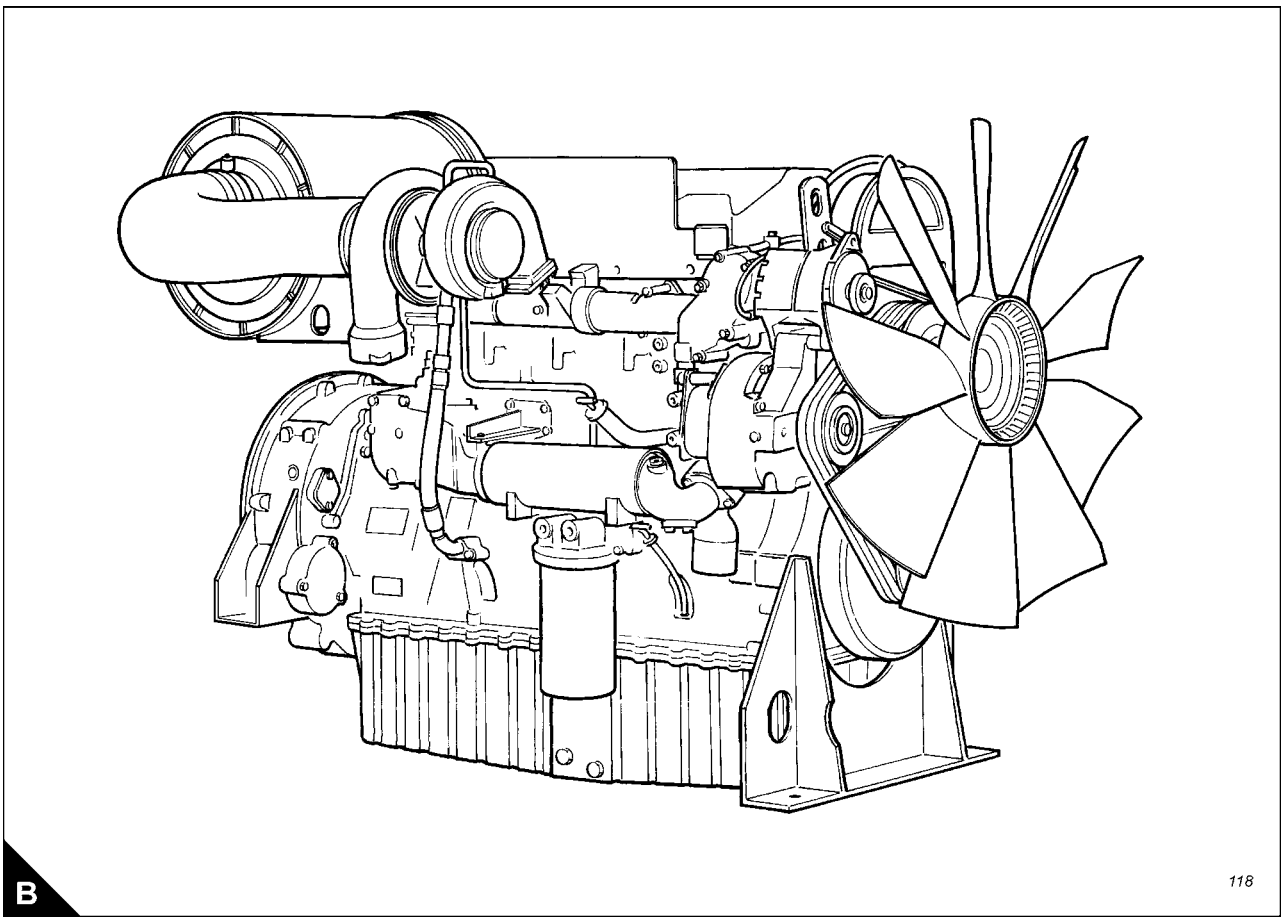
119



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118

Engine identification

If you need parts, service or information for your engine, you must give the complete engine number. The engine number is stamped on a data plate which is fastened to the right side of the engine.

A typical engine number is: HGA060125U 1103H, which consists of these codes:

H	Code for engine capacity
G	Engine application
A	Engine type
06	Number of engine cylinders
0125	Engine specification number
U	The country of manufacture
1103	Build line number
H	Year of manufacture

Engine lift equipment

A dry engine weighs approximately 1551 kg (3,419 lb). Ensure that the lift equipment used is suitable. An adjustable lifting beam should be used and the chains or cables must be parallel to each other during use.

Before the engine is lifted:

- Always use lift equipment of the approved type and of the correct capacity to lift the engine. Never use a single lift bracket to raise an engine.
- Check the engine lift brackets for damage and security before the engine is lifted.

Use suitable lift equipment or obtain assistance to lift heavy engine components such as the cylinder block, cylinder head, damper unit, flywheel housing, crankshaft and flywheel.

Warning! *The lifting eyes which are fitted to the engine must be used for lifting only the engine. Do NOT use them to lift the engine if it is still attached to its driven unit.*

2

Specifications

Basic engine data - 2306 engine

Number of cylinders. 6
Cylinder arrangement.. ... ... .In line
Cycle ... ... Four stroke
Induction system.. ... ... Turbocharged
Combustion system. ... ...Direct injection
Nominal bore ... ... .137 mm (5.394 in)
Nominal stroke. ... ... .165 mm (6.496 in)
Compression ratio 15.9:1
Cubic capacity . ... 14,6 litres (893 in^3)
Firing order 1, 5, 3, 6, 2, 4
Direction of rotation . ... Anti-clockwise viewed on flywheel

Lubricating oil capacity:

Total system ... ...68 litres (120 UK pints)
Sump maximum... ... ...60 litres (106 UK pints)
Sump minimum ... ... 45 litres (79 UK pints)

Lubricating oil pressure:

At rated speed . ...4,5 bar
Typical coolant capacity of engine... ... ... 20,8 litres (4.6 UK gallons)
Typical coolant capacity of engine and radiator .. .. .47 litres (10.3 UK gallons)

Basic engine data - 2806 engine

Number of cylinders. 6
Cylinder arrangement.. ... ... .In line
Cycle ... ... Four stroke
Induction system.. ... ... Turbocharged
Combustion system. ... ...Direct injection
Nominal bore ... ... .140 mm (5.512 in)
Nominal stroke. ... ... .171 mm (6.732 in)
Compression ratio 15.9:1
Cubic capacity . ...15,8 litres (964.18 in^3)
Firing order 1, 5, 3, 6, 2, 4
Direction of rotation . ... Anti-clockwise viewed on flywheel

Lubricating oil capacity:

Total system ... ...68 litres (120 UK pints)
Sump maximum... ... ...60 litres (106 UK pints)
Sump minimum ... ... 45 litres (79 UK pints)

Lubricating oil pressure:

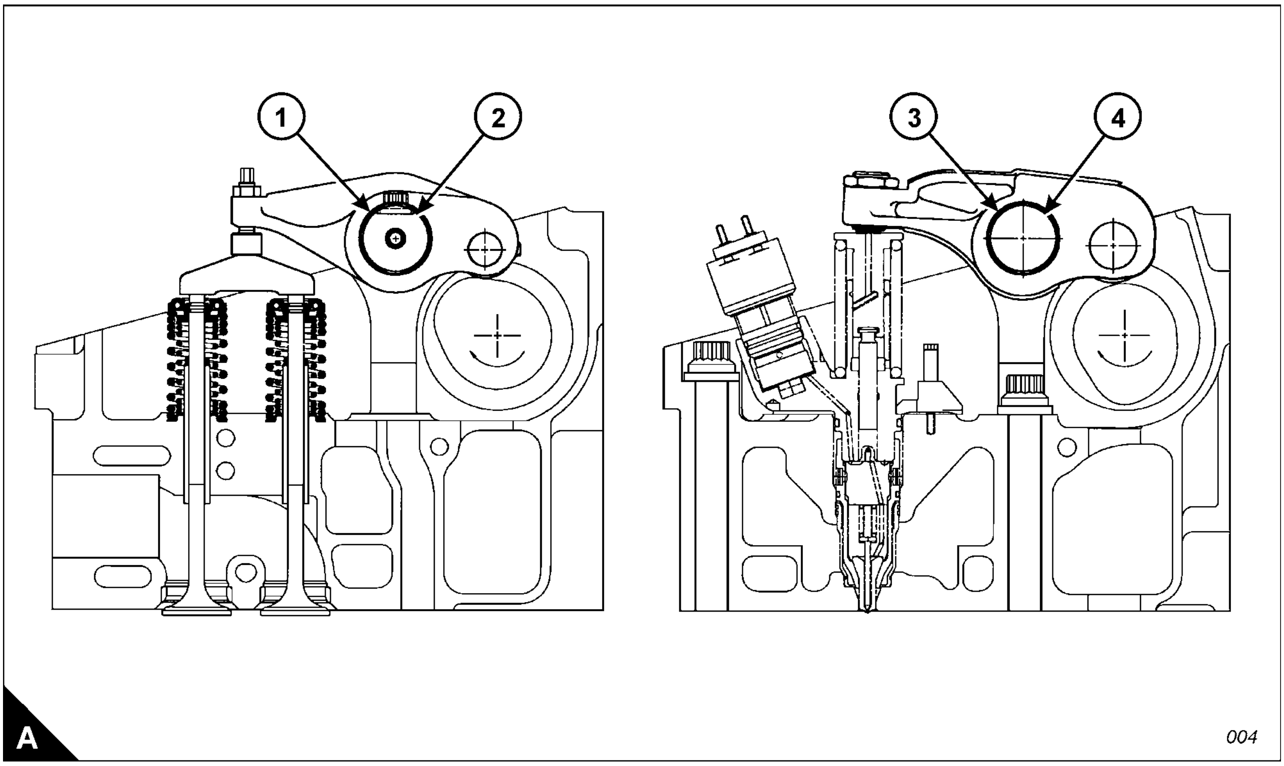
At rated speed . ...4,5 bar
Typical coolant capacity of engine... ... ... 20,8 litres (4.6 UK gallons)
Typical coolant capacity of engine and radiator .. .. 50 litres (11 UK gallons)

Rocker assemblies

Rocker shaft diameter (A2) ... ... 40,000 +/- 0,010 mm (1.5748 +/- 0.0004 in)
Valve rocker lever bore (A1) .. .. 40,065 +/- 0,015 mm (1.5774 +/- 0.0006 in)
Bearing clearance between valve rocker lever and shaft .. .. 0,040 to 0,090 mm (0.0016 to 0.0035 in)
Unit injector rocker lever bore (A3) ... ... 43,000 +/- 0,020 mm (1.6929 +/- 0.0008 in)

If a new bearing is fitted to the unit injector rocker lever, the oil hole in the bearing must be aligned with the oil passage in the rocker lever within 2,4 mm (0.09 in). The bearing must not extend beyond either face of the rocker lever.

Bore in the rocker lever bearing (A4). ... ... 40,065 +/- 0,15 mm (1.5774 +/- 0.0006 in)
Maximum permissible worn dimension.. ... ...40,193 (1.5824 in)



Valves

Diameter of valve stem (B1) ... ... 9,441 +/- 0,010 mm (0.3717 +/- 0.0004 in)
Permissible worn dimension ... ... 9,408 mm (0.3704 in)

Diameter of valve head (B3):

Inlet valve ... ... 47,00 +/- 0,13 mm (1.850 +/- 0.005 in)
Exhaust valve .. .. 41,81 +/- 0,13 mm (1.646 +/- 0.005 in)

Angle of face of valve (B2):

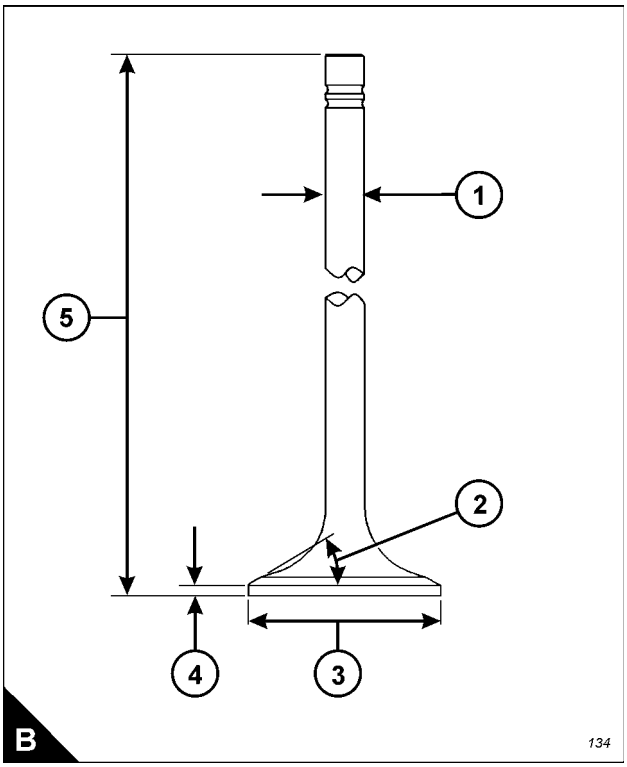
Inlet valve ... ...29 1/4 +/- 1/4 degrees
Exhaust valve .. ..44 1/4 +/- 1/4 degrees

Minimum thickness of valve lip (B4):

Inlet valve ... ... 2,75 mm (0.108 in)
Exhaust valve .. .. 2,05 mm (0.081 in)

Length of valve:

Inlet.. ... ... 202,00 +/- 0,45 mm (7.953 +/- 0.018 in)
Exhaust ... ... 202,06 +/- 0,45 mm (7.955 +/- 0.018 in)

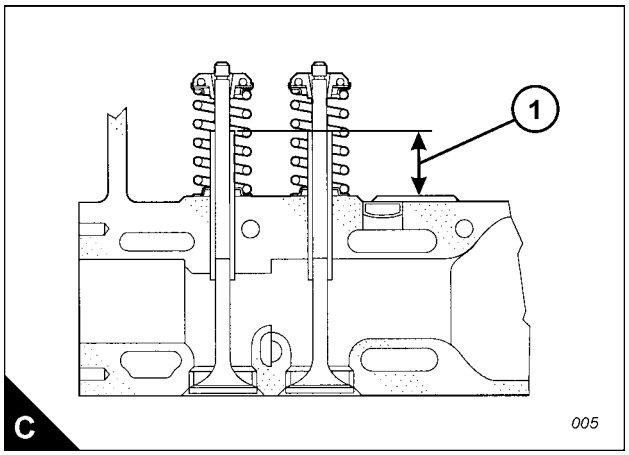


Valve guides

Bore of valve guide when installed ... ... 9,487 +/- 0,025 mm (0.3735 +/- 0.010 in)
Maximum permissible dimension... ... ...9,538 mm (0.3755 in)

Do not use a combination of a valve and valve guide which have a difference of 0,13 mm (0.005 in) or more.

Height from cylinder head to top of valve guide (C1). ... ... 35,00 +/- 0,50 mm (1.378 +/- 0.020 in)



Valve springs

Inner

Assembled length .. .. 60,14 mm (2.368 in)
Load at assembled length.. ... ...118 +/- 12 N (27 +/- 3 lb)
Minimum operating length.. ... ... 44,02 mm (1.733 in)
Load at minimum operating length. ... ...356 +/- 18 N (80 +/- 4 lb)
Free length after test.. ... ... 71,03 mm (2.797 in)
Outside diameter ... ... 25,20 mm (0.992 in)

Outer

Assembled length .. .. 67,12 mm (2.643 in)
Load at assembled length.. ... ...248 +/- 25 N (56 +/- 6 lb)
Minimum operating length.. ... ... 51,00 mm (2.008 in)
Load at minimum operating length. ... ... 756 +/- 35 N (165 +/- 8 lb)
Free length after test.. ... ... 77,88 mm (3.066 in)
Outside diameter ... ... 36,30 mm (1.429 in)

Valve seat inserts

Depth of bore in cylinder head for valve seat insert (D5):

Inlet valve ... ... 14,00 +/- 0,10 mm (0.551 +/- 0.004 in)
Exhaust valve .. .. 13,90 +/- 0,10 mm (0.547 +/- 0.004 in)

Diameter of valve seat insert (D2):

Inlet valve ... ... 48,025 +/- 0,13 mm (1.8907 +/- 0.0005 in)
Exhaust valve .. .. 42,840 +/- 0,13 mm (1.6866 +/- 0.0005 in)

Bore in cylinder head for valve seat insert (D2):

Inlet valve ... ... 47,950 +/- 0,025 mm (1.8878 +/- 0.0010 in)
Exhaust valve .. .. 42,774 +/- 0,025 mm (1.6840 +/- 0.0010 in)

Angle of face of valve seat insert (D1):

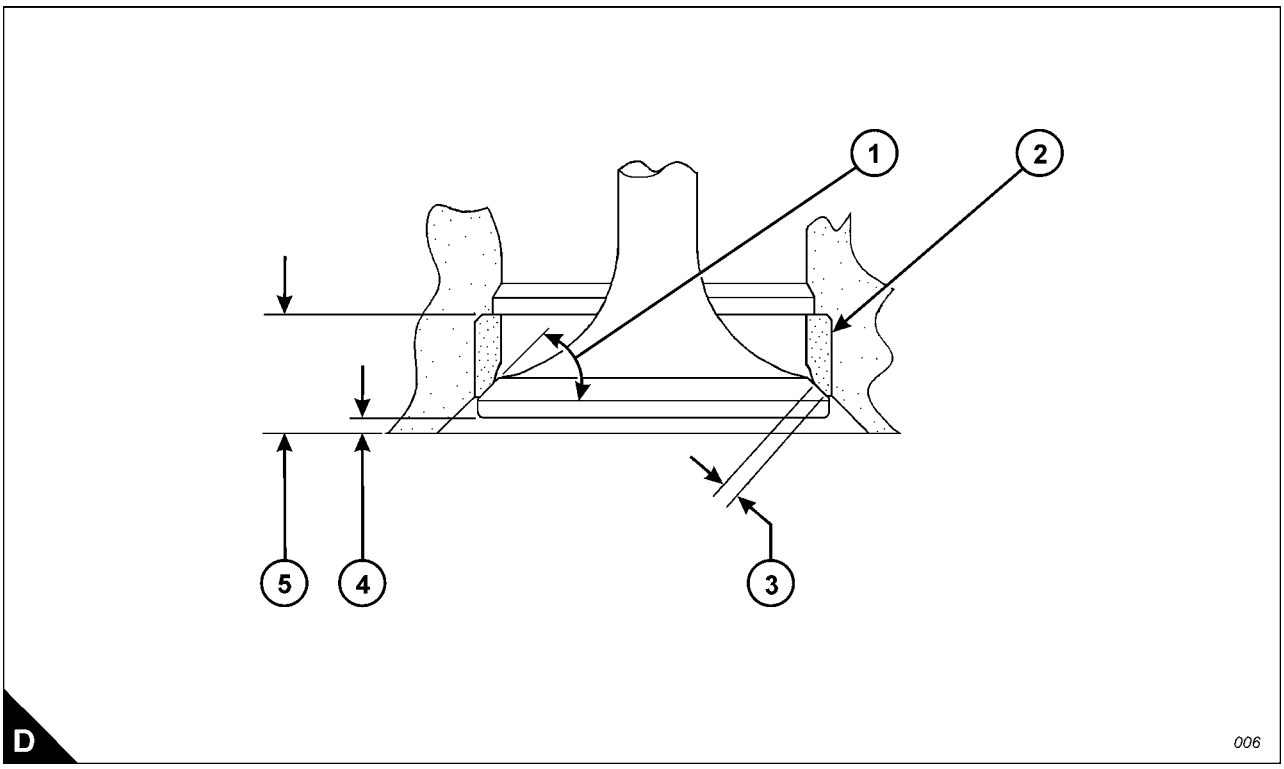
Inlet valve insert... ... ...30 1/4 +/- 1/2 degrees
Exhaust valve insert ... ...45 1/4 +/- 1/2 degrees

Valve recess (D4):

Inlet valve (new parts) . ...2,20 to 2,80 mm (0.087 to 0.110 in)
Exhaust valve (new parts) ... ...1,20 to 1,80 mm (0.047 to 0.071 in)
Inlet valve (reconditioned parts) .. ..2,20 to 3,29 mm (0.087 to 0.129 in)
Exhaust valve (reconditioned parts) ... ...1,20 to 2,29 mm (0.047 to 0.090 in)

Minimum recommended width of valve seat (D3):

Inlet.. ... ... 2,00 mm (0.079 in)
Exhaust ... ... 1,25 mm (0.049 in)



Cylinder head

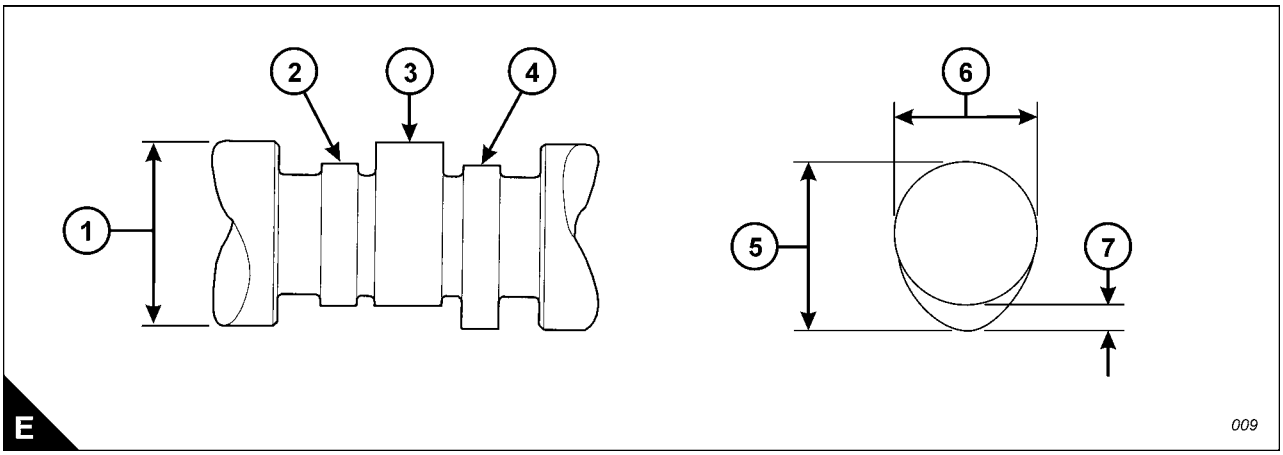
Thickness of cylinder head (new) .. .. 120,00 +/- 0,15 mm (4.724 +/- 0.006 in)
Minimum thickness for a used cylinder head . ...119,50 mm (4.705 in)

Flatness of cylinder head: The cylinder head must be flat to within a total of 0,13 mm (0.005 in). Additionally, the cylinder head must be flat within a maximum of 0,03 mm (0.001 in) across any 76,2 mm (3.00 in) span.

Camshaft and bearings

Diameter of camshaft journal (E3) . ... 84,85 +/- 0,02 mm (3.341+/- 0.001 in)
Exhaust lobe lift.. ... ...8,515 mm (0.3352 in)
Inlet lobe lift ... ...9,431 mm (0.3713 in)
Injector lobe lift... ... ... 10,451 mm (0.4114 in)
Maximum permissible difference between the actual lobe lift (E7)
and the specified dimension .. ..1,0 mm (0.0394 in)

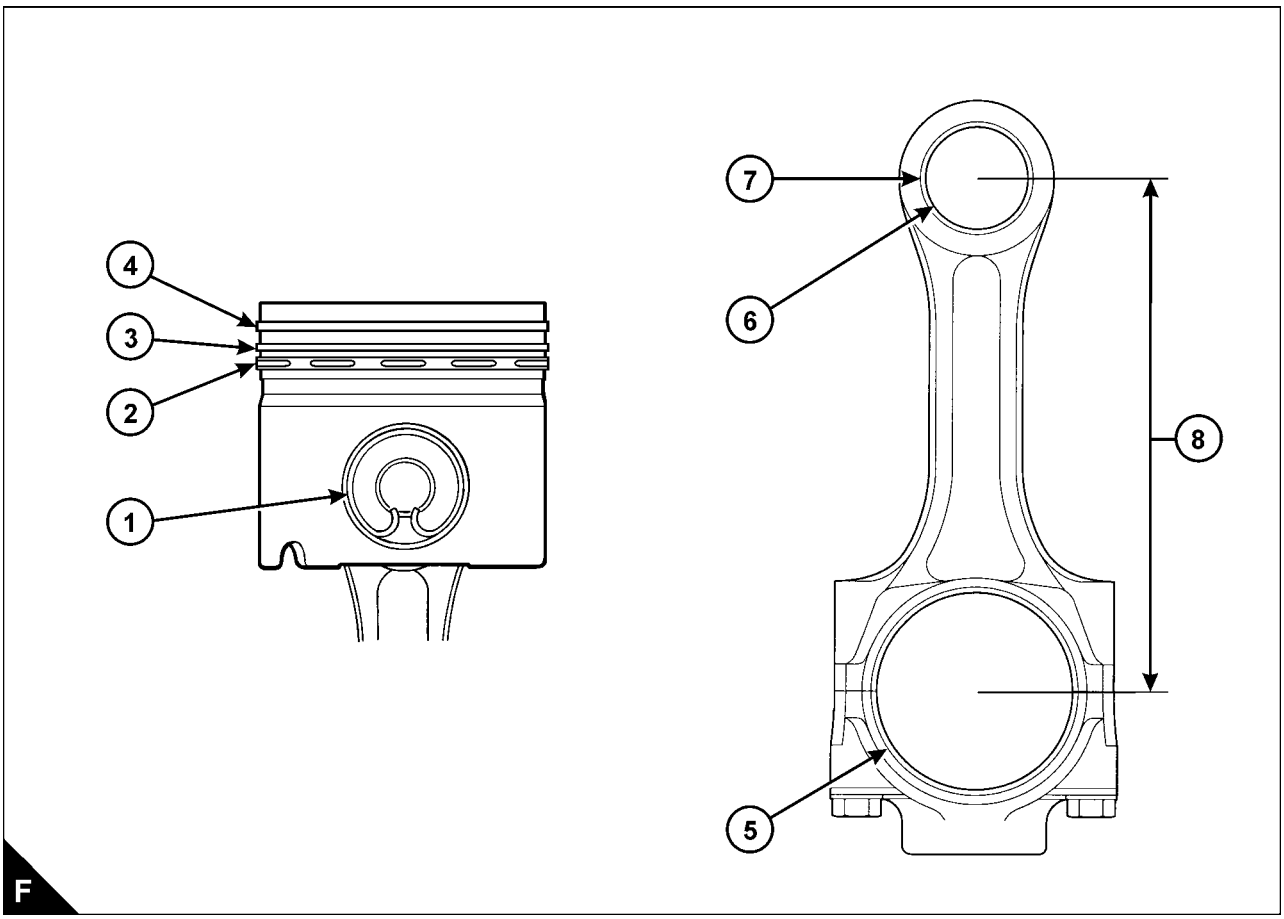
To obtain the lobe lift (E7) proceed as follows: Measure the lobe height (E5) and measure the base circle (E6). Subtract the base circle from the lobe height to give the lobe lift.



Pistons and connecting rods - 2306 engine

Piston ring gaps measured with the ring fitted in a new liner with a bore size 137.16 mm (5.400 in):

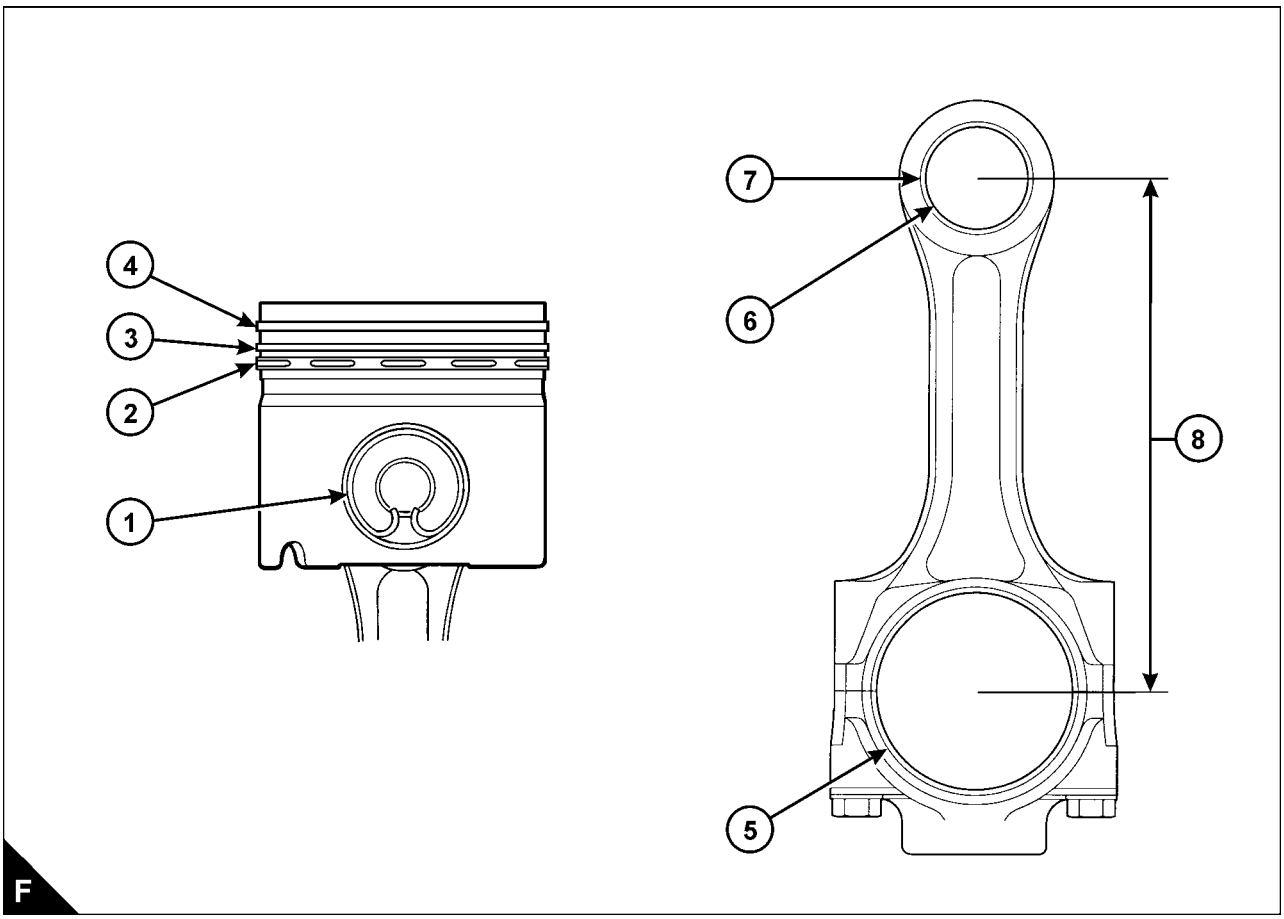
Top piston ring (F4) . ... 0,55 +/- 0,15 mm (0.022 +/- 0.006 in)
Intermediate ring (F3) .. .. 0,83 +/- 0,15 mm (0.033 +/- 0.006 in)
Oil control ring (F2) .. .. 0,550 +/- 0,15 mm (0.022 +/- 0.0059 in)
Width of groove for oil control ring in new piston . ... 4,03 +/- 0,01 mm (0.159 +/- 0.0004 in)
Thickness of a new oil control ring .. .. 3,98 +/- 0,01 mm (0.1567 +/- 0.0004 in)
Clearance between piston ring groove and new oil control ring .. .. 0,05 +/- 0,02 mm (0.002 +/- 0.0008 in)
Maximum permissible clearance between piston
ring groove and a used oil control ring ... ... 0,15 mm (0.006 in)
Bore of piston crown bearing (F1) ... ... 55,0355 +/- 0,0055 mm (2.1667 +/- 0.0002 in)
Bore of piston skirt bearing (F1) .. .. 55,020 +/- 0,005 mm (2.1661 +/- 0.0002 in)
Gudgeon pin diameter (F1) . ... 55,000 +/- 0,005 mm (2.1654 +/- 0.0002 in)
Length of gudgeon pin . ... 113,20 +/- 0,15 mm (4.457 +/- 0.006 in)
Bore in connecting rod for small end bearing (F7) .. .. 59,640 +/- 0,013 mm (2.3480 +/- 0.0005 in)
Bore of connecting rod small end bearing (F6) ... ... 55,035 +/- 0,008 mm (2.1667 +/- 0.0003 in)
Bore in connecting rod for big end bearing shells (F5) ... ... 96,200 +/- 0,013 mm (3.7874 +/- 0.0005 in)
Distance between centres of big and small end bearings (F8) ... . 261,62 +/- 0,05 mm (10.300 +/- 0.002 in)



Pistons and connecting rods - 2806 engine

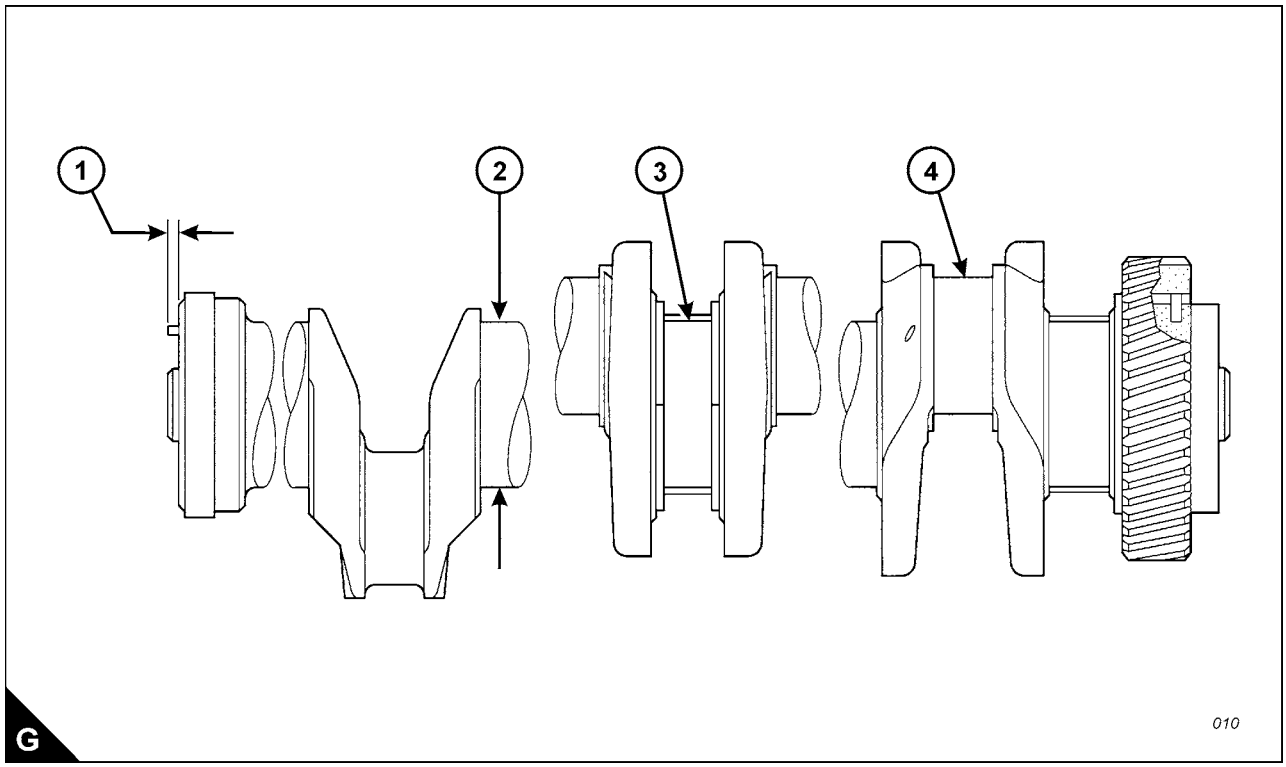
Piston ring gaps measured with the ring fitted in a new liner with a bore size 139,66 mm (5.498 in):

Top piston ring (F4) ... ... 0,50 +/- 0,10 mm (0.020 +/- 0.004 in)
Intermediate ring (F3) ... ... 0,83 +/- 0,15 mm (0.033 +/- 0.006 in)
Oil control ring (F2) ... ... 0,450 +/- 0,150 mm (0.0177 +/- 0.0059 in)
Width of groove for oil control ring in new piston ... ... 4,033 +/- 0,013 mm (0.1588 +/- 0.0005 in)
Thickness of a new oil control ring. ... ... 3,980 +/- 0,010 mm (0.1567 +/- 0.0004 in)
Clearance between piston ring groove and new oil control ring ... . 0,053 +/- 0,023 mm (0.0021 +/- 0.0009 in)
Maximum permissible clearance between piston
ring groove and a used oil control ring... ... ...0,15 mm (0.006 in)
Bore of piston crown bearing (F1).. ... ... 55,0355 +/- 0,0055 mm (2.1667 +/- 0.0002 in)
Bore of piston skirt bearing (F1). ... ... 55,020 +/- 0,005 mm (2.1661 +/- 0.0002 in)
Gudgeon pin diameter (F1) ... ... 55,000 +/- 0,005 mm (2.1654 +/- 0.0002 in)
Length of gudgeon pin ... ... 113,20 +/- 0,15 mm (4.457 +/- 0.006 in)
Bore in connecting rod for small end bearing (F7). ... ... 59,640 +/- 0,013 mm (2.3480 +/- 0.0005 in)
Bore of connecting rod small end bearing (F6).. ... ... 55,035 +/- 0,008 mm (2.1667 +/- 0.0003 in)
Bore in connecting rod for big end bearing shells (F5) .. .. 96,200 +/- 0,013 mm (3.7874 +/- 0.0005 in)
Distance between centres of big and small end bearings (F8) .. .. 261,62 +/- 0,05 mm (10.300 +/- 0.002 in)



Crankshaft, main bearings and flywheel

Diameter of main bearing journal (G2) ... ... 120,650 +/- 0,020 mm (4.7500 +/- 0.0008 in)
Journal undersize by 0,63 mm (0.025 in) ... ... 120,015 +/- 0,020 (4.7250 +/- 0.0008 in)
Journal undersize by 1,27 mm (0.050 in) ... ... 119,380 +/- 0,020 mm (4.7000 +/- 0.0008 in)
Clearance between a new bearing and the journal (G3). ... ...0,091 to 0,186 mm (0.0036 to 0.0073 in)
Maximum permissible clearance between the
bearing and journal.. ... ... 0,25 mm (0.010 in)
Diameter of main bearing bore ... ... 129,891 +/- 0,013 mm (5.1138 +/- 0.0005 in)
Diameter of main bearing bore, oversize by 0,63 mm (0.025 in). 130,526 +/- 0,013 mm (5.1388 +/- 0.0005 in)
Diameter of connecting rod journal (G4) . ... 90,000 +/- 0,020 mm (3.5433 +/- 0.0008 in)
Journal undersize by 0,63 mm (0.025 in) ... ... 89,370 +/- 0,020 (3.5185 +/- 0.0008 in)
Journal undersize by 1,27 mm (0.050 in) ... ... 88,730 +/- 0,020 mm (3.4933 +/- 0.0008 in)
Clearance between a new bearing and the journal. ... ...0,062 to 0,160 mm (0.0024 to 0.0063 in)
Maximum permissible clearance between the
bearing and journal.. ... ... 0,20 mm (0.008 in)
End-float of crankshaft. ... ...0,15 to 0,55 mm (0.006 to 0.022 in)
Maximum permissible end-float (with used bearings) . ... 0,89 mm (0.035 in)
Maximum protrusion of dowel (G1) . ... 6,4 mm (0.25 in)



Crankshaft damper

Maximum permissible run-out of face of damper ... ... 2,03 mm (0.080 in)

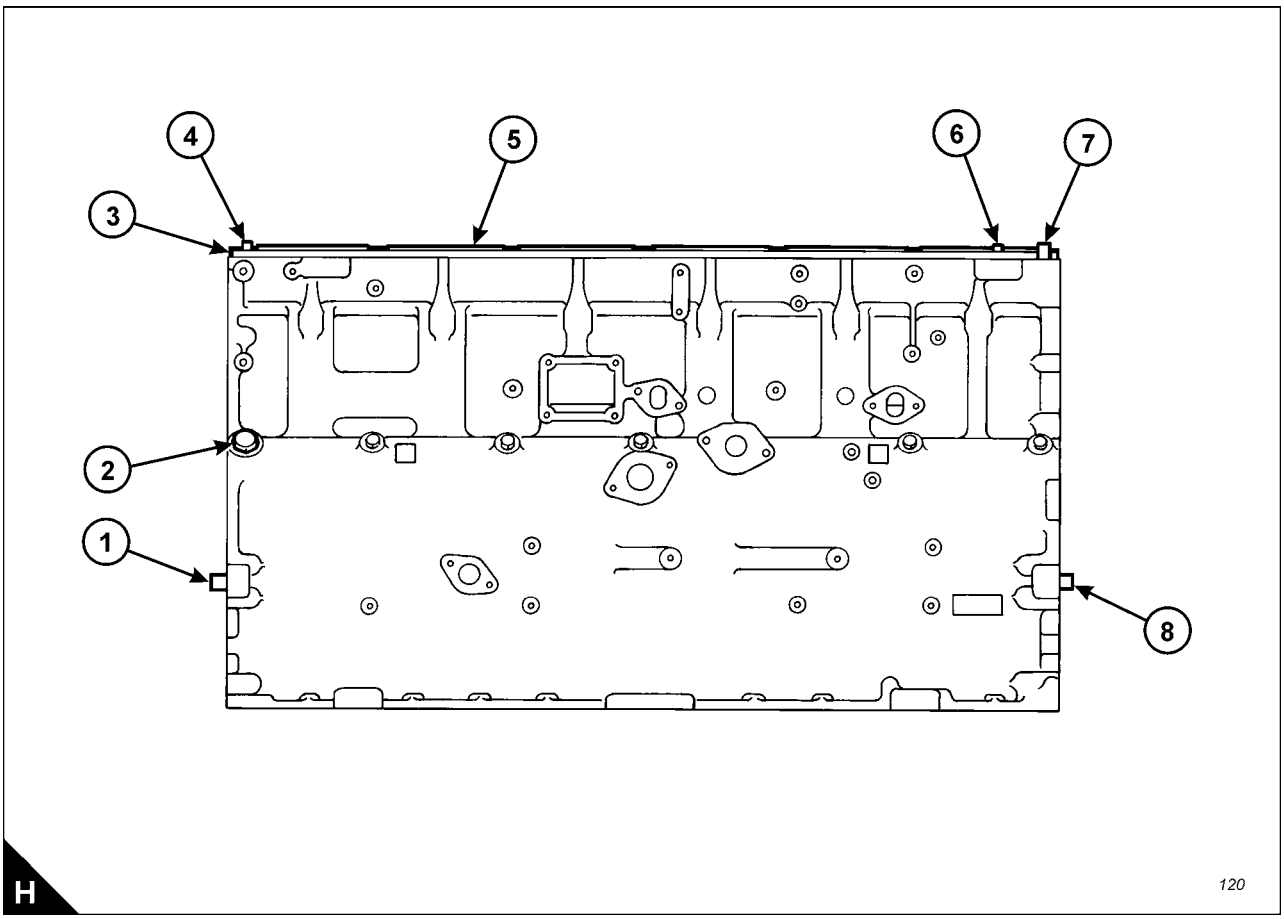
Crankcase and cylinder liners

Thickness of spacer plate (H3) .. .. 8,585 +/- 0,025 mm (0.3380 +/- 0.0010 in)
Thickness of gasket fitted between spacer plate and crankcase... . 0,238 +/- 0,032 mm (0.0094 +/- 0.0013 in)
Cylinder liner protrusion (H5) above the spacer plate ... ... 0,025 to 0,152 mm (0.0010 to 0.0060 in)
Maximum variation in each cylinder liner... ... ...0,051 mm (0.0020 in)
Maximum average variation between adjacent cylinder liners... ... ...0,051 mm (0.0020 in)
Maximum variation between all cylinder liners... ... ...0,102 mm (0.0040 in)

Refer to Operation 7-3 for further cylinder liner information.

Protrusion of front cylinder head dowel (H6) above top face of crankcase ... 16,0 +/- 0,5 mm (0.63 +/- 0.02 in)
Protrusion of rear cylinder head dowel (H4) above top face of crankcase ... 18,5 +/- 0,5 mm (0.73 +/- 0.02 in)
Protrusion of oil transfer tube (H7) above top face of crankcase... ... ... 20,0 +/- 0,5 mm (0.79 +/- 0.02 in)
Protrusion of flywheel housing dowels (H1) from rear face of crankcase .. ... 19,1 +/- 0,5 mm (0.75 +/- 0.02 in)
Protrusion of gear case dowels (H8) from front face of crankcase ... ... 19,1 +/- 0,5 mm (0.75 +/- 0.02 in)
Plug (H2) must be tightened to a torque of ... ... 70 +/- 10 Nm (52 +/- 7 lbf ft)

The total flatness of the top face of the crankcase must be within 0,10 mm (0.004 in). The flatness must also be within 0,05 mm (0.002 in) for any 177,5 mm (6.99 in) section of the surface.



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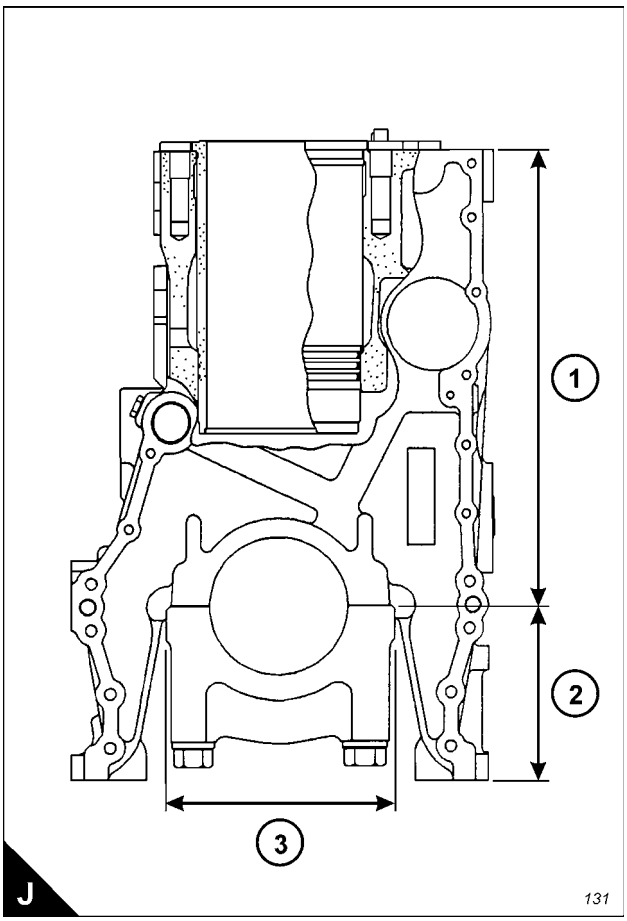
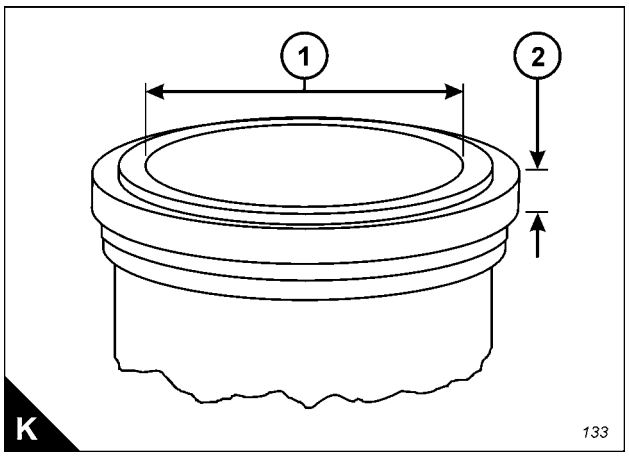
Distance from top of crankcase to centre of main
bearing bore (J1) . ... 425,45 +/- 0,15 mm (16.750 +/- 0.006 in)
Minimum permissible (J1) ... ...425,02 mm (16.733 in)
Distance from bottom of crankcase to centre of main
bearing bore (J2) . ... 165,10 +/- 0,10 mm (6.500 +/- 0.004 in)
Bore in new cylinder liner - 2306 engine (K1).. ... ... 137,185 +/- 0,025 mm (5.4010 +/- 0.0010 in)
Bore in new cylinder liner - 2806 engine (K1).. ... ... 139,685 +/- 0,025 mm (5.4994 +/- 0.0010 in)
Thickness of liner flange (K2) .. .. 8,890 +/- 0,020 mm (0.3500 +/- 0.0008 in)
Minimum thickness permissible (K2)... ... ... 8,870 mm (0.3492 in)



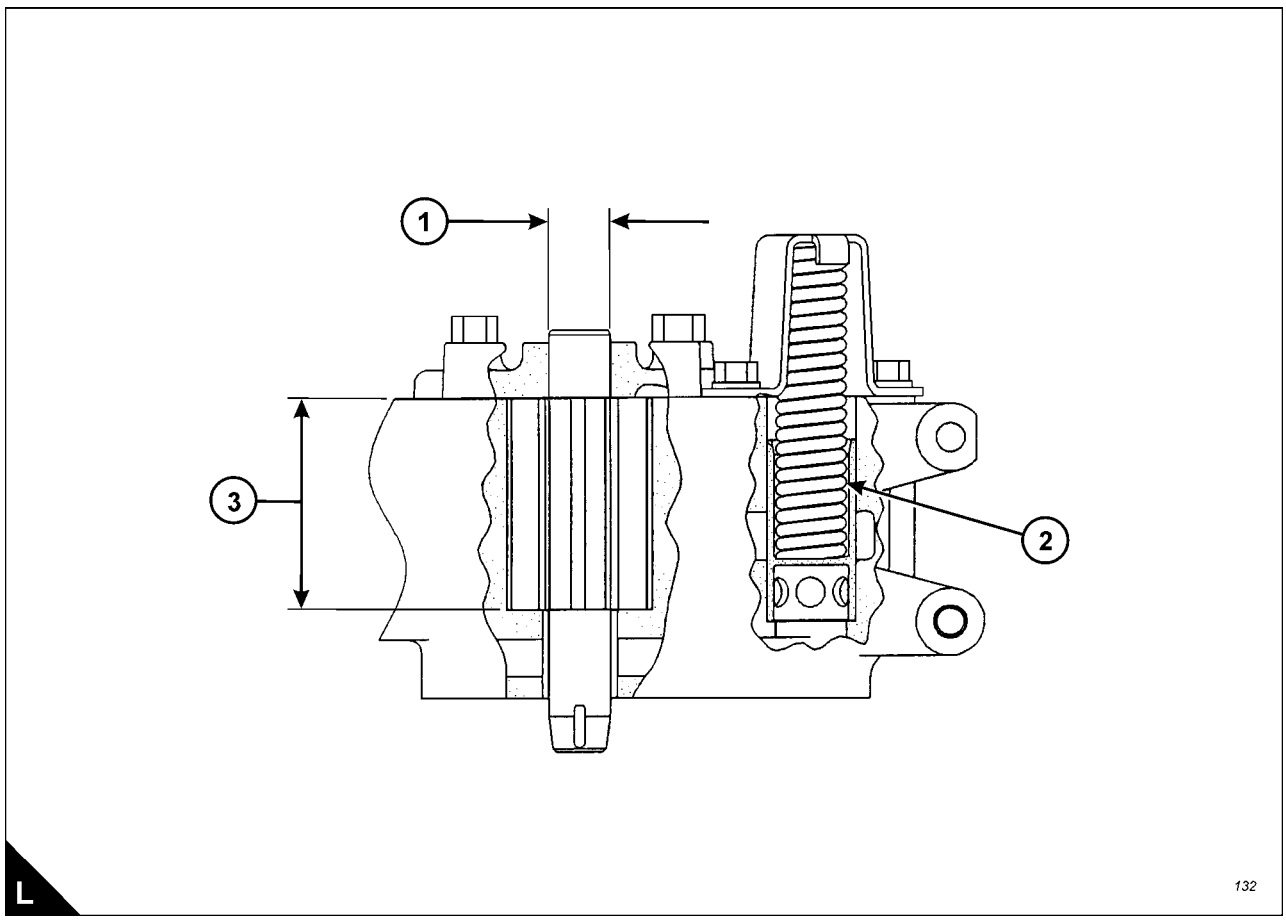


Lubricating oil pump

Diameter of shafts (L1) .. .. 22,217 +/- 0,005 mm (0.8747 +/- 0.0002 in)
Diameter of bores in cover for shafts. ... ... 22,258 +/- 0,008 mm (0.8763 +/- 0.0003 in)
Length of gears (L3)... ... ... 79,375 +/- 0,025 mm (3.1250 +/- 0.0010 in)
Depth of bores for gears (L3). ... ... 79,502 +/- 0,020 mm (3.1300 +/- 0.0008 in)

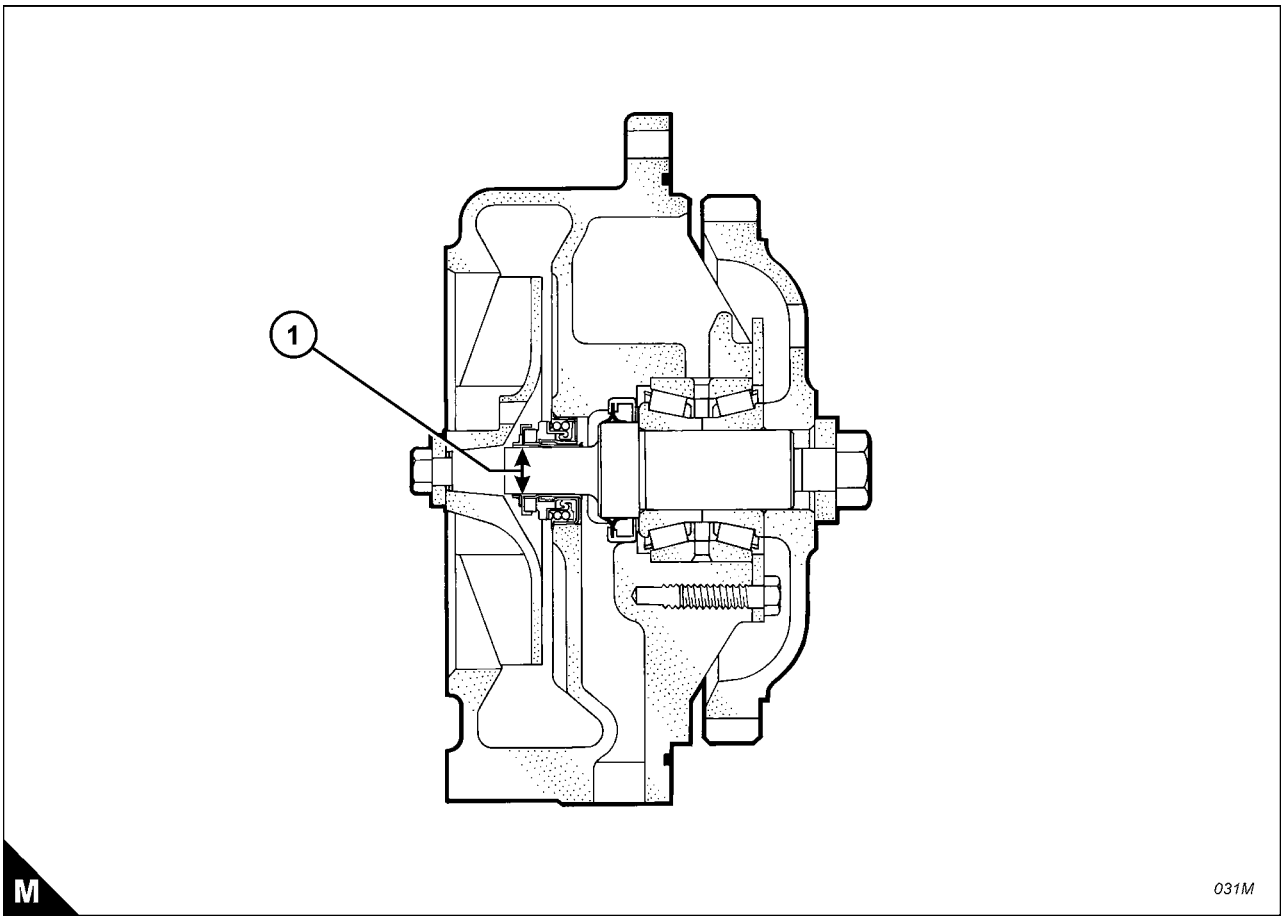
Spring (L2):

Test force ... ... 150 +/- 8 Nm (110 +/- 6 lbf ft)
Length under test force .. ..117,9 mm (4.64 in)
Free length after test .. ..152,9 mm (6.02 in)
Outside diameter ... ... .27 mm (1.063 in)



Coolant pump

Shaft diameter at the position of the coolant seal (M1) ... ... 19,10 +/- 0,01 mm (0.7520 +/- 0.0004 in)



Recommended torque figures

Exceptions to these torque figures are given in the Workshop Manual where necessary.

Before any components are fitted to the engine, ensure that they are in a new or close to new condition. Bolts or threads must not be worn or damaged. Components must be free from rust or other corrosion. Clean with a non-corrosive cleaner if necessary. Do not lubricate the threads of fasteners. Rust preventative which has been applied by the component supplier for shipping and storage is acceptable. Certain components may require an application of a particular lubricant, details are given in the Workshop Manual where relevant.

Standard torque figures for metric fasteners

Metric nuts and bolts	
Thread size metric	**Standard torque**
M6	12 +/- 3 Nm (9 +/- 2 lbf ft)
M8	28 +/- 7 Nm (21 +/- 5 lbf ft)
M10	55 +/- 10 Nm (41 +/- 7 lbf ft)
M12	100 +/- 20 Nm (75 +/- 15 lbf ft)
M14	160 +/- 30 Nm (120 +/- 22 lbf ft)
M16	240 +/- 40 Nm (175 +/- 30 lbf ft)
M20	460 +/- 60 Nm (340 +/- 44 lbf ft)
M24	800 +/- 100 Nm (590 +/- 75 lbf ft)
M30	1600 +/- 200 Nm (1180 +/- 150 lbf ft)
M36	2700 +/- 300 Nm (2000 +/- 220 lbf ft)

Metric taperlock studs	
Thread size metric	**Standard torque**
M6	8 +/- 3 Nm (6 +/- 2 lbf ft)
M8	17 +/- 5 Nm (13 +/- 4 lbf ft)
M10	35 +/- 5 Nm (26 +/- 4 lbf ft)
M12	65 +/- 10 Nm (48 +/- 7 lbf ft)
M16	110 +/- 20 Nm (80 +/- 15 lbf ft)
M20	170 +/- 30 Nm (125 +/- 22 lbf ft)
M24	400 +/- 60 Nm (300 +/- 44 lbf ft)
M30	750 +/- 80 Nm (550 +/- 60 lbf ft)
M36	1200 +/- 150 Nm (880 +/- 110 lbf ft)

Standard torque figures for imperial fasteners

Imperial nuts and bolts	
Thread size inches	**Standard torque**
1/4	12 +/- 3 Nm (9 +/- 2 lbf ft)
5/16	25 +/- 6 Nm (18 +/- 4 lbf ft)
3/8	47 +/- 9 Nm (35 +/- 7 lbf ft)
7/16	70 +/- 15 Nm (50 +/- 11 lbf ft)
1/2	105 +/- 20 Nm (75 +/- 15 lbf ft)
9/16	160 +/- 30 Nm (120 +/- 22 lbf ft)
5/8	215 +/- 40 Nm (160 +/- 30 lbf ft)
3/4	370 +/- 50 Nm (275 +/- 37 lbf ft)
7/8	620 +/- 80 Nm (460 +/- 60 lbf ft)
1	900 +/- 100 Nm (660 +/- 75 lbf ft)
1 1/8	1300 +/- 150 Nm (960 +/- 110 lbf ft)
1 1/4	1800 +/- 200 Nm (1320 +/- 150 lbf ft)
1 3/8	2400 +/- 300 Nm (1780 +/- 220 lbf ft)
1 1/2	3100 +/- 350 Nm (2280 +/- 260 lbf ft)

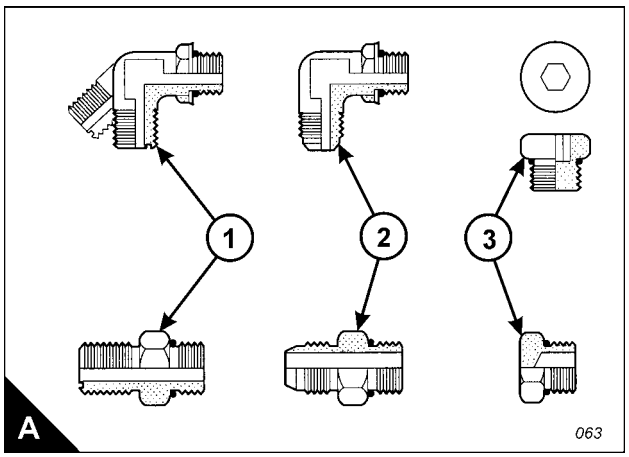
Imperial taperlock studs	
Thread size inches	**Standard torque**
1/4	8 +/- 3 Nm (6 +/- 2 lbf ft)
5/16	17 +/- 5 Nm (13 +/- 4 lbf ft)
3/8	35 +/- 5 Nm (26 +/- 4 lbf ft)
7/16	45 +/- 10 Nm (33 +/- 7 lbf ft)
1/2	65 +/- 10 Nm (48 +/- 7 lbf ft)
5/8	110 +/- 20 Nm (80 +/- 15 lbf ft)
3/4	170 +/- 30 Nm (125 +/- 22 lbf ft)
7/8	260 +/- 40 Nm (190 +/- 30 lbf ft)
1	400 +/- 60 Nm (300 +/- 44 lbf ft)
1 1/8	525 +/- 60 Nm (390 +/- 44 lbf ft)
1 1/4	750 +/- 80 Nm (550 +/- 60 lbf ft)
1 3/8	950 +/- 125 Nm (700 +/- 90 lbf ft)
1 1/2	1200 +/- 150 Nm (880 +/- 110 lbf ft)

Standard torque figures for ‘O’ ring face seal fittings and 37 degree flared fittings

Torque figures for ferrous straight thread ‘O’ ring fittings when connected to ferrous materials		
Outside diameter of nominal tube	**Thread size Inches**	**Standard torque**
3,18 mm (0.125 in)	5/16 - 24	5,0 +/- 1,5 Nm (4 +/- 1 lbf ft)
4,76 mm (0.188 in)	3/8 - 24	12 +/- 2 Nm (9 +/- 1 lbf ft)
6,35 mm (0.250 in)	7/16 - 20	22 +/- 2 Nm (16 +/- 1 lbf ft)
7,94 mm (0.312 in)	1/2 - 20	30 +/- 3 Nm (22 +/- 2 lbf ft)
9,52 mm (0.375 in)	9/16 - 18	48 +/- 5 Nm (35 +/- 4 lbf ft)
12,70 mm (0.500 in)	3/4 - 16	82 +/- 8 Nm (60 +/- 6 lbf ft)
15,88 mm (0.625 in)	7/8 - 14	143 +/- 15 Nm (105 +/- 11 lbf ft)
19,05 mm (0.750 in)	1 1/16 - 12	190 +/- 20 Nm (140 +/- 15 lbf ft)
22,22 mm (0.875 in)	1 3/16 - 12	250 +/- 25 Nm (185 +/- 18 lbf ft)
25,40 mm (1.000 in)	1 5/16 - 12	300 +/- 30 Nm (220 +/- 22 lbf ft)
31,75 mm (1.250 in)	1 5/8 - 12	350 +/- 30 Nm (260 +/- 22 lbf ft)
38,10 mm (1.500 in)	1 7/8 - 12	430 +/- 40 Nm (320 +/- 30 lbf ft)
50,80 mm (2.000 in)	2 1/2 - 12	450 +/- 45 Nm (330 +/- 33 lbf ft)

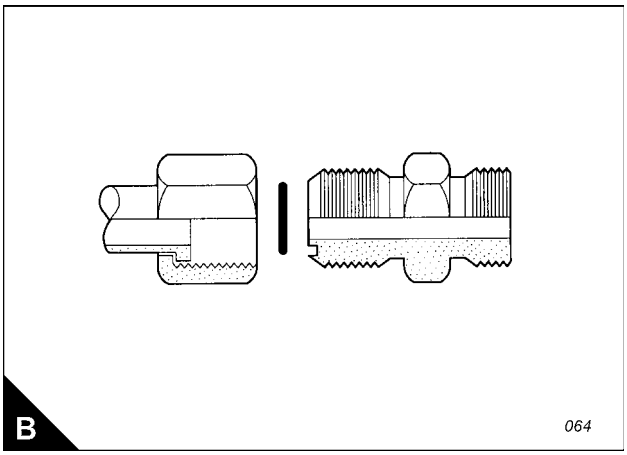
Note: For the table above, use 50 percent of the torque figure when the fitting, the plug or the port material is nonferrous.

Examples of relevant fittings are shown (A): ‘O’ ring face seal (A1), 37 degree flare (A2) and plug with a hexagon or socket-type head (A3).



‘O’ ring face seal fittings

Torque figures for ferrous straight thread ‘O’ ring fittings (B)	
Thread size inches	**Standards torque**
1/4	8 +/- 3 Nm (6 +/- 2 lbf ft)
5/16	17 +/- 5 Nm (13 +/- 4 lbf ft)
3/8	35 +/- 5 Nm (26 +/- 4 lbf ft)
7/16	45 +/- 10 Nm (33 +/- 7 lbf ft)
1/2	65 +/- 10 Nm (48 +/- 7 lbf ft)
5/8	110 +/- 20 Nm (80 +/- 15 lbf ft)
3/4	170 +/- 30 Nm (125 +/- 22 lbf ft)
7/8	260 +/- 40 Nm (190 +/- 30 lbf ft)
1	400 +/- 60 Nm (300 +/- 44 lbf ft)
1 1/8	525 +/- 60 Nm (390 +/- 44 lbf ft)
1 1/4	750 +/- 80 Nm (550 +/- 60 lbf ft)
1 3/8	950 +/- 125 Nm (700 +/- 90 lbf ft)
1 1/2	1200 +/- 150 Nm (880 +/- 110 lbf ft)

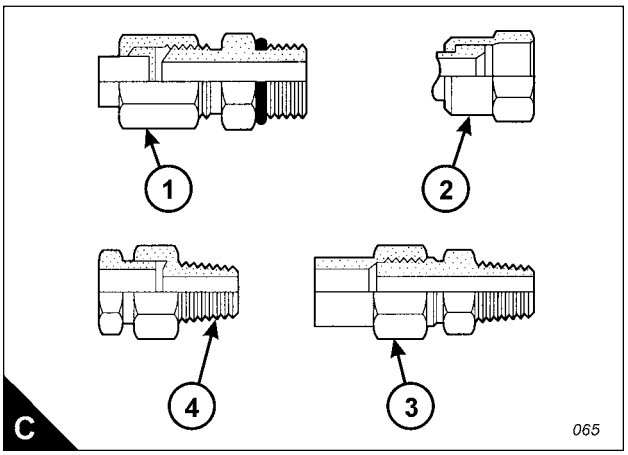


Torque figures for flared and ‘O’ ring fittings

The torque figures given in the table below and the table given on page 17 should be applied to the nut of the fittings which follow: 37 degree flared fittings (C1), 45 degree flared fittings (C3), inverted flared fittings (C2), ‘O’ ring fittings for a recessed drive, ‘O’ ring fittings for air conditioning and swivel nuts (C2). The figures should be used for applications which allow these working pressures: 7750 to 34450 kPa (1125 to 5000 lb/in²). The torque figure depends on the size and type of fitting.

Nuts for 37 degree flared fittings		
Outside diameter of nominal tube	**Thread size Inches**	**Standard torque**
3,18 mm (0.125 in)	5/16	5,0 +/- 1,5 Nm (4 +/- 1 lbf ft)
4,76 mm (0.188 in)	3/8	11 +/- 2 Nm (8 +/- 1 lbf ft)
6,35 mm (0.250 in)	7/16	16 +/- 4 Nm (12 +/- 3 lbf ft)
7,94 mm (0.312 in)	1/2	20 +/- 5 Nm (15 +/- 4 lbf ft)
9,52 mm (0.375 in)	9/16	25 +/- 5 Nm (18 +/- 4 lbf ft)
9,52 mm (0.375 in)	5/8	35 +/- 5 Nm (26 +/- 4 lbf ft)
12,70 mm (0.500 in)	3/4	50 +/- 7 Nm (37 +/- 5 lbf ft)
15,88 mm (0.625 in)	7/8	65 +/- 7 Nm (48 +/- 5 lbf ft)
19,05 mm (0.750 in)	1 1/16	100 +/- 10 Nm (75 +/- 7 lbf ft)
22,22 mm (0.875 in)	1 3/16	120 +/- 10 Nm (90 +/- 7 lbf ft)
25,40 mm (1.000 in)	1 5/16	135 +/- 15 Nm (100 +/- 11 lbf ft)
31,75 mm (1.250 in)	1 5/8	180 +/- 15 Nm (135 +/- 11 lbf ft)
38,10 mm (1.500 in)	1 7/8	225 +/- 15 Nm (165 +/- 11 lbf ft)
50,80 mm (2.000 in)	2 1/2	320 +/- 30 Nm (240 +/- 22 lbf ft)

Note: For the table above, use 50 percent of the torque figure when the fitting, the plug or the port material is nonferrous.



45 degree flared and 45 degree inverted flare fittings

45 degree flared and 45 degree inverted flare fittings		
Outside diameter of nominal tube	**Thread size Inches**	**Standard torque**
3,18 mm (0.125 in)	5/16	5,0 +/- 1,5 Nm (4 +/- 1 lbf ft)
4,76 mm (0.188 in)	3/8	8 +/- 1,5 Nm (6 +/- 1 lbf ft)
6,35 mm (0.250 in)	7/16	11 +/- 2 Nm (8 +/- 1 lbf ft)
7,94 mm (0.312 in)	1/2	17 +/- 3 Nm (13 +/- 2 lbf ft)
9,52 mm (0.375 in)	5/8	30 +/- 3 Nm (22 +/- 2 lbf ft)
11,11 mm (0.438 in)	11/16	30 +/- 3 Nm (22 +/- 2 lbf ft)
12,70 mm (0.500 in)	3/4	38 +/- 4 Nm (28 +/- 3 lbf ft)
15,88 mm (0.625 in)	7/8	50 +/- 5 Nm (37 +/- 4 lbf ft)
19,05 mm (0.750 in)	1 1/16	90 +/- 8 Nm (65 +/- 6 lbf ft)
22,22 mm (0.875 in)	1 1/4	100 +/- 10 Nm (75 +/- 7 lbf ft)

Tapered pipe thread fittings

Tapered pipe thread fittings		
Thread size Inches	**Standard torque**	
	Threads with pipe sealant (CV60891)	**Threads without pipe sealant**
1/16 - 27	10 Nm (7 lbf ft)	10 Nm (7 lbf ft)
1/8 - 27	16 Nm (12 lbf ft)	16 Nm (12 lbf ft)
1/4 - 18	20 Nm (15 lbf ft)	25 Nm (18 lbf ft)
3/8 - 18	35 Nm (26 lbf ft)	45 Nm (33 lbf ft)
1/2 - 14	45 Nm (33 lbf ft)	60 Nm (44 lbf ft)
3/4 - 14	60 Nm (44 lbf ft)	75 Nm (55 lbf ft)
1 - 11 1/2	75 Nm (55 lbf ft)	90 Nm (65 lbf ft)
1 1/4 - 11 1/2	90 Nm (65 lbf ft)	110 Nm (80 lbf ft)
1 1/2 - 11 1/2	110 Nm (80 lbf ft)	130 Nm (95 lbf ft)
2 - 11 1/2	130 Nm (95 lbf ft)	160 Nm (120 lbf ft)

Note: For the table above, use 50 percent of the torque figure when the fitting, the plug or the port material is nonferrous.

Torque figures for standard hose clamps of the worm drive band type

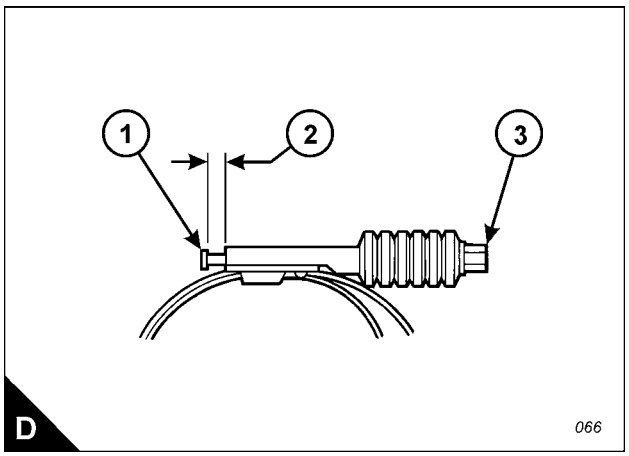
Width of clamp	Torque figure for initial installation on a new hose
7,9 mm (0.31 in)	0,9 +/- 0,2 Nm (8 +/- 2 lbf in)
13,5 mm (0.53 in)	4,5 +/- 0,5 Nm (40 +/- 4 lbf in)
15,9 mm (0.63 in)	7,5 +/- 0,5 Nm (65 +/- 4 lbf in)
Width of clamp	Torque figure for used clamp
7,9 mm (0.31 in)	0,7 +/- 0,2 Nm (6 +/- 2 lbf in)
13,5 mm (0.53 in)	3,0 +/- 0,5 Nm (27 +/- 4 lbf in)
15,9 mm (0.63 in)	4,5 +/- 0,5 Nm (40 +/- 4 lbf in)

Torque figures for constant torque hose clamps

Use a torque wrench for the correct installation of a constant torque hose clamp. For a constant torque hose clamp to be installed correctly, these conditions must exist:

The screw tip (D1) must extend by 6,35 mm (0.250 in) beyond the housing (D2).

The belleville washers must be collapsed almost flat after the screw (D3) has been tightened to a torque of 11 +/- 1 Nm (98 +/- 9 lb in).



3

Cylinder head assembly

General information

The cylinder head is a single-piece cast iron component. The camshaft is mounted in the cylinder head and runs in shell bearings. The bearings are pressed into each journal and are lubricated under pressure. Bridge piece guides have been eliminated as floating valve bridges have been utilised.

Special thermal sleeves manufactured from stainless steel are fitted to the exhaust ports. These reduce the amount of heat transferred to the cooling system and direct the thermal energy to the turbocharger.

The electronic unit injectors are mounted in stainless steel sleeves which have been pressed into the injector bores of the cylinder head.

The operations to remove and to fit valve seat inserts and to remove and to fit camshaft bearings are not included as specialist equipment is required. It is recommended that operators take advantage of the Perkins service exchange scheme if these procedures become necessary.

Rocker cover

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

To remove

Warning! *The electrical circuit for the fuel injector units operates on 110 volts. Do NOT work on the fuel injector units unless the power supply to the ECM has been disconnected.*

1 Disconnect the wiring harness at the socket on the rocker cover (A1).

2 Disconnect and remove the engine breather pipe (A2).

3 Loosen fully the bolts which retain the rocker cover, but do not remove the bolts from the assembly; allow them to be retained by the seal.

4 Remove the rocker cover.

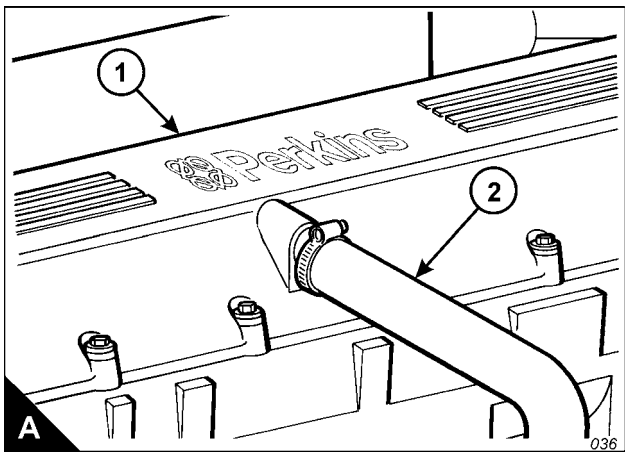
To fit

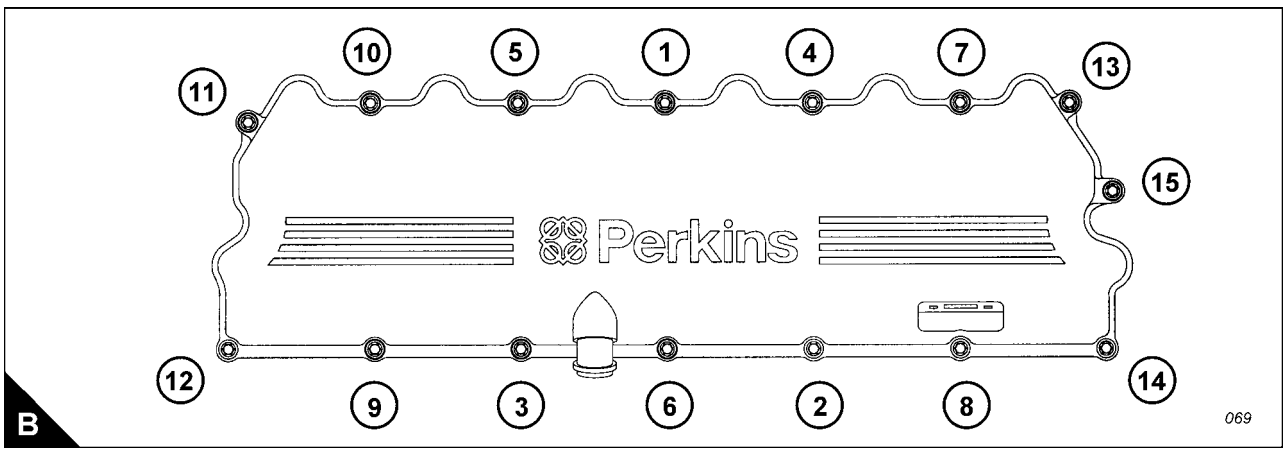
1 Inspect the seal of the rocker cover and renew if worn of damaged.

2 Fit the rocker cover, complete with seal and bolts. Tighten the bolts to a torque of 20 Nm (15 lbf ft); use the sequence shown (B).

3 Fit the engine breather pipe (A2).

4 Connect the wiring harness. Ensure that the wiring harness is fully engaged with the connector.





Rocker lever and rocker shaft assemblies

To remove and to fit **Operation 3-2**

To remove

1 Remove the rocker cover, Operation 3-1.

2 The valve rocker levers (A1) and the unit injector rocker levers (A2) can move on the shaft (A6) after the four bolts (A5) have been removed. The shaft (A6) should be kept level when removed from the cylinder head. To avoid possible personal injury, keep fingers clear of the rocker levers (A1 and A2) during removal of the assembly from the cylinder head.

3 Remove the four bolts (A5).

4 Remove the shaft (A6), valve rocker levers (A1) and unit injector rocker levers (A2) as a unit.

5 Repeat steps 1 and 2 for the rocker shaft assemblies which remain.

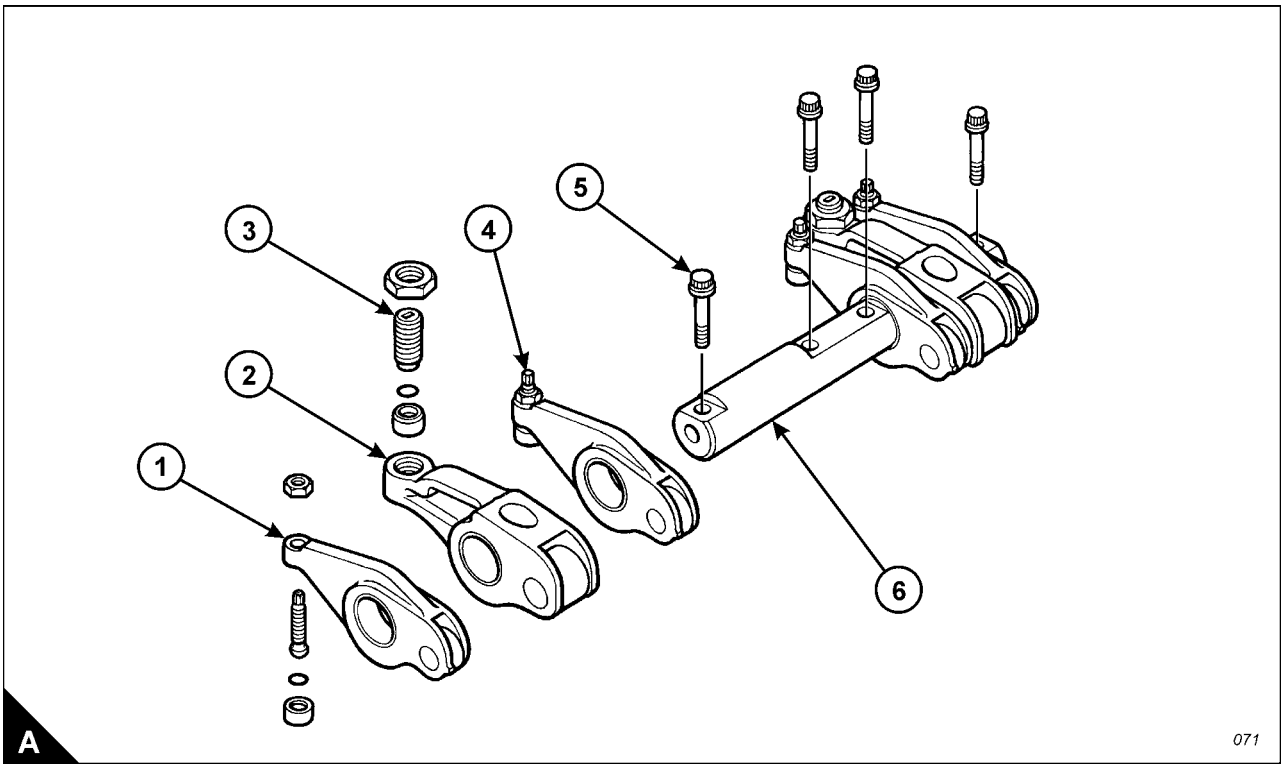
To fit

1 Loosen the adjustment screws (A3 and A4) of each of the rocker levers which have been removed. Install the rocker shaft assembly in the reverse order to removal.

2 Set the tappet clearances, Operation 3-4.

3 Check/adjust the unit injectors, Operation 3-13.

4 Fit the rocker cover, Operation 3-1.



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

To dismantle

Note: Check the condition of all components and renew any which are worn or damaged.

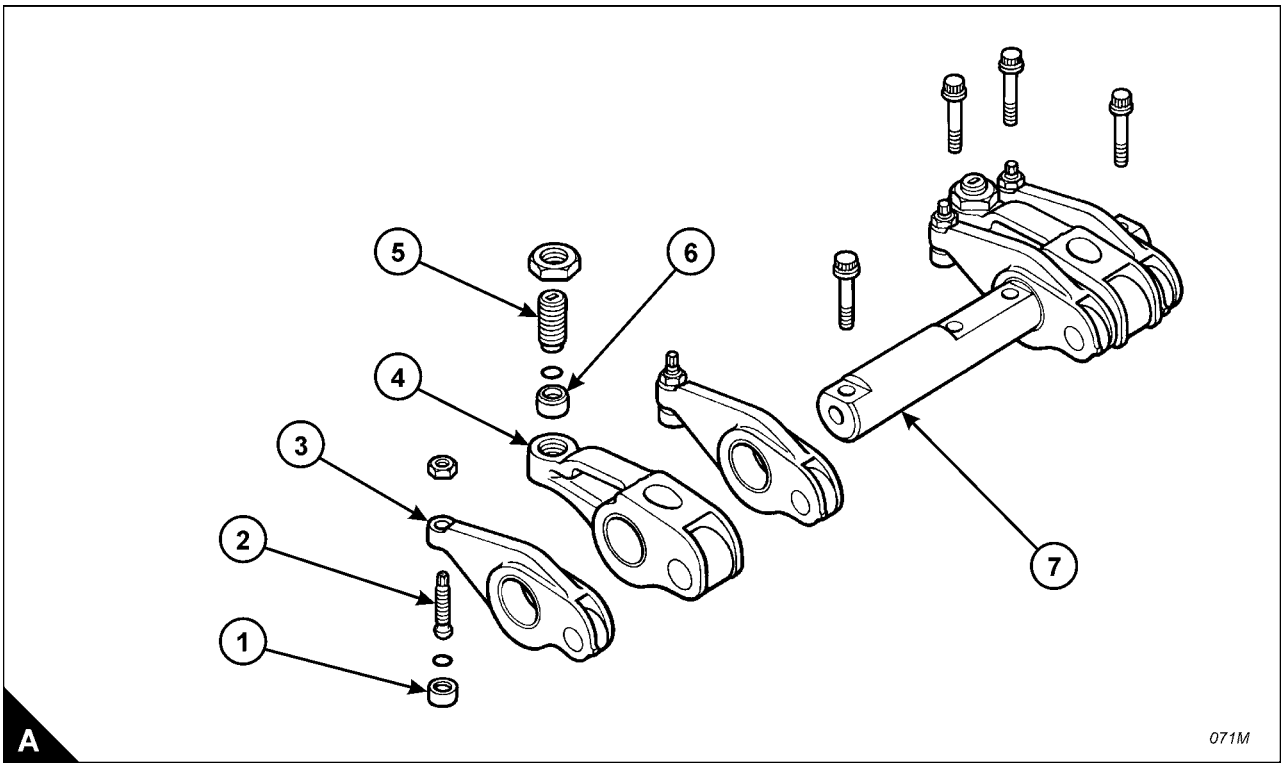
1 Slide the valve rocker levers (A3) and the unit injector rocker levers (A4) from the shaft (A7).

Note: Fit a new 'O' ring seal to any rocker lever adjuster if its button (A1) has been removed from the adjustment screw (A2).

2 Remove the button (A1) from the adjustment screw (A2) in the valve rocker lever (A3).

3 Remove the button (A6) from the adjustment screw (A5) in the unit injector rocker lever (A4).

4 Repeat steps 1 to 3 for the rocker lever assemblies which remain.



To assemble

1 Install new ‘O’ ring seals in the buttons (A1).

2 Install new ‘O’ ring seals in the buttons (A6).

3 To fit the ‘O’ ring seals and buttons to the valve rocker levers, proceed as follows:

a. Support the valve rocker lever (A3) in a vice which has soft jaws.

b. Put the ‘O’ ring seal and button (A1) on the round end of the adjustment screw (A2).

c. Use a soft hammer to seat the button on the adjustment screw.

4 To fit the ‘O’ ring seals and buttons to the unit injector rocker levers, proceed as follows:

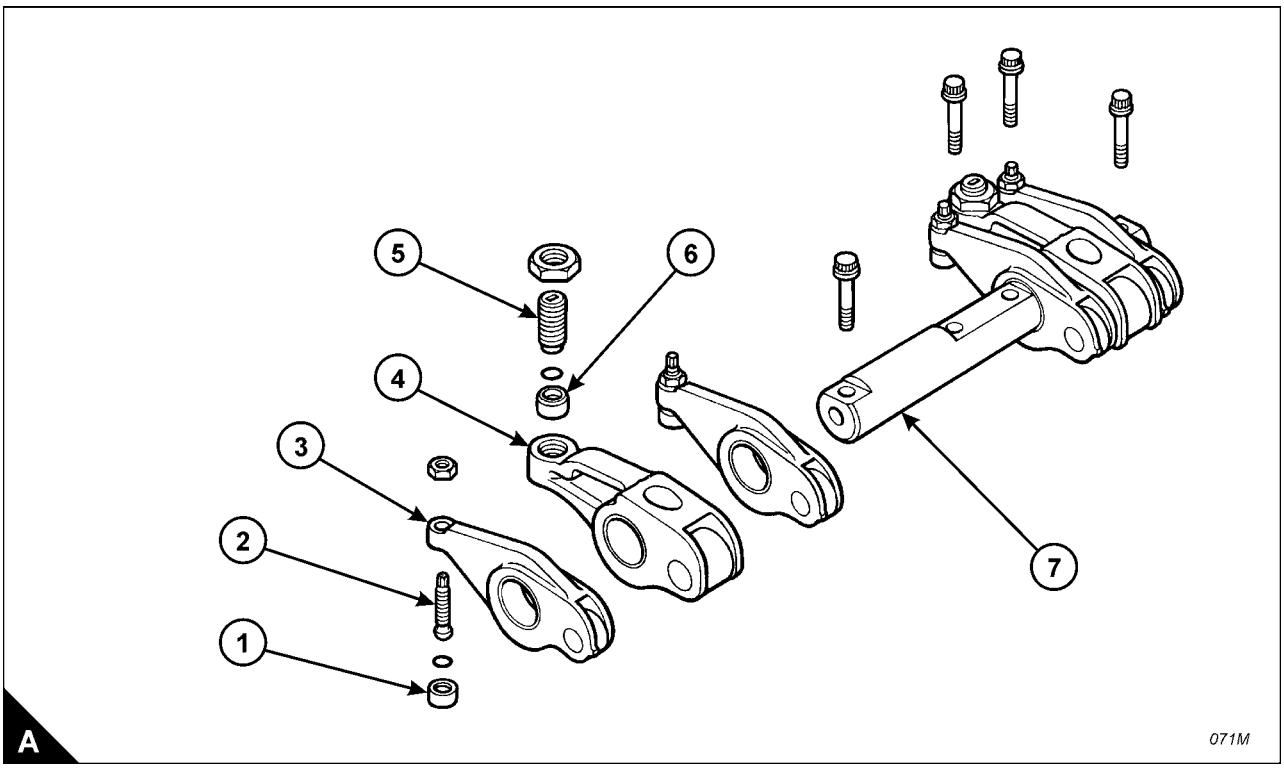
a. Support the unit injector rocker lever (A4) in a vice which has soft jaws.

b. Put the ‘O’ ring seal and button (A6) over the end of adjustment screw (A5).

c. Use a soft hammer to seat the button on the adjustment screw.

5 Repeat steps 3 and 4 for the rocker levers which remain.

6 Fit the assembled rocker levers to the shafts (A7). Ensure that they are fitted to their original positions.



How to check/adjust the tappet clearances **Operation 3-4**

Special requirements

Special tools		Tappet clearances	
Description	**Part number**	**Inlet**	**Exhaust**
Engine turning tool	CH11148	0,38 mm (0.015 in)	0,76 mm (0.030 in)

The tappet clearance is measured between the rocker levers and the top of the valve bridge pieces. The operation must be done with the engine cold and stopped. Refer also to Operation 3-13, How to check/adjust the electronic unit injectors.

1 Remove the rocker cover, Operation 3-1.

2 Remove the cover (A2) from the flywheel housing. The top bolt (A1) is the timing bolt.

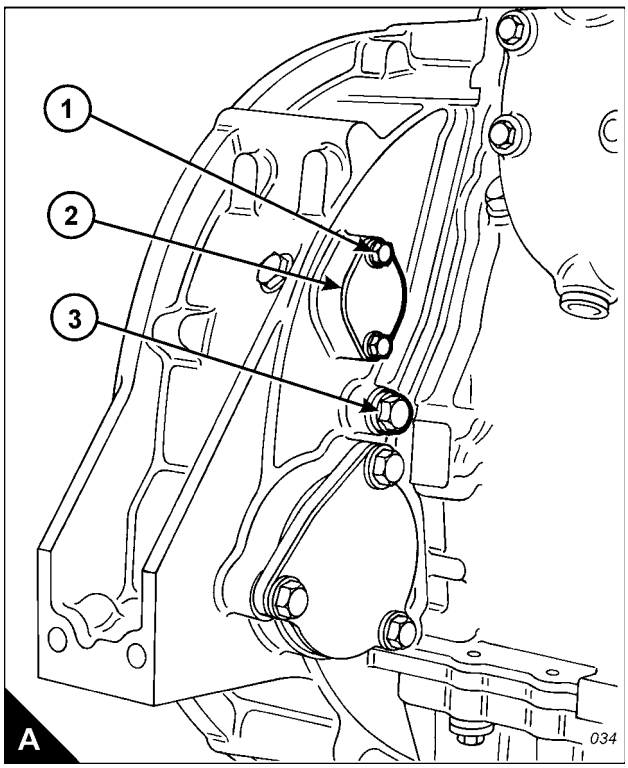
Caution: *If a customer-fitted speed sensor is fitted to the flywheel housing, it must be removed before the engine turning tool can be inserted.*

3 Remove the plug (A3) from the timing bolt location in the flywheel housing and fit the timing bolt.

Note: There are two locations for the timing bolt, one at each side of the flywheel housing. Use the location that is the most convenient.

4 Insert the engine turning tool, CH11148, into the flywheel housing through the aperture behind the cover (A2). Use a $^{1}/_{2}$ inch drive ratchet with the turning tool to rotate the engine flywheel in the normal direction of rotation (anti-clockwise when viewed on the flywheel) until the timing bolt engages with the threaded hole in the flywheel. The piston of number 1 cylinder is now at TDC (top dead centre).

Caution: *If the flywheel is turned past the threaded hole, the flywheel must be turned in the opposite direction for approximately 45 degrees and then back in the normal direction of rotation until the timing bolt engages with the threaded hole. This is to eliminate backlash.*



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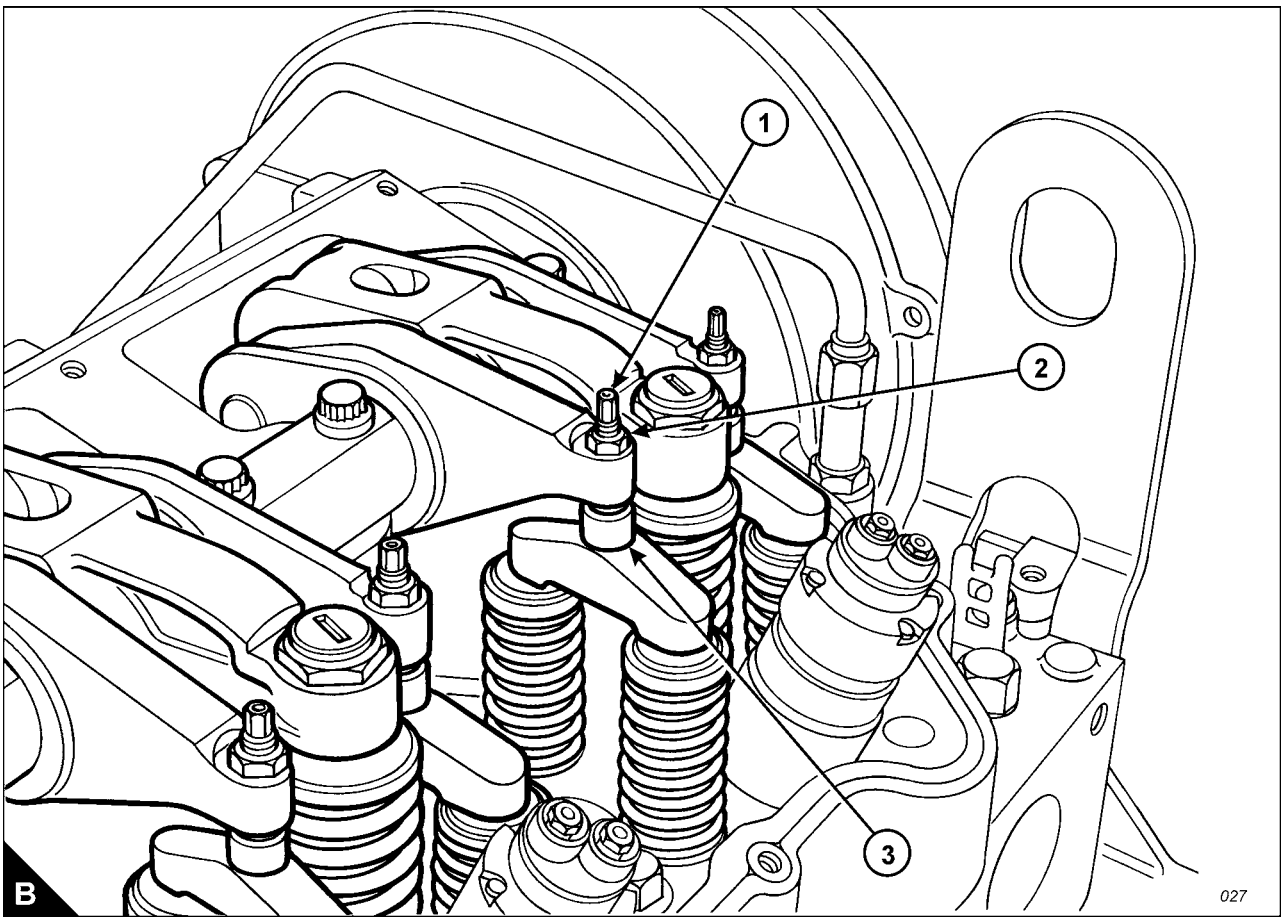
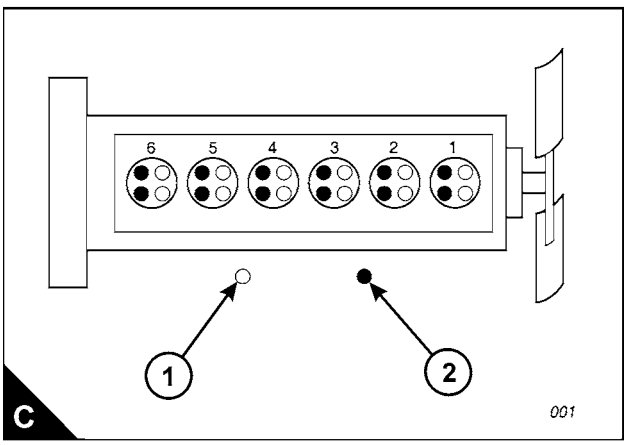
5 Check the inlet and exhaust valves of the number 1 cylinder. If they are fully closed the piston is on its compression stroke and the rocker levers can be moved by hand. If the rocker levers can not be moved because the valves are slightly open, the piston is on its exhaust stroke. If it is on its exhaust stroke, withdraw the timing bolt and turn the flywheel a further 360 degrees in the normal direction of rotation so that the number 1 cylinder is set to TDC on its compression stroke, then insert again the timing bolt.

6 Before each set of tappet clearances is adjusted, ensure that the roller of the rocker lever is fully against the camshaft lobe.

7 Use a set of feeler gauges, inserted at the position shown (B3) between the valve bridge piece and the rocker lever button, to check the tappet clearances for the inlet valves (C1) on cylinders 1, 2 and 4. Adjust the clearances if necessary. Check the tappet clearance for the exhaust valves (C2) on cylinders 1, 3 and 5, and adjust the clearances if necessary.





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Notes:

- Move each valve bridge piece before the feeler gauge is inserted to reduce the effect of the oil film.
- During the procedure, ensure that the feeler gauge is fully inserted

8 After each unit has been adjusted, tighten the lock nut (B2) of the adjustment screw (B1) to a torque of 30 +/ - 4 Nm (22 +/- 3 lbf ft).

9 Withdraw the timing bolt and rotate the flywheel by 360 degrees so that the number 6 piston is at TDC on its compression stroke. Insert again the timing bolt into the threaded hole.

10 Check the tappet clearances for the inlet valves (C1) on cylinders 3, 5 and 6. Adjust the clearances if necessary. Check the tappet clearances for the exhaust valves (C2) on cylinders 2, 4 and 6, and adjust the clearances if necessary.

11 After each unit has been adjusted, tighten the lock nut of the adjustment screw to a torque of 30 +/- 4 Nm (22 +/- 3 lbf ft).

12 Check again the tappet clearances for all six cylinders.

13 Fit the rocker cover. Remove the engine turning tool and the timing bolt and fit the cover to the flywheel housing. Fit the plug to the timing bolt location.

Cylinder head assembly

To remove and to fit **Operation 3-5**

Special requirements

Special tools		Consumable products	
Description	**Part number**	**Description**	**Part number**
Guide bolt, camshaft gear	GE50019	Special lubricant	CV60895
Socket, cylinder head bolt	GE50020	Retaining compound	21820 638
Lifting bracket	VP12712		

To remove

1 Remove the thermostat housing, Operation 12-10.

2 Remove the exhaust manifold, Operation 9-1.

3 Remove the rocker lever and rocker shaft assemblies, Operation 3-2.

4 Remove the electronic unit injectors, Operation 3-12.

5 Remove the gear case cover, Operation 6-1.

6 Disconnect the cable and remove the timing sensor from the cylinder head.

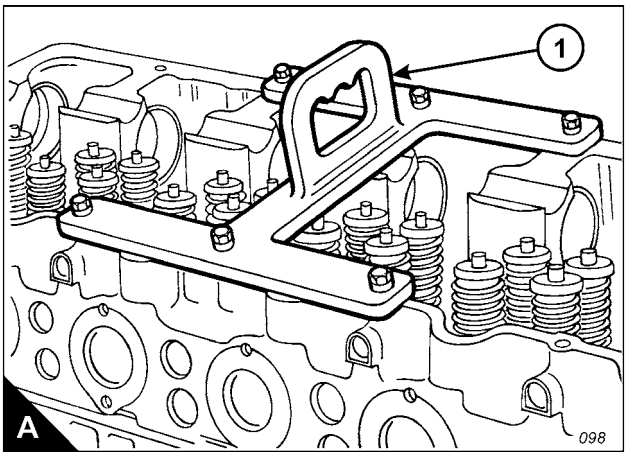
7 Remove the support bracket which is fitted between the gear case and the cylinder head.

8 Remove one bolt from the camshaft gear and install the guide stud, GE50019. Remove the five bolts which remain and withdraw carefully the camshaft gear. Remove the guide stud.

9 Disconnect the fuel lines from the front and rear of the cylinder head. Fit temporary covers to the fuel lines and also to the ports on the cylinder head.

10 Remove the cylinder head bolts; use the special socket, GE50020.

11 Fit the lifting bracket (A1), VP12712, to the cylinder head and attach a suitable hoist. Remove the cylinder head. The cylinder head weighs approximately 148 kg (325 lb).



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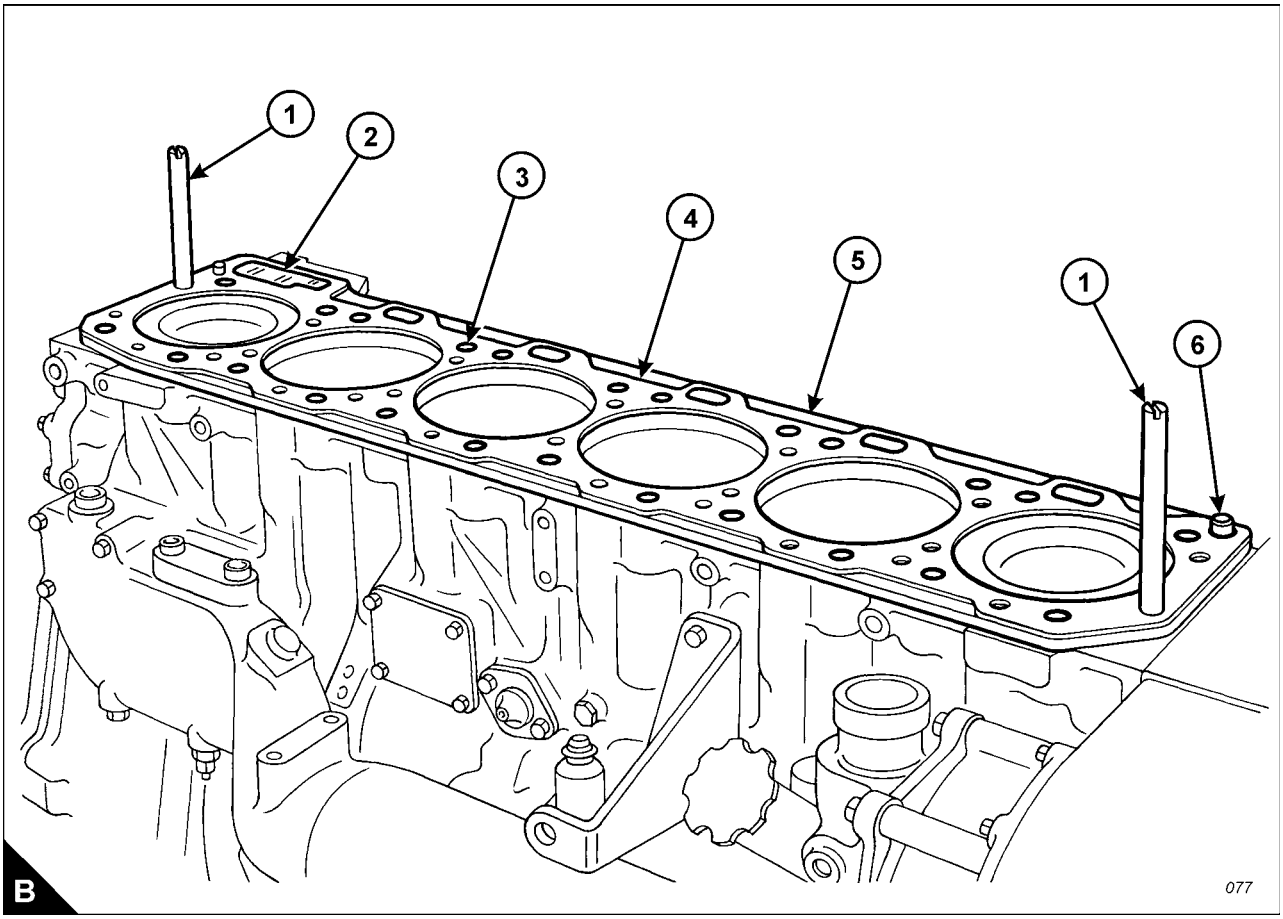
12 Remove the cylinder head gasket (B4).

13 Remove the ‘O’ ring seal from the oil transfer tube (B6) and remove the 24 coolant seals (B3).

14 Remove the seal (B2).

15 Remove the spacer plate (B5) and discard the spacer plate gasket.

16 Remove the second ‘O’ ring seal from the oil transfer tube (B6).



To fit

1 If the oil transfer tube (B6) has been removed, apply retaining compound, 21820 638, and insert it in the crankcase. It must protrude from the top face of the crankcase by 20,0 +/- 0,5 mm (0.79 +/- 0.02 in). Remove any excess compound and ensure that the bore of the oil transfer tube is clean.

2 If the rear dowel has been removed, apply retaining compound, 21820 638, and insert it in the crankcase. It must protrude from the top face of the crankcase by 18,5 +/- 0,5 mm (0.73 +/- 0.02 in).

3 If the front dowel, close to the oil transfer tube, has been removed, it must be fitted in a dry condition. It must protrude from the top face of the crankcase by 16,0 +/- 0,5 mm (0.63 +/- 0.02 in).

Note: Ensure that the spacer plate and the machined surface of the cylinder block are clean and free from dirt and gasket material. Both surfaces of the spacer plate gasket and the top of the cylinder block must be clean. Do NOT use a gasket adhesive on the surfaces.

4 Fit suitable guide studs (B1) to the cylinder block. Fit a new spacer plate gasket over the dowels in the cylinder block.

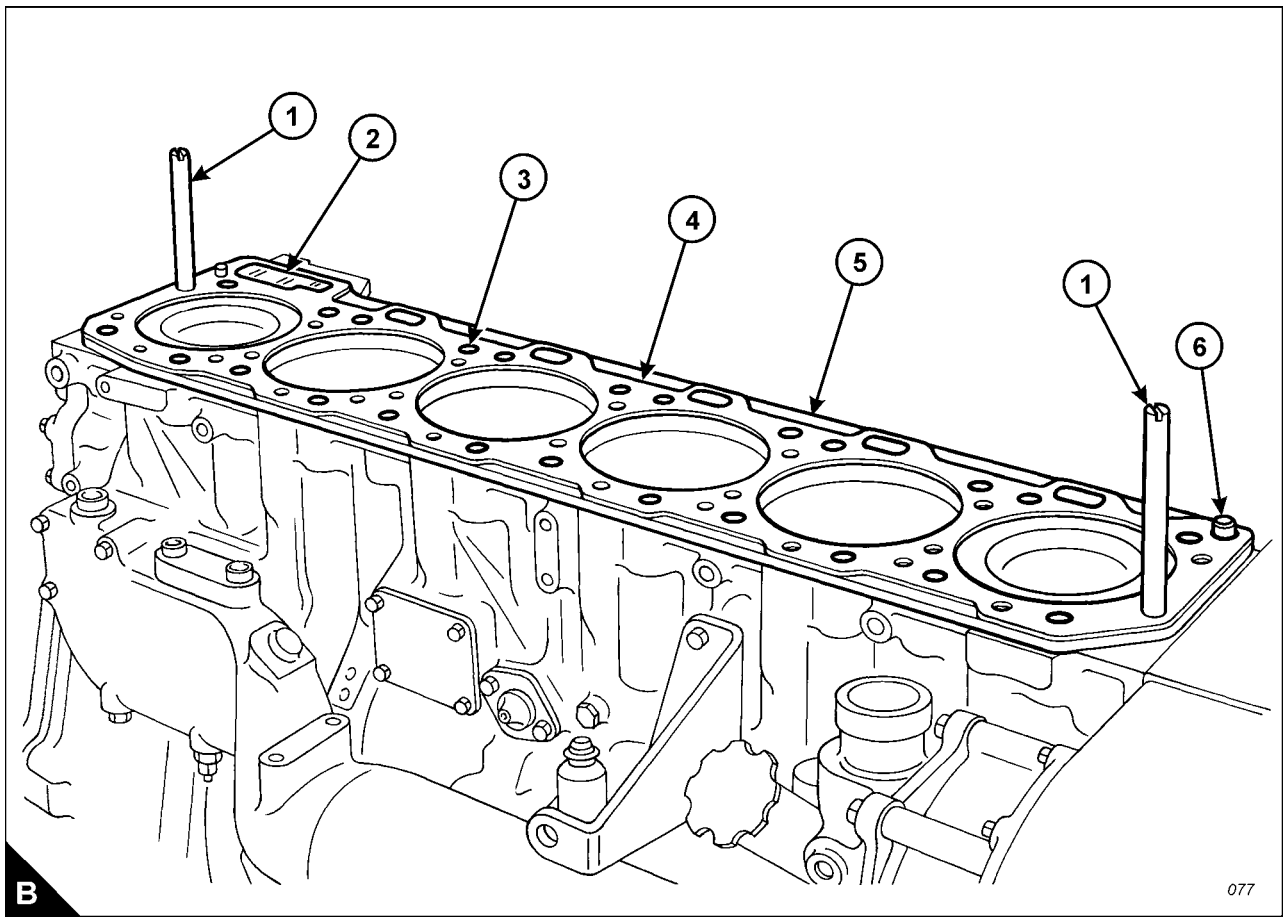
Note: Apply a small amount of clean engine oil to the seals and 'O' ring seals before installation.

5 Fit a new 'O' ring seal to the oil transfer tube (B6).

6 Fit the spacer plate (B5) and fit the second 'O' ring seal to the oil transfer tube (B6). Fit the 24 coolant seals (B3) and a new seal (B2) to the oil drain passage.

7 Check, and if necessary adjust, the protrusion of the cylinder liners, Operation 7-3.

8 Fit a new cylinder head gasket (B4) to the spacer plate.



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9 Fasten a hoist to the cylinder head, use the lifting bracket VP12712, and lower the cylinder head onto the spacer plate.

10 Apply special lubricant, CV60895, to the washers, the threads and under the heads of the bolts and fit the cylinder head bolts and washers. The long bolts must be fitted at the positions shown in the black circles (C). Use the special socket, GE50020, and the procedure which follows to tighten the bolts correctly:

a. Tighten the cylinder head bolts in the sequence given (C) to a torque of 270 +/- 15 Nm (200 +/- 11 lbf ft).

b. Tighten the cylinder head bolts in the sequence given (C) to a torque of 450 +/- 20 Nm (333 +/- 15 lbf ft).

c. Again, tighten the cylinder head bolts in the sequence given (C) to a torque of 450 +/- 20 Nm (333 +/- 15 lbf ft).

Caution: *After the cylinder head assembly has been removed and fitted, it is necessary to check the backlash between the camshaft and the idler gears. Incorrect adjustment can cause damage to components.*

11 Fit the camshaft gear. Check and, if necessary, adjust the backlash between the camshaft gear and the idler gear, Operation 3-11.

12 Fit the gear case cover, Operation 6-1.

13 Fit the support bracket between the cylinder head and the gear case.

14 Fit the electronic unit injectors, Operation 3-12.

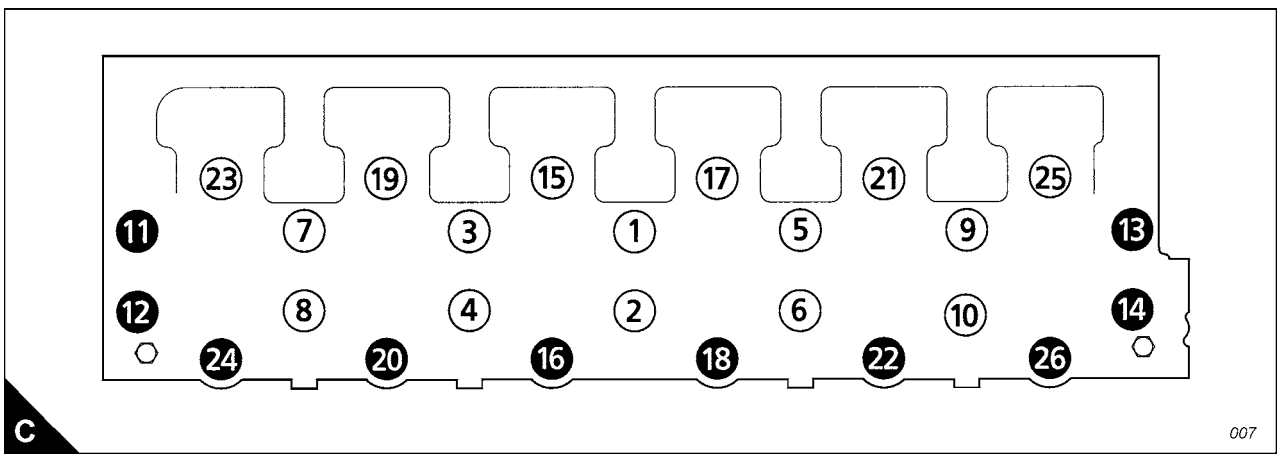
15 Fit the rocker lever and shaft assemblies, Operation 3-2.

16 Fit the exhaust manifold, Operation 9-1.

17 Fit the thermostat housing, Operation 12-10.

18 Remove the covers from the fuel lines and from the fuel line ports on the cylinder head. Connect the fuel lines to the cylinder head and attach any relevant clamps.

19 Fit the timing sensor and connect the cable.



Valve springs

To remove and to fit **Operation 3-6**

Special requirements

Special tools	
Description	**Part number**
Valve spring compressor	GE50026

To remove

Note: The valve springs can be removed with the cylinder head either fitted to or removed from the engine. The procedure given here is for use when the cylinder head is fitted to the engine. Before any components are removed, ensure that the relevant piston is set to the top of its compression stroke. If the piston is not at this position, the valves can fall into the cylinder liner.

Caution: *If a valve falls into the cylinder liner, the cylinder head must be removed.*

1 Remove the rocker lever and rocker shaft assemblies, Operation 3-2.

2 Remove the electronic unit injectors, Operation 3-12.

3 Set the piston for the relevant valve spring assembly to the top of its compression stroke.

4 Use the hold-down clamp from the electronic unit injector to secure the valve spring compressor, GE50026, to the cylinder head.

5 Insert the stud and base of the valve spring compressor into the bore of the injector sleeve. Use the bolt and clamp from the electronic unit injector to secure the stud and base to the cylinder head. Fit the compressor plate (A1) over the stud and fit the thrust bearing, the washer and the nut (A2)

6 Tighten the nut until the collets are loose on the valves.

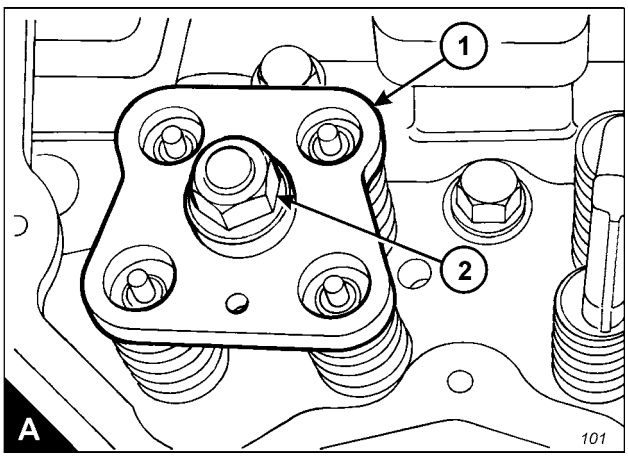
7 Remove two collets from each valve.

8 Loosen slowly, then remove the nut, washer, thrust bearing and plate.

9 Remove the rotocoils, valve springs and washers from each valve.

10 Inspect the valve springs, refer to Chapter 2, Specifications for the correct dimensions and spring force.

11 Repeat steps 3 to 10 for the other valve spring assemblies which are to be removed.



To fit

1 Apply clean engine oil to the relevant valve stems.

2 Fit the washer, valve spring and rotocoil to each valve.

3 Use the valve spring compressor, GE50026, to compress the valve springs.

Note: The collets are tapered. When fitted, the large (thick) diameter must be uppermost.

4 Fit two collets to each valve.

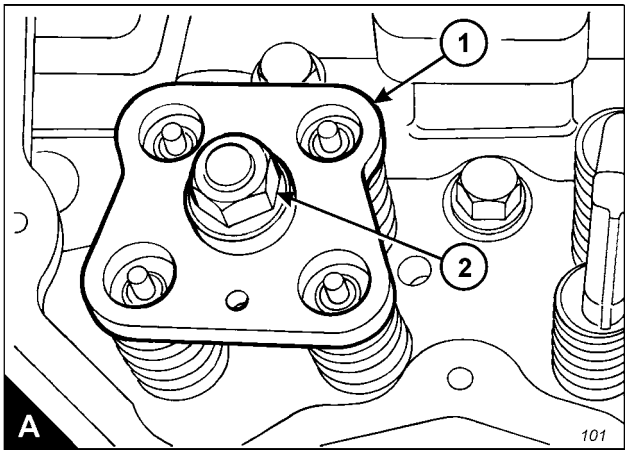
Caution: *The collets can be dislodged from the valve stem during the removal of the valve spring compressor. Ensure that the collets are seated correctly during this procedure.*

5 Loosen slowly and then remove the nut (A2) and plate (A1) of the valve spring compressor. Remove the other parts of the valve spring compressor tool and ensure that the collets are fitted correctly to the valve stems.

6 Tap lightly each valve with a soft hammer to ensure that the collets are seated correctly.

7 Fit the electronic unit injectors, Operation 3-12.

8 Fit the rocker lever and rocker shaft assemblies, Operation 3-2.



To remove and to fit — **Operation 3-7**

Special requirements

Special tools	
Description	**Part number**
Valve spring compressor	GE50026

To remove

1 Remove the cylinder head, Operation 3-5.

Note: If more than one valve is to be removed, make a note of the position of the valves as they are removed from the cylinder head.

2 Put the cylinder head, flame face down, on a bench with a soft surface and release the valves by use of the valve spring compressor, GE50026. Use the procedure given in Operation 3-6.

3 Withdraw the valves from the cylinder head.

4 Repeat the procedure for all valves which are to be removed.

To fit

1 Apply clean engine oil to the stems of the valves. Fit the valves to their original positions in the cylinder head.

2 Use the special tool, GE50026, and the procedure given in Operation 3-6, to install the valve springs.

3 Fit the cylinder head, Operation 3-5.

Valve seals

To renew **Operation 3-8**

Special requirements

Special tools	
Description	**Part number**
Insertion tool, valve seal	GE50027

Note: The valve seals can be removed with the cylinder head either fitted to or removed from the engine.

1 Remove the relevant valve spring assembly, Operation 3-6.

2 Remove the valve seal from the valve and valve guide.

3 Apply a thin film of clean engine oil to the new valve seal and slide the seal over the valve stem.

4 If the valve seal is to be fitted to a valve guide with the valve removed, fit the seal to the special tool, GE50027. Insert the seal pin (part of the special tool GE50027) through the insertion tool, then enter the seal pin into the bore of the valve guide.

5 Use the special tool, GE50027, and hand pressure only to push the valve seal into its position in the valve guide.

6 Withdraw the tool and fit the valve spring assembly, Operation 3-6.

Valve guides

To remove and to fit **Operation 3-9**

Special requirements

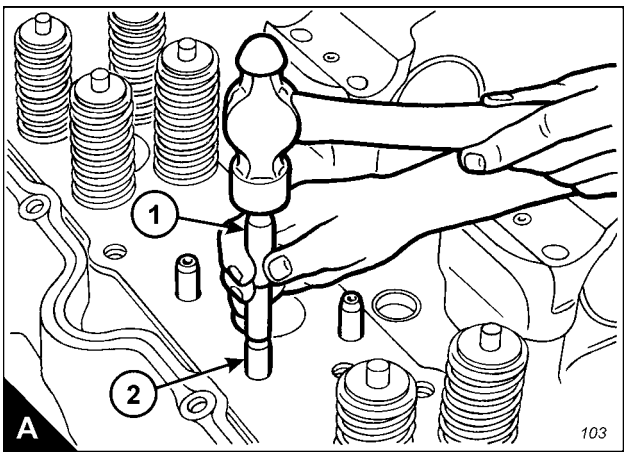
Special tools	
Description	**Part number**
Removal/installation tool	GE50043
Sleeve	GE50044

To remove

1 Remove the cylinder head, Operation 3-5.

2 Remove the valves, Operation 3-7.

3 Use the special tool (A1), GE50043, and a hammer to drive the valve guide (A2) from the cylinder head.



To fit

1 Apply clean engine oil to the outside diameter of the new valve guides.

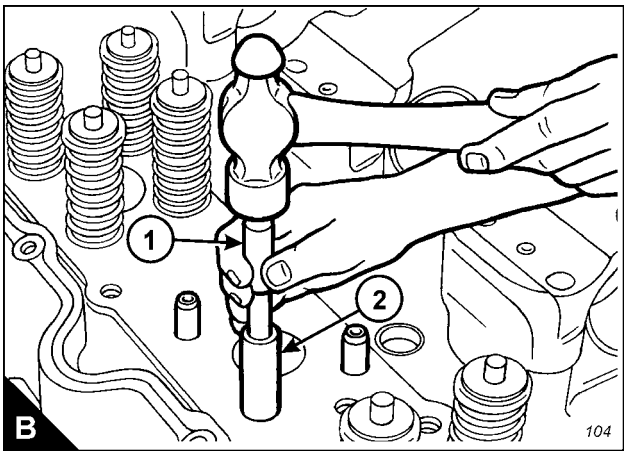
2 Use the special tool (B1), GE50043, together with the sleeve (B2), GE50044, to install the valve guide. The guide must protrude from the cylinder head, as shown (C1), by 35,0 +/- 0,5 mm (1.38 +/- 0.02 in).

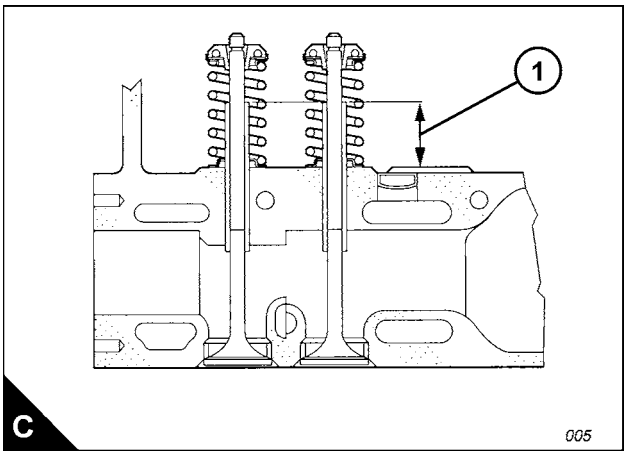
Refer to Chapter 2, Specifications for the correct dimensions for the inside diameter of new and used valve guides.

3 When a new valve guide has been fitted, check that there is full contact between the valve and the valve seat. If necessary, lap the valve to the seat.

4 Fit the valves, Operation 3-7.

5 Fit the cylinder head, Operation 3-5.





To remove and to fit — **Operation 3-10**

Special requirements

Special tools		Consumable products	
Description	**Part number**	**Description**	**Part number**
Engine turning tool	CH11148	Thread lock compound (10 ml)	21820 117
Guide stud	GE50019		
Cradle tool	GE50018		
Camshaft guide	GE50017		
Pilot	GE50015		
Lifting hooks	GE50025		
Alignment sleeve	GE50016		

To remove

1 Remove the radiator, Operation 12-4.

2 Remove the fan, Operation 12-5.

3 Remove the gear case cover, Operation 6-1.

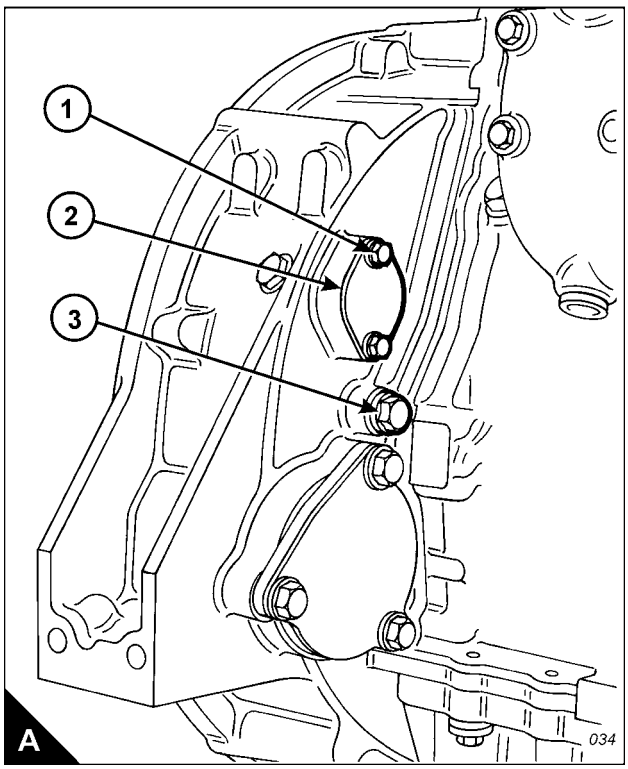
4 Remove the rocker cover, Operation 3-1.

5 Remove the rocker lever and shaft assemblies, Operation 3-2.

6 Remove the cover (A2) from the flywheel housing. The top bolt (A1) is the timing bolt.

7 Remove the plug (A3) from the timing bolt location in the flywheel housing and fit the timing bolt.

Note: There are two locations for the timing bolt, one at each side of the flywheel housing. Use the location which is the most convenient.



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8 Insert the engine turning tool, CH11148, into the flywheel housing through the aperture behind the cover (A2). Use a $^{1}/_{2}$ inch drive ratchet with the turning tool to rotate the engine flywheel in the normal direction of rotation (anti-clockwise when viewed on the flywheel) until the timing bolt engages with the threaded hole in the flywheel. The piston of number 1 cylinder is now at TDC (top dead centre). When the number one piston is at top dead centre on its compression stroke, the mark on the camshaft gear is be aligned with the mark on the gear case. If the mark is not aligned, withdraw the timing bolt, rotate the crankshaft a further 360 degrees in the normal direction of rotation and insert the timing bolt again.

***Cautions*:**

- *If the flywheel is turned past the threaded hole, the flywheel must be turned in the opposite direction for approximately 45 degrees and then back in the normal direction of rotation until the timing bolt engages with the threaded hole. This is to eliminate backlash.*
- *Do not rotate the crankshaft with the camshaft gear or any of the idler gears removed and the rocker shaft assemblies installed. Damage can be caused to the pistons and valves, or to both.*

9 Disconnect the lead and remove camshaft timing sensor from behind the top of the gear case.

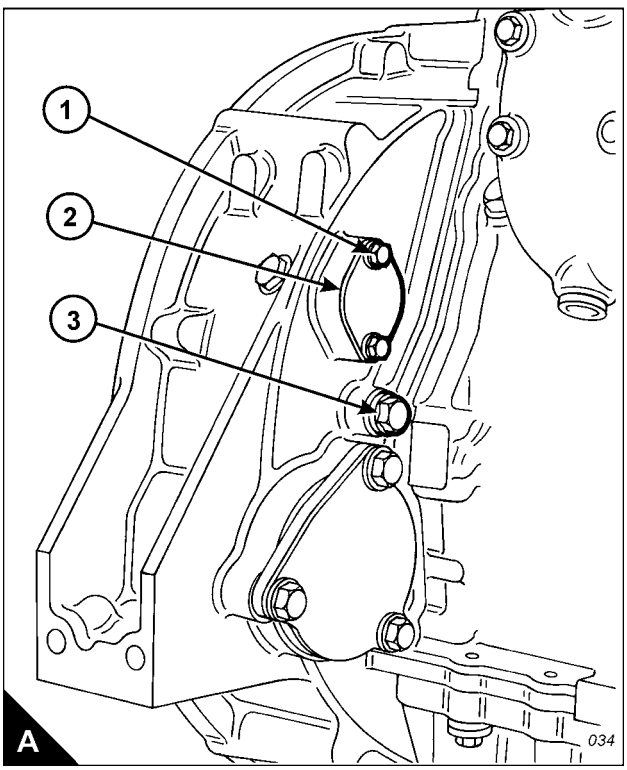
10 Remove one bolt from the camshaft gear and install the guide stud, GE50019. Remove the five bolts which remain.

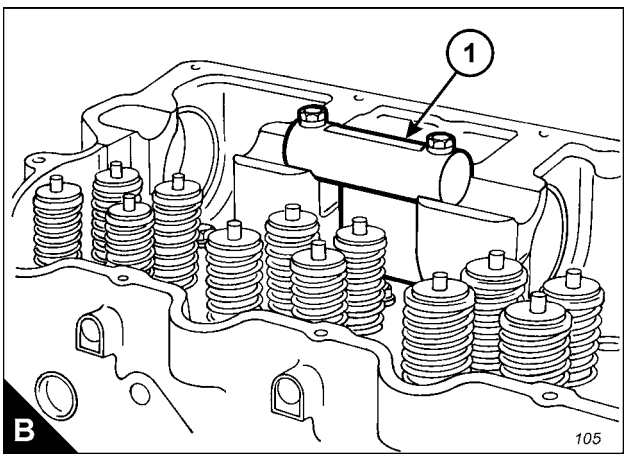
11 Attach a hoist to the camshaft gear and withdraw the gear from the camshaft. Remove the guide stud.

12 Remove three bolts and withdraw the thrust plate, the adaptor plate and the seal assembly.

Note: Take care during removal of the camshaft to ensure that the surfaces of both the camshaft and the camshaft bearings are not damaged. Use the procedure which follows, together with the relevant special tools, to avoid damage to the engine and components.

13 Use the bolts of the rocker shaft to retain the cradle tool (B1), GE50018, at the position shown (B).





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14 Remove the rear cover (C1), complete with seal (C3).

15 Fit the camshaft guide (D1), GE50017, to the gear case. Do not tighten the bolts for the guide at this stage.

Note: It is necessary to install two pilots, GE50015, on the rear end of the camshaft. The second pilot will support the rear of the camshaft as it is moved from the cylinder head and into the guide, GE50017.

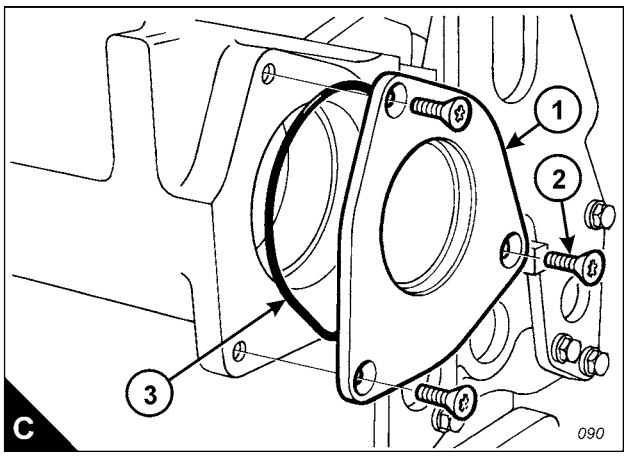
16 Install a pilot tool, GE50015, into the threaded hole at the rear end of the camshaft. Then attach the second pilot tool, GE50015, to the first.

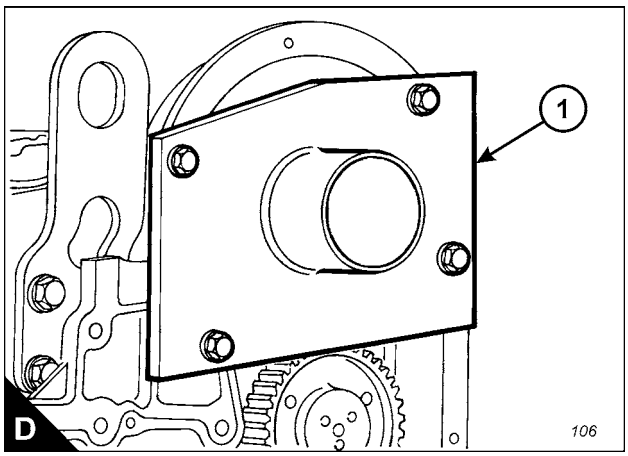
17 Withdraw the camshaft until it enters the bore of the camshaft guide. Tighten the bolts which retain the guide on the gear case.

18 Use the lifting hooks, GE50025, to move the camshaft toward the front of the engine.

Caution: *During use of the lifting hooks do not raise the camshaft; the camshaft should be supported by the cradle, GE50018. If the camshaft is raised, damage to the camshaft bearings can occur.*

19 Withdraw the camshaft from the cylinder head just enough for a strap and hoist to be attached. Attach a suitable strap and hoist to support the camshaft, ensure that the camshaft is kept level and withdraw it from the cylinder head. The camshaft weighs approximately 39 kg (85 lb).





To fit

1 Fit the two pilot tools, GE50015, to the rear end of the camshaft. Ensure that the camshaft and camshaft bearings have been cleaned thoroughly. Apply clean engine oil to the lobes and journals of the camshaft. Apply a thin coat of clean engine oil to the camshaft bearings.

2 Fit the camshaft guide (E1), GE50017, to the gear case cover, but do not tighten the bolts fully.

3 Insert the alignment sleeve (E2), GE50016, through the camshaft guide (E1) and into the camshaft bearings to align the camshaft guide correctly. Tighten the bolts which retain the camshaft guide, GE50017, on the gear case. Remove the alignment sleeve; the sleeve should move freely from the bore of the camshaft guide, GE50017.

4 Fit the cradle tool (F1), GE50018, at the position shown (F).

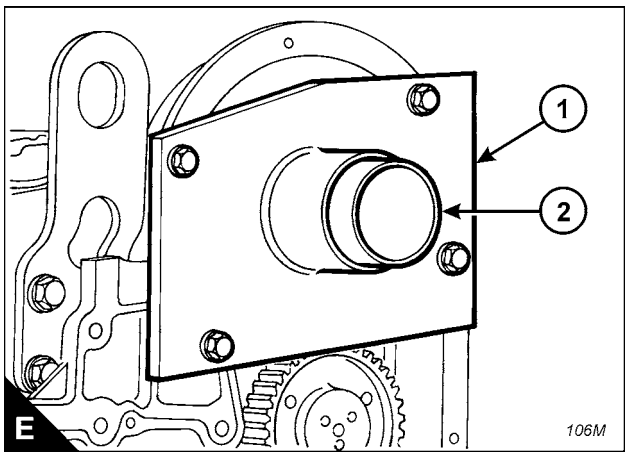
Note: Rotate the camshaft in both directions during installation to prevent binding.

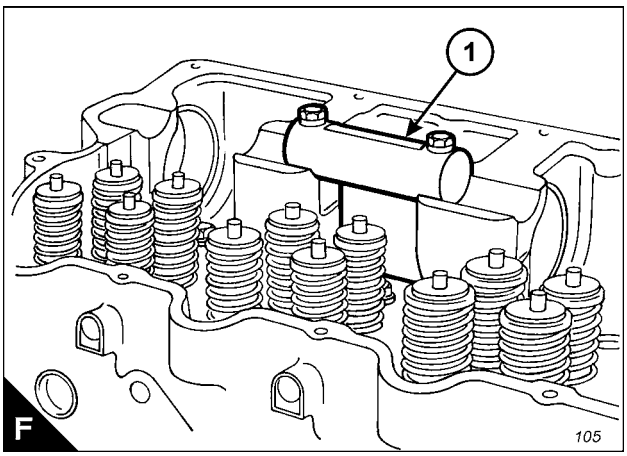
5 Use a suitable strap and hoist to support the camshaft. Insert the camshaft through the guide and into the cylinder head. Move the camshaft into the head as far as the strap and hoist will allow.

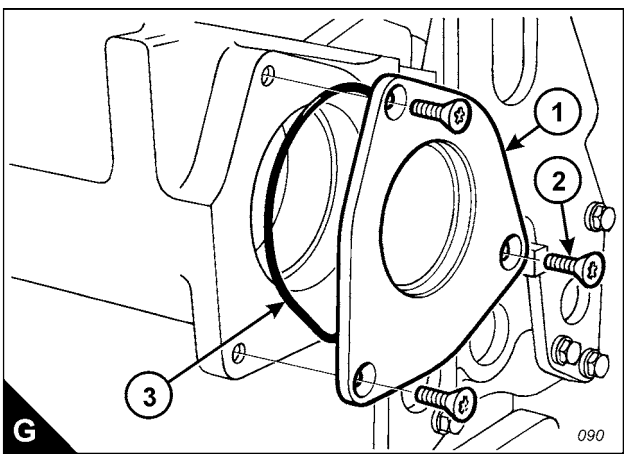
6 Remove the strap and hoist. Rotate the camshaft during installation. Do not allow the end of the camshaft to drop during removal of the hoist as the bearings can be damaged. Use the lifting hooks, GE50025, to support the camshaft during installation.

7 Remove the pilot tools and push the camshaft fully into its bore.

8 Inspect the seal (G3) and renew if necessary. Fit the rear cover (G1), complete with seal (G3).







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9 Remove the cradle tool and the camshaft guide.

10 Fit new 'O' ring seals to the camshaft front seal plate. Apply a small amount of engine lubricating oil to the 'O' ring seal on the outside of the plate. Fit the seal plate with the face seal against the cylinder head. Insert the adapter plate and fit the thrust plate. Apply thread lock compound, 21820 117, to the three bolts, fit the bolts and tighten.

Note: Camshaft timing is very important. During installation of the camshaft assembly, ensure that the timing marks on the camshaft gear and the gear case cover are aligned when number one cylinder is at top centre (TDC).

11 Fit the guide stud, GE50019, to the camshaft.

12 Fit the camshaft gear; align the hole in the gear with the dowel pin on the adapter plate. If the timing mark on gear does not align with the pointer at the top of the gear case, remove the gear and rotate the camshaft until the gear can be installed with the marks aligned.

13 Fit the bolts which retain the gear, remove the guide stud and fit the bolt which remains. Tighten the bolts to a torque of 240 +/- 40 Nm (177 +/- 30 lbf ft).

14 Fit the camshaft timing sensor to its location behind the top of the gear case and connect the lead.

15 Fit the gear case cover, Operation 6-1.

16 Remove the timing bolt from the flywheel and fit the cover and plug.

17 Install the rocker lever and shaft assemblies, Operation 3-2.

How to set the backlash for the camshaft gear **Operation 3-11**

If the cylinder head or the camshaft is removed, the backlash between the camshaft gear (A1) and the adjustable idler gear (A2) must be checked and, if necessary, adjusted. The backlash between the camshaft gear and the adjustable idler gear, and also between the adjustable idler gear (A2) and the main idler gear (A3), must be 0,25 +/- 0,08 mm (0.010 +/- 0.003 in).

Note: This procedure must be performed before the rocker lever and shaft assemblies are fitted.

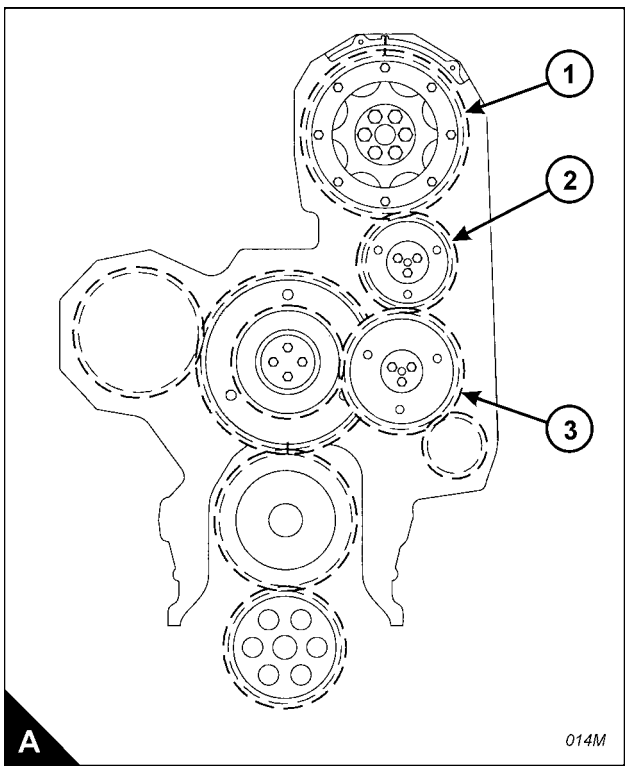
1 Remove the main idler gear (A3). Hold the camshaft gear stationary and use a dial test indicator (DTI), mounted on the gear case, to check the backlash of the adjustable idler gear.

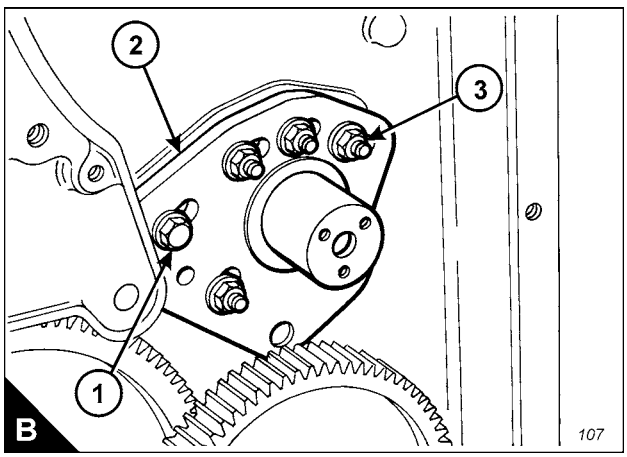
2 Fit the main idler gear (A3), hold the main idler gear stationary and measure the backlash on the adjustable idler gear.

3 To adjust the backlash, remove the three bolts and thrust plate which retain the adjustable idler gear (A2) and remove the gear. Loosen the five nuts (B3) and the bolt (B1) which retain the stub axle (B2) and move the stub axle by the relevant amount. Tighten the nuts and bolt to a torque of 47 +/- 9 Nm (35 +/- 7 lbf ft).

4 Fit the idler gear. Retain with the thrust plate and three bolts. Check again the backlash between the adjustable idler gear and the camshaft gear, and also between the adjustable idler gear (A2) and the main idler gear (A3), as given in steps 1 and 2. Repeat the procedure if necessary until the correct backlash settings have been obtained.

5 When the correct backlash settings have been obtained, remove the adjustable idler gear and proceed as follows: Remove one of the nuts which retains the idler axle, apply a small amount of Loctite 542 to the threads of the stud, fit the nut and tighten to a torque of 47 +/- 9 Nm (35 +/- 7 lbf ft). Repeat this procedure for the other four nuts and the bolt; work on one nut or bolt at a time so that the position of the stub axle is not affected.





Electronic injector units

To remove and to fit **Operation 3-12**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Injector installer/removal	GE50021	Brush	GE50022
Vacuum pump	GE50028	Brush	GE50023
Tube	GE50030	Brush	GE50024
Bottle	GE50029		

To remove

Warning! *The electrical circuit for the fuel injector units operates on 110 volts. Do NOT work on the fuel injector units unless the power supply to the ECM has been disconnected.*

1 Remove the relevant rocker shaft assembly, Operation 3-2.

2 Loosen the two nuts and remove the electrical connector from the injector unit.

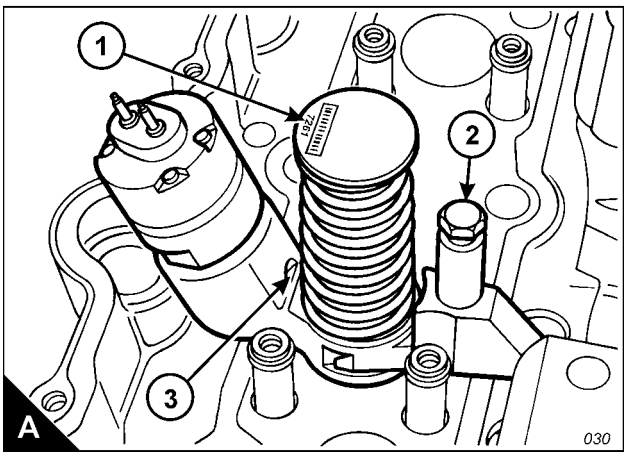
3 Mark the valve bridge pieces to assist during assembly, then remove them.

4 Remove the bolt (A2) from the spacer and clamp which retain the injector unit and use the special tool, GE50021, to release the injector unit from the cylinder head.

Caution: *If more than one injector unit is to be removed, make a note of the trim code (A1), a four-digit number adjacent to the bar code, and also the cylinder to which the unit is fitted.*

5 Remove the injector unit, together with the spacer and clamp.

6 Use the vacuum pump, GE50028, together with the tube, GE50030, and bottle, GE50029, to extract any fuel which has spilled into the combustion chamber during removal of the injector.



To fit

1 Clean thoroughly the bore of the injector sleeve and cylinder head. Use the special brushes (GE50022, GE50023 and GE50024) to remove carbon or dirt.

2 Check the condition of the 'O' ring seals (B1 and B2); renew the seals if they are worn or damaged. Lubricate the 'O' ring seals with clean engine oil before the injector unit is installed in the cylinder head.

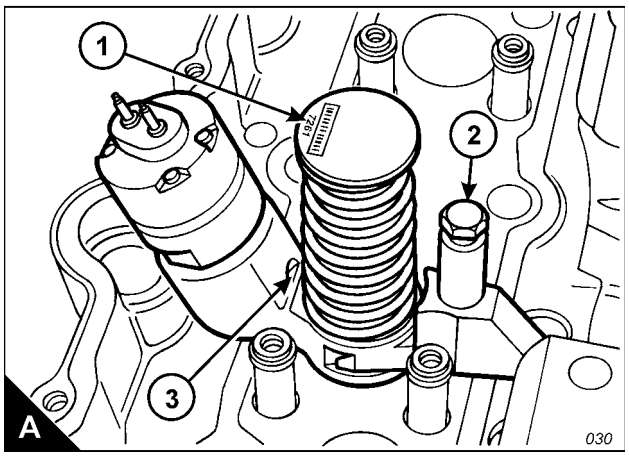
Caution: *Injector units MUST be fitted to their original positions or the information in the ECM will need to be updated.*

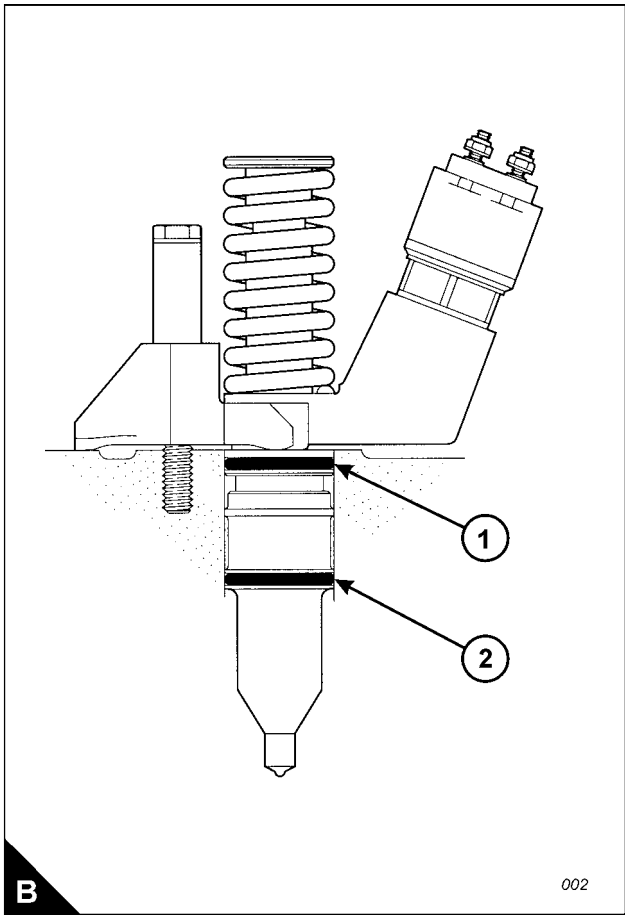
3 Fit the injector unit to the cylinder head. Fit the clamp, spacer and retaining bolt. Tighten the bolt (A2) to a torque of 47 +/- 9 Nm (35 +/- 7 lbf ft).

4 Fit the bridge pieces.

5 Attach the electrical connector to the injector unit and retain with the two nuts. Tighten the nuts to a torque of 2,5 Nm (22 lbf in).

6 Fit the rocker shaft assembly, Operation 3-2.





To check and to adjust **Operation 3-13**

Special requirements

Special tools	
Description	**Part number**
Injector height gauge	CH11149

This operation should be performed at the same time as the operation to check the valve tappet clearances.

Warning! *The electrical circuit for the fuel injector units operates on 110 volts. Do NOT work on the fuel injector units unless the power supply to the ECM has been disconnected.*

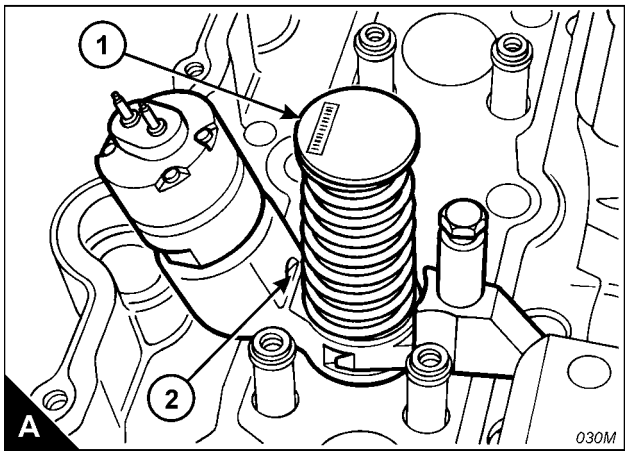
1 With the rocker covers removed, set the number 1 piston to TDC (top dead centre) on its compression stroke. Check/adjust the height dimensions for the fuel injectors of cylinders 3, 5 and 6.

2 Use the fuel injector setting gauge, CH11149, to obtain the correct height for the fuel injector. The dimension to be measured is from the top of the unit injector (A1) to the machined ledge on the fuel injector body (A2). This dimension should be 78,0 +/- 0,2 mm (3.07 +/- 0.01 in). Slacken the lock nut and use the adjustment screw of the rocker lever to obtain the correct dimension. Tighten the lock nut to a torque of 55 +/- 10 Nm (41 +/- 7 lbf ft).

3 Remove the timing bolt from the flywheel housing and rotate the flywheel by 360 degrees in the normal direction of engine rotation until the timing bolt can be inserted into the threaded hole. This will put the number 1 piston at TDC in its exhaust stroke.

4 Check/adjust the height dimensions for the fuel injectors of cylinders 1, 2 and 4 as given in step 2.

When all adjustments have been made, remove the timing bolt, fit the cover to the flywheel housing, fit the plug to the timing bolt position and fit the rocker covers.



Injector sleeves

To remove and to fit **Operation 3-14**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Injector installer/removal	GE50021	Brush	GE50022
Vacuum pump	GE50028	Brush	GE50023
Tube	GE50030	Brush	GE50024
Bottle	GE50029		

To remove

1 Remove the rocker shaft assemblies, Operation 3-2.

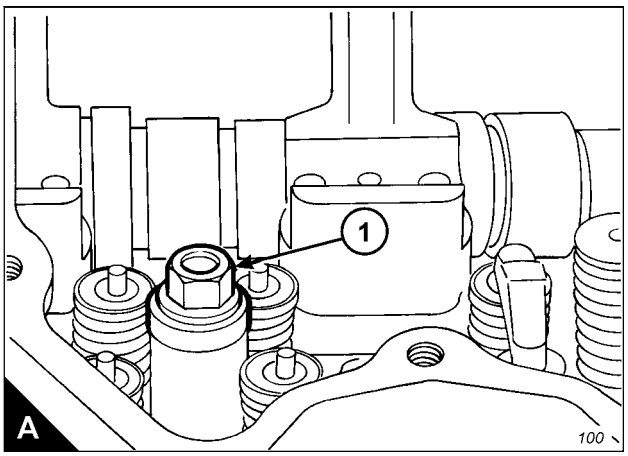
2 Remove the electronic injector units, Operation 3-12.

3 Mark the bridge pieces and make a note of their position to assist during assembly, then remove the bridge pieces.

4 Fit the puller stud from the special tool, GE50021, into the injector sleeve as shown (A). Fit the bridge, thrust bearing, washer and nut, from the special tool, over the stud as shown. Tighten the nut (A1) of the special tool until the sleeve is drawn from the cylinder head. Remove the special tool from the sleeve.

5 Remove the 'O' ring seals from the injector sleeve. Check the condition of the injector sleeve and renew if necessary.

6 Repeat steps 1 to 5 for the injector sleeves which remain.



To fit

Caution: *Before installation ensure that the injector sleeve and its bore in the cylinder head are clean and free from oil, dirt and sealant.*

1 Use the brushes, special tool numbers: GE50023, GE50024 and GE50022, to clean thoroughly the bore for the injector sleeve.

Caution: *Ensure that the fuel passage in the cylinder head is clean.*

2 Fit new 'O' ring seals to the injector sleeve.

3 Fit the stud from the special tool into the threads of the injector sleeve.

Caution: *Do not apply retaining and anti-seize compounds to the cylinder head surfaces. These compounds must ONLY be applied to the injector sleeve.*

4 Apply CV60889 anti-seize compound to the 'O' ring seals and to the large diameter (B1) off the injector sleeve.

5 Apply CV60893 retaining compound to the small diameter (B2) off the injector sleeve.

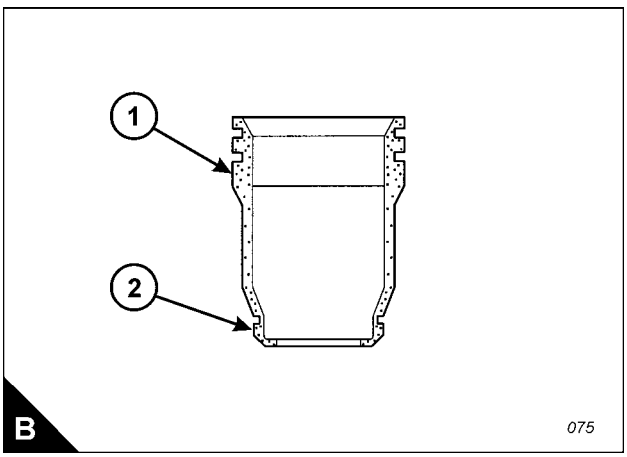
6 Using the stud, insert the injector sleeve into its bore in the cylinder head. Take care to prevent damage to the 'O' ring seals. Use that only hand force is used to push the injector sleeve into the cylinder head.

7 Fit the driver tool over the stud and tap lightly with a hammer to ensure that the injector sleeve is fully seated in the cylinder head. The tool and sleeve will "ring" when the sleeve is in full contact with the base of the bore.

8 Use a clean cloth to remove any retaining or anti-seize compound from the bores of the cylinder and injector sleeve.

9 Fit the electronic injector units, Operation 3-12.

10 Fit the rocker shaft assemblies, Operation 3-2.



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4

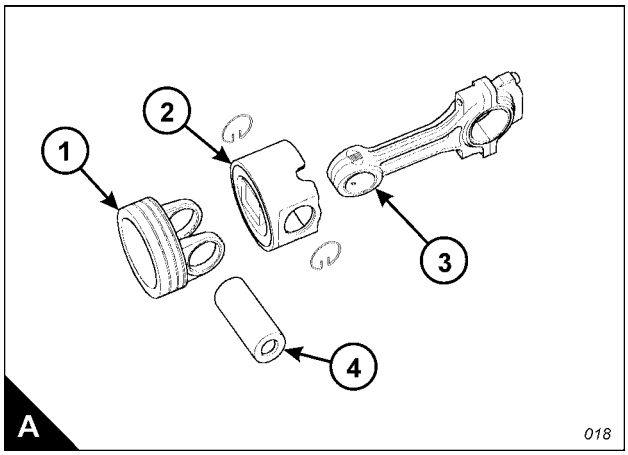
Pistons and connecting rod assemblies

General information

The pistons fitted to the 2300 and 2800 Series engines consist of two parts: a forged steel crown (A1) and a cast aluminium skirt (A2). The two parts are retained on the connecting rod by the gudgeon pin (A4). The pistons each have three rings fitted to grooves in the crown. The top ring is keystone shaped and its face is plasma coated. The second ring has a tapered face which has a chrome finish. The third ring is an oil control ring and also has a chrome finish on its face. The oil control ring contains a coil spring which expands the ring. Small holes in the piston groove allow oil from the oil control ring to drain back to the sump.

The connecting rods are of a conventional design. The small end is wedge shaped and the big end bearing cap is retained by two special bolts. A split type shell bearing is fitted at the big end and a single piece bearing is pressed into the small end.

Piston squirter jets provide a supply of oil to cool the piston crown. On 2806 engines, an oil cooling chamber is formed by the lip at the top of the piston skirt and the cavity behind the ring grooves in the piston crown. The oil returns to the sump through the clearance gap between the crown and the skirt. For pistons fitted to the 2306 engine, the oil cooling chamber is formed between the cavity behind the ring grooves and two flat plates fitted in the piston crown. There is a hole in each plate; the oil supply is squirted through one hole, flows around the cooling chamber and returns to the sump through the hole at the opposite side.



Pistons and connecting rod assemblies

To remove and to fit **Operation 4-1**

Special requirements

Special tools		Consumable products	
Description	**Part number**	**Description**	**Part number**
Installer, piston (2806 engine)	GE50003	Anti-seize compound	CV60890
Installer, piston (2306 engine)	GE50045		

To remove

1 Remove the cylinder head assembly, Operation 3-5.

2 Remove the oil pump, Operation 10-4.

3 Remove the stiffener plate from the base of the crankcase.

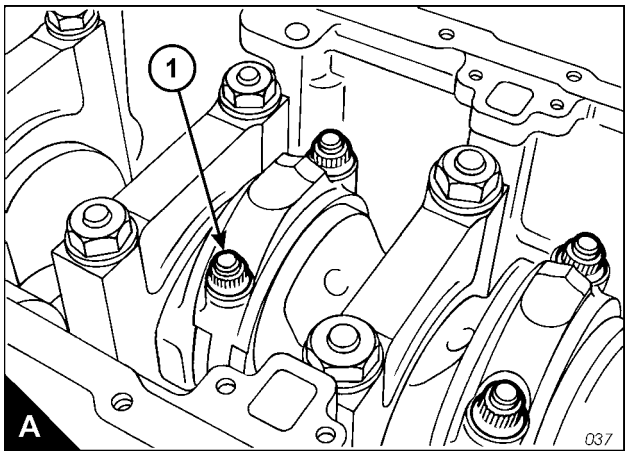
4 Remove the carbon ridge from the top inside surface of the cylinder liners.

5 Turn the crankshaft until two pistons are at bottom centre.

6 Remove the bolts (A1) and the bearing caps. Push the connecting rods and pistons up until the rings are free from the cylinder liners.

7 Withdraw carefully the pistons and connecting rods from the cylinder liners. Store the bearing caps with their relevant connecting rods.

8 Repeat steps 3 to 6 for the remainder of the pistons and connecting rods.



To fit

1 Apply clean engine oil to the piston rings, the connecting rod bearings and the cylinder liners.

2 Ensure that the piston ring gaps are set at 120 degree intervals to each other.

3 Use the special tool (B1), GE50003 for 2806 engines or GE50045 for 2306 engines, to install the piston and the connecting rod in the cylinder liner (B2). The connecting rod must be fitted with tab groove side of the big end bearing at the opposite side to the camshaft. Proceed with care to ensure that the piston rings are not damaged during the operation.

Caution: *Bearing caps must be fitted to their original connecting rods,*

4 Fit the bearing cap to the connecting rod. The cap must be fitted with its number on the same side as that on the connecting rod and the number must be the same.

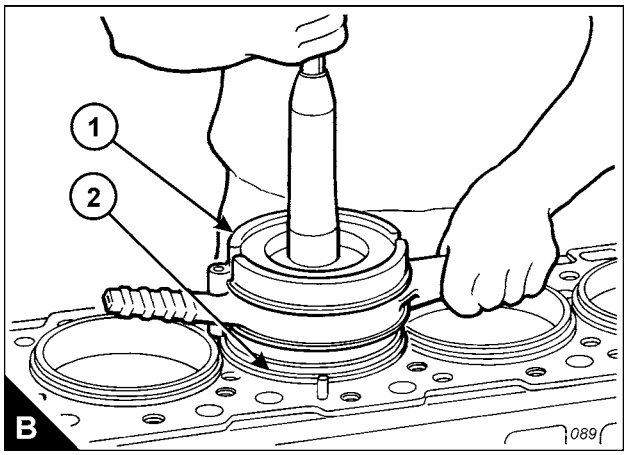
5 Apply anti-seize compound, CV60890, to the bolt threads. Install the bolts and bearing cap. Tighten each bolt in the bearing cap to a torque of 90 +/- 8 Nm (66 +/- 6 lbf ft). Make a temporary mark on each bolt and the bearing cap, then tighten each bolt by an additional 90 +/- 5 degrees.

6 Repeat steps 1 to 4 for the remainder of the pistons and connecting rods.

7 Fit the stiffener plate to the base of the crankcase.

8 Fit the oil pump, Operation 10-4.

9 Fit the cylinder head assembly, Operation 3-5.



To dismantle and assemble **Operation 4-2**

To dismantle

1 Remove the pistons and connecting rod assemblies, Operation 4-1.

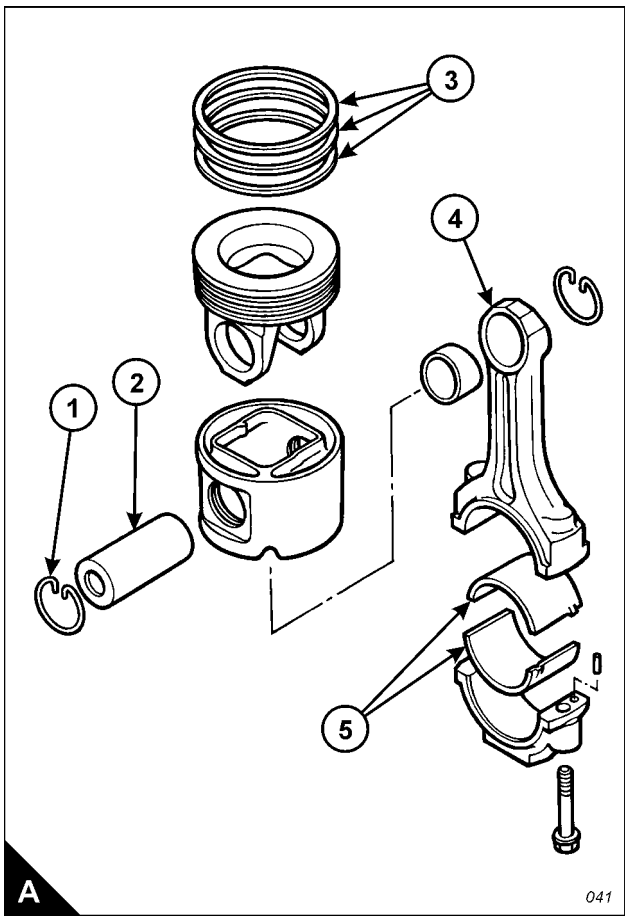
2 Remove the big-end bearing shells (A5) from the connecting rod (A4) and connecting rod cap. If the bearings are to be used again, make a note of the position where they were fitted.

3 Remove the circlips (A1).

4 Remove the gudgeon pin (A2) and separate the connecting rod and the piston crown from the piston.

5 Remove carefully the piston rings (A3) from the piston crown and clean the piston ring grooves with a suitable cleaning tool.

Special equipment is required to renew the small end bearing. If this operation becomes necessary, contact your Perkins dealer.



To assemble

1 Check the gaps between the ends of the piston rings when the rings are inserted in a new liner. The rings can also be checked by insertion in an unworn part of a used liner.

For the correct dimensions refer to Chapter 2, Specifications.

2 Fit the spring of the oil control ring to its groove in the piston crown.

Note: The oil control ring must be fitted over the spring with the gap of the oil control ring at 180 degrees from the joint of the spring.

3 Use a suitable piston ring expander to fit the oil control ring to its groove in the piston crown.

4 Fit the second (intermediate) piston ring with the side that has the identification "UP-2" toward the top of the piston. Use a suitable piston ring expander.

5 Fit the first (top) piston ring with the side that has the identification "UP-1" toward the top of the piston. Use a suitable piston ring expander.

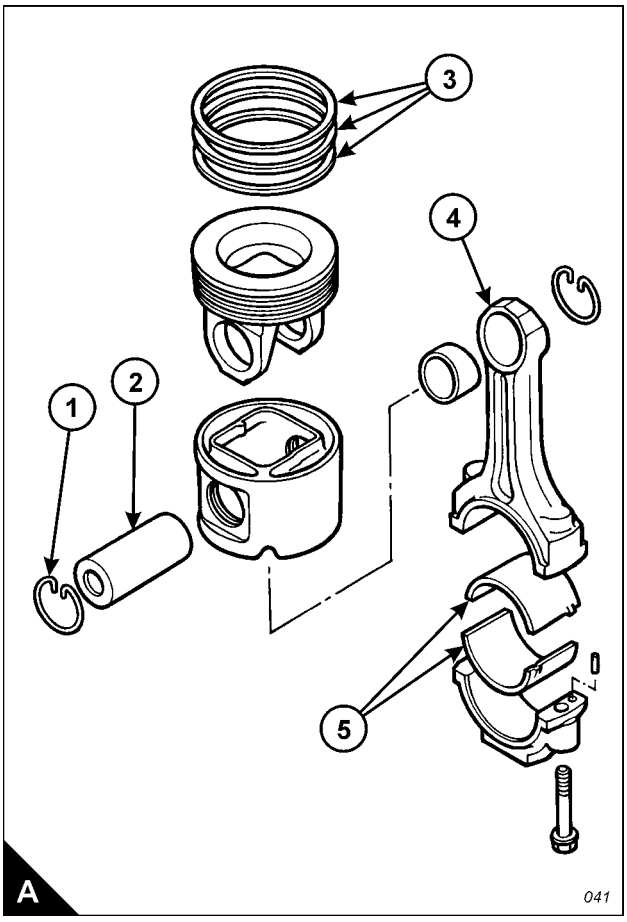
6 When all three piston rings have been fitted, adjust the position of the piston ring gaps so that they are 120 degrees apart.

7 Fit the piston crown into the piston skirt and insert the connecting rod. Apply clean engine oil to the gudgeon pin (A2) and install the pin. Fit the circlips (A1). Ensure that the circlips are located fully in the grooves of the piston.

8 Fit the big-end bearings to the connecting rod (A4) and connecting rod cap. If the original bearings are to be used, ensure that they are fitted to their original positions.

Note: The tabs at back of the bearings must be located correctly in the tab slots of the connecting rod and connecting rod cap.

9 Fit the pistons and connecting rod assemblies, Operation 4-1.



Piston cooling jets

To remove and to fit — Operation 4-3

Special requirements

Special tools	
Description	**Part number**
Engine turning tool	CH11148
Jet alignment tool	GE50004

To remove

1 Remove oil pump, Operation 10-4.

2 Use the engine turning tool, CH11148, to turn the crankshaft in a clockwise direction (as seen from the front of the engine) to obtain access to the relevant piston cooling jet.

3 Remove the bolt which retains the cooling jet and remove the cooling jet from the engine.

4 Repeat steps 2 and 3 for the cooling jets which remain.

To fit

1 Before a piston cooling jet is fitted to the engine, use the jet alignment tool, GE50004, to ensure that the direction of the nozzles is correct.

Caution: *If, when fitted to the alignment tool, a nozzle does not align correctly with the relevant dowel, discard the cooling jet; do NOT fit a damaged or distorted cooling jet to the engine.*

2 Carefully fit the piston cooling jets to the engine, ensure that the nozzles of the cooling jets are not damaged or distorted during the operation. Turn the crankshaft clockwise (as seen from the front of the engine) as necessary to obtain access to the relevant positions.

3 Fit the oil pump, Operation 10-4.

5

Crankshaft assembly

General information

The crankshaft fitted to the 2300 and 2800 Series engines has 13 bearing surfaces, which consists of seven main journals and six crank pins. Each crank pin holds two connecting rods.

Eight counterweights are included within the crankshaft forging and a vibration damper is fitted at the front end to reduce torsional vibrations.

A gear at the front end of the crankshaft provides the drive for the engine timing gears, the coolant pump and the lubricating oil pump.

To seal the crankcase, crankshaft seals are fitted in the gear case and the flywheel housing.

Crankshaft

To remove and to fit **Operation 5-1**

Special requirements

Consumable products	
Description	**Part number**
Anti-seize compound	CV60890

To remove

1 Remove the gear case cover, Operation 6-1.

2 Remove the flywheel housing, Operation 13-2.

3 Remove the pistons and connecting rod assemblies, Operation 4-1.

4 Remove the crankshaft rear seal and wear sleeve, Operation 5-3.

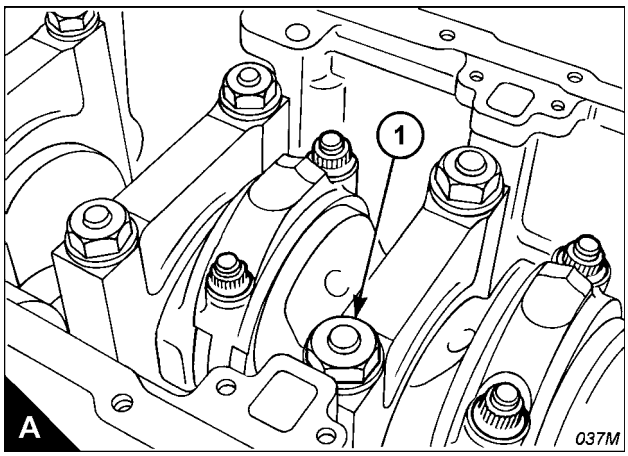
5 Remove the crankshaft front seal and wear sleeve, Operation 5-2.

Note: Make a note of the number on the bearing caps for assembly purposes. If a number cannot be seen, put a number on the left side of the crankcase with a corresponding number on the bearing cap.

6 Remove the bolts (A1) which retain the main bearing caps in the crankcase and remove the bearing caps.

7 Fit one of the bolts from the front pulley to each end of the crankshaft. Fasten a hoist to the crankshaft and lift the crankshaft from the crankcase. The weight of the crankshaft is approximately 159 kg (350 lb).

Note: If new main bearings are not to be installed, make a note of the position of the used bearings. Used bearings must be fitted to their original positions.



To fit

1 Clean the crankcase and the main bearing caps thoroughly. Apply clean engine oil to the main bearings and fit the upper halves of the main bearings into the crankcase.

2 Install one of the bolts from the front pulley in each end of the crankshaft, fasten a suitable hoist and fit the crankshaft into the crankcase. Ensure that the line mark on the crankshaft gear is in alignment with the line on the idler gear.

3 Fit the thrust bearings for the centre main bearing. Ensure that the bearings are fitted with the side identification "BLOCK SIDE" against the crankcase.

4 Fit the main bearings to the bearing caps.

5 Ensure that the tabs on the back of the bearing shells fit into the tab slots of the bearing caps and crankcase.

Caution: *Ensure that the main bearing caps are fitted to the correct positions. The numbers on the side of the crankcase must be the same as the numbers on the bearing caps, and the arrows on the bearing caps must be directed toward the front of the crankcase.*

6 Apply anti-seize compound, CV60890, to the bolts and install the main bearing caps and bolts.

7 Begin at the tab end of the bearing cap first, tighten each bearing cap bolt to a torque of 260 +/- 14 Nm (190 +/- 10 lbf ft). Make a temporary mark on each bolt and bearing cap. Start with the bolt opposite the tab end of the bearing cap and again tighten each bolt by an additional 120 +/- 5 degrees.

8 Use a dial test indicator (DTI) to check the end-float of the crankshaft. Ensure that the pointer of the DTI is against a machined surface. The end-float is controlled by the thrust bearings of the centre main bearing. The end-float with new bearings must be between 0,15 and 0,51 mm (0.006 and 0.020 in). The maximum permissible end-float with used bearings is 0,89 mm (0.035 in).

9 Fit the crankshaft front seal and wear sleeve, Operation 5-2.

10 Fit the crankshaft rear seal and wear sleeve, Operation 5-3.

11 Fit the pistons and connecting rod assemblies, Operation 4-1.

12 Fit the flywheel housing, Operation 13-2.

13 Fit the gear case cover, Operation 6-1.

Crankshaft front seal and wear sleeve

To renew **Operation 5-2**

Special requirements

Special tools		Consumable products	
Description	**Part number**	**Description**	**Part number**
Locator assembly	GE50008	Quick cure primer	CV60892
Bolt	GE50009		
Distorter protection ring	GE50010		
Distorter tool	GE50011	Retaining compound	CV60893
Installer	GE50012		
Nut	GE50014		

To remove

1 Remove the vibration damper, Operation 5-4.

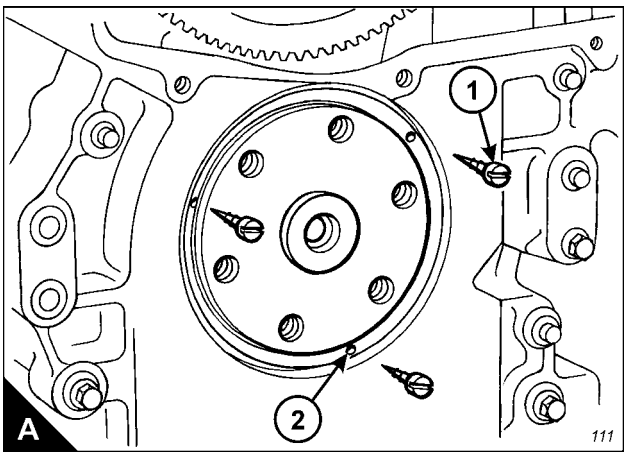
Note: The crankshaft front seal and wear sleeve are supplied as a set and must be installed as a set. If a seal is renewed, the wear sleeve must also be renewed.

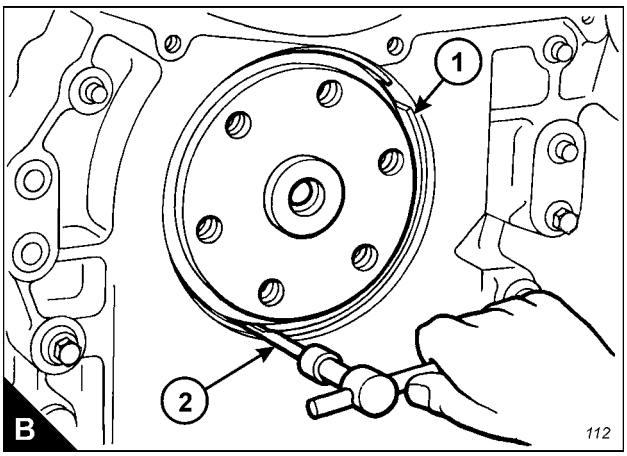
2 Drill three holes (A2) at an equal distance around the circumference of the seal. Fit self-tapping screws (A1), complete with washers if necessary, to the holes and use a screwdriver as a lever to remove the seal from the crankcase. Ensure that the gear case does not become damaged during this operation.

3 Fit the distorter protection ring (B1), GE50010, to the seal bore and at the same depth as the wear sleeve. The distorter ring is fitted to protect the seal bore in the crankcase during the removal of the wear sleeve.

4 Insert the distorter tool (B2), GE50011, between the protection ring and the wear sleeve. With the sharp edge of the tool against the wear sleeve, use a socket and spanner to rotate the distorter and cause a crease to form in the wear sleeve. Repeat this procedure in three or more places until the wear sleeve becomes loose on the crankshaft.

5 Remove the distorter tool, the protection ring and the wear sleeve.





To fit

Note: Before the new seal and wear sleeve are installed, read carefully the special instruction which is supplied with each seal and wear sleeve.

1 Clean and the wear sleeve inside diameter and crankshaft outside diameter with quick cure primer, CV60892. Apply some retaining compound, CV60893, to the crankshaft outside diameter before the wear sleeve is installed on the crankshaft. Do not allow any quick cure primer or retaining compound to touch the lip of the seal.

2 Use the bolts (C3), GE50009, to install the guide, GE50008, on the crankshaft.

Notes:

- The seal and the wear sleeve must be installed in a dry condition.
- Ensure that the seal is fitted with the part number and the crankshaft rotation arrows toward the outside.

Caution: *The front and rear seals and wear sleeves have different spiral grooves. The seal will not function if it is installed at the wrong end of the engine.*

3 Fit the wear sleeve and seal (C4) as a unit onto the locator, GE50008.

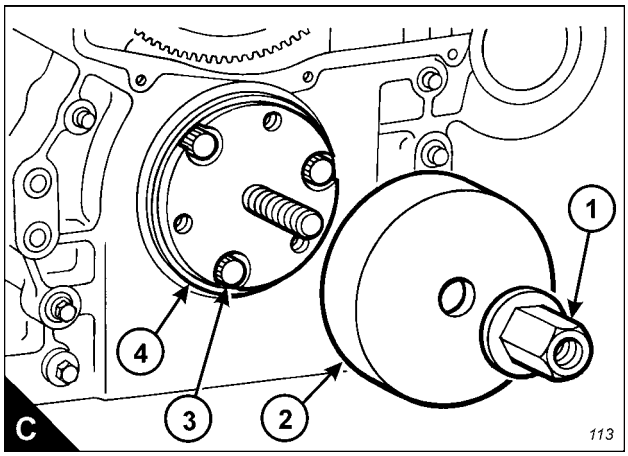
4 Fit the installer (C2), GE50012, onto the locator.

5 Apply clean engine oil to the face of the nut (C1), GE50014, and to its contact area on the installer, GE50012.

6 Fit the nut to the locator and tighten the nut until the inside surface of the installer is in contact with the locator.

7 Remove all of the tools from the crankshaft.

8 Fit the vibration damper, Operation 5-4.



Crankshaft rear seal and wear sleeve

To renew **Operation 5-3**

Special requirements

Special tools		Consumable products	
Description	**Part number**	**Description**	**Part number**
Locator assembly	GE50008	Quick cure primer	CV60892
Bolt	GE50009		
Distorter protection ring	GE50010		
Distorter tool	GE50011	Retaining compound	CV60893
Installer	GE50013		
Nut	GE50014		

To remove

1 Remove the flywheel, Operation 13-1.

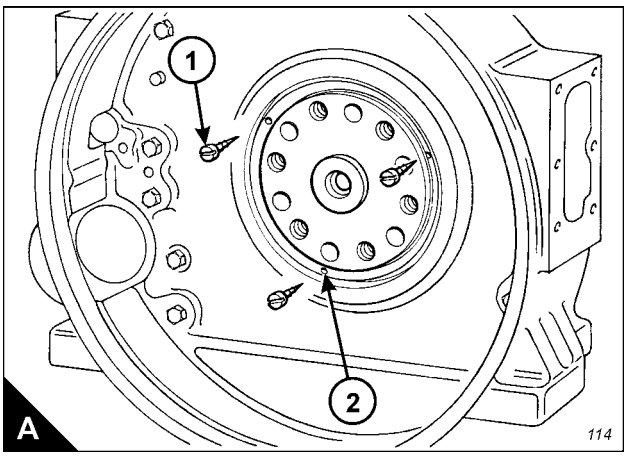
Note: The crankshaft front seal and wear sleeve are supplied as a set and must be installed as a set. If a seal is renewed, the wear sleeve must also be renewed.

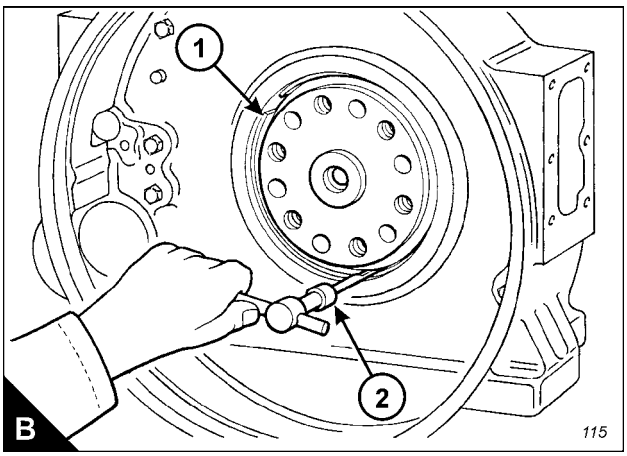
2 Drill three holes (A2) at an equal distance around the circumference of the seal. Fit self-tapping screws (A1), complete with washers if necessary, to the holes and use a screwdriver as a lever to remove the seal from the crankcase. Ensure that the flywheel housing does not become damaged during this operation.

3 Fit the distorter protection ring (B1), GE50010, to the seal bore and at the same depth as the wear sleeve. The distorter ring is fitted to protect the seal bore in the crankcase during the removal of the wear sleeve.

4 Insert the distorter tool (B2), GE50011, between the protection ring and the wear sleeve. With the sharp edge of the tool against the wear sleeve, use a socket and spanner to rotate the distorter and cause a crease to form in the wear sleeve. Repeat this procedure in three or more places until the wear sleeve becomes loose on the crankshaft.

5 Remove the distorter tool, the protection ring and the wear sleeve.





To fit

Note: Before the new seal and wear sleeve are installed, read carefully the special instruction which is supplied with each seal and wear sleeve.

1 Clean and the wear sleeve inside diameter and crankshaft outside diameter with quick cure primer, CV60892. Apply some retaining compound, CV60893, to the crankshaft outside diameter before the wear sleeve is installed on the crankshaft. Do not allow any quick cure primer or retaining compound to touch the lip of the seal.

2 Use the bolts (C4), GE50009, to install the guide, GE50008, on the crankshaft.

Notes:

- The seal and the wear sleeve must be installed in a dry condition.
- Ensure that the seal is fitted with the part number and the crankshaft rotation arrows toward the outside.

Caution: *The front and rear seals and wear sleeves have different spiral grooves. The seal will not function if it is installed at the wrong end of the engine.*

3 Fit the wear sleeve and seal (C3) as a unit onto the locator, GE50008.

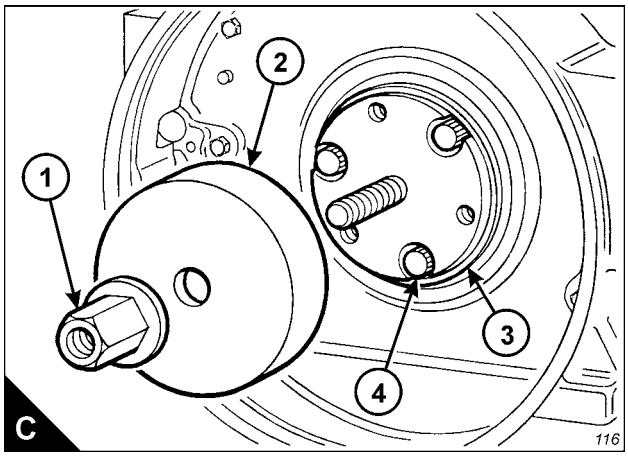
4 Fit the installer (C2), GE50012, onto the locator.

5 Apply clean engine oil to the face of the nut (C1), GE50014, and to its contact area on the installer, GE50012.

6 Fit the nut to the locator and tighten the nut until the inside surface of the installer is in contact with the locator.

7 Remove all of the tools from the crankshaft.

8 Fit the flywheel, Operation 13-1.



Crankshaft vibration damper

To remove and to fit **Operation 5-4**

To remove

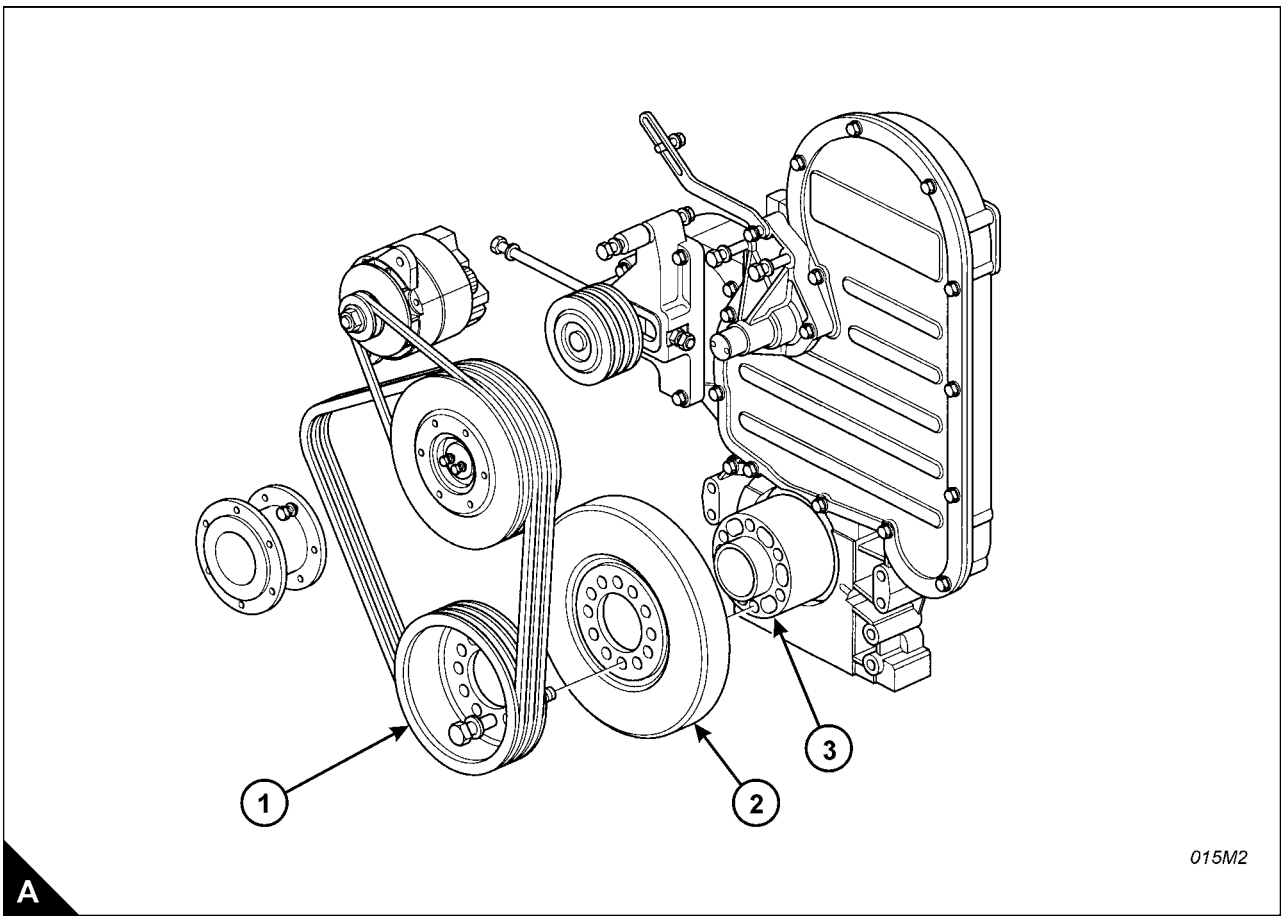
1 Remove the fan guards.

2 Slacken the tension on the fan drive belts, then remove the belts from the crankshaft pulley (A1).

3 Attach a strap and a suitable lifting device to the vibration damper (A2). Remove the six bolts and washers which retain the vibration damper and the adapter (A3) to the crankshaft.

4 Remove damper and adapter. The weight of the vibration damper is approximately 25 kg (55 lb).

Note: The dash marks at the front of the damper assembly must be in alignment with each other. If the dash marks are not in alignment, renew the damper assembly.



To fit

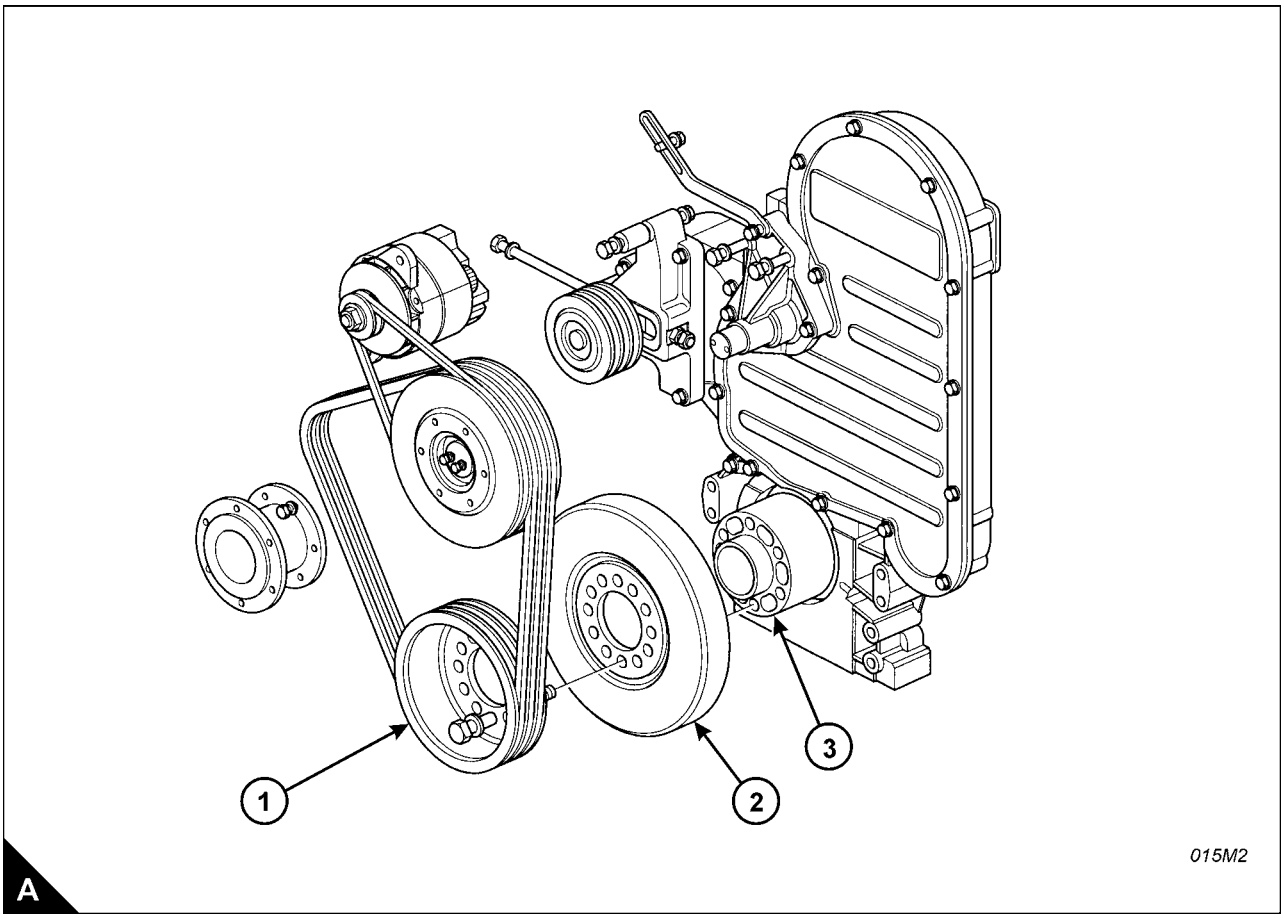
1 Attach a strap and a suitable lifting device to the vibration damper (A2). Use a 5/8 -18 x 6 in (152 mm) long guide stud, and fit the vibration damper (A2) and adapter (A3) to the crankshaft. The weight of the vibration damper is approximately 25 kg (55 lb).

2 Fit the crankshaft pulley (A1). Apply clean engine oil to the threads of the bolts and install five of the six bolts and washers which retain the pulley, the damper and the adapter.

3 Remove the guide stud and install the final bolt and washer. Tighten the bolts to a torque of 215 Nm (158 lbf ft).

4 Fit the fan belts and adjust the tension as given in Operation 12-7.

5 Fit the fan guards.



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6

Gear case and drive assembly

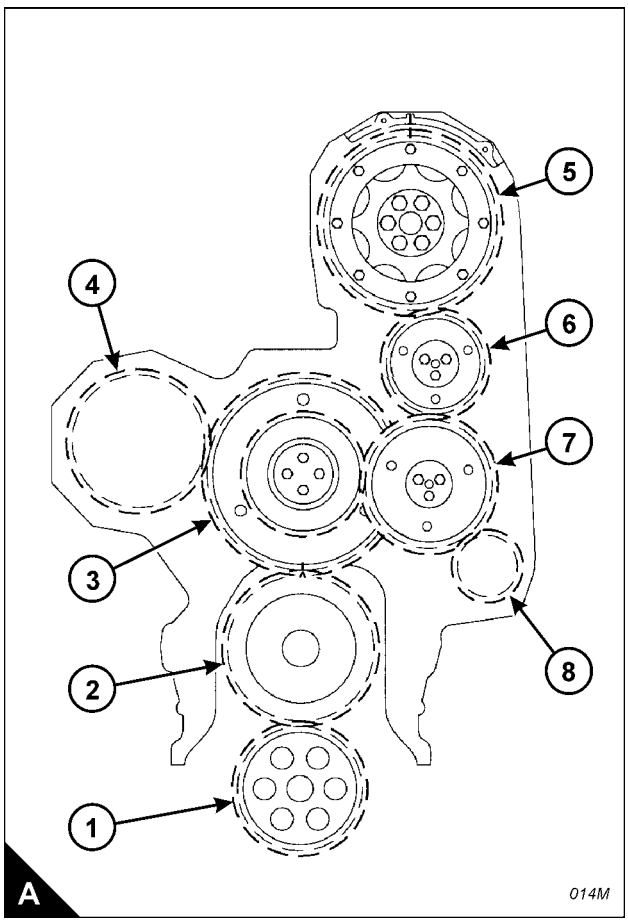
General information

The cast iron gear case contains the timing gears for the engine and the gears which drive the coolant pump (A4), the lubricating oil pump (A1) and the fuel transfer pump (A8). All of the gears are spur gears.

An adjustable idler gear (A6) provides the backlash between the main idler (A7) and the camshaft gear (A5). If the cylinder head and head gasket are removed, the tolerances may change and the position of the adjustable idler gear can be adjusted to obtain the correct backlash settings.

The camshaft drive gear (A5) is fitted with pendulum rollers. These are designed to counteract the injector pulses and eliminate vibration and noise.

For correct engine timing, a line is provided on the large gear (A3) of the compound idler which aligns with a 'V' on the crankshaft gear (A2), and a mark on the camshaft drive gear aligns with a line at the top of the gear case.



Gear case cover

To remove and to fit **Operation 6-1**

To remove

1 Remove the radiator, Operation 12-4.

2 Remove the fan, Operation 12-5.

3 Loosen the bolts which retain the gear case cover. Do not remove the bolts from the assembly, allow them to be retained by the seal.

4 Remove the gear case cover.

To fit

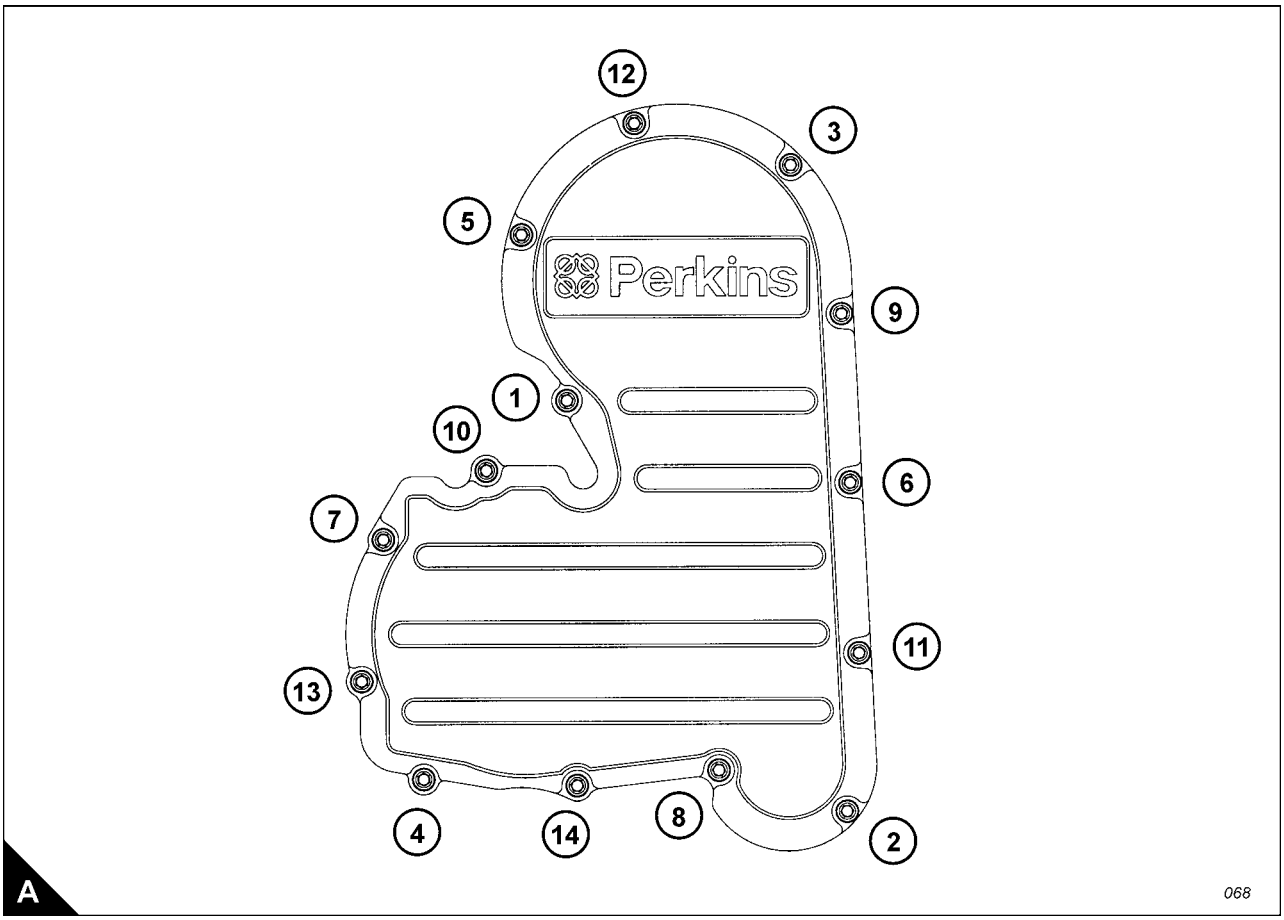
Note: Ensure that all contact surfaces of the seal and the gear case are clean and free from oil, paint, burrs or debris.

1 Examine the seal and renew if necessary, clean the contact surfaces of the seal and the gear case.

2 Fit the gear case cover and tighten the bolts, in the sequence shown (A), to a torque of 20 Nm (15 lbf ft).

3 Fit the fan, Operation 12-5.

4 Fit the radiator, Operation 12-4.



To remove and to fit — **Operation 6-2**

Special requirements

Special tools		Consumable products	
Description	**Part number**	**Description**	**Part number**
Engine turning tool	CH11148	Thread lock compound (10 ml)	21820 117
Guide stud	GE50019		

To remove

1 Remove the gear case cover, Operation 6-1, and set the engine to the correct timing position for number one cylinder as follows:

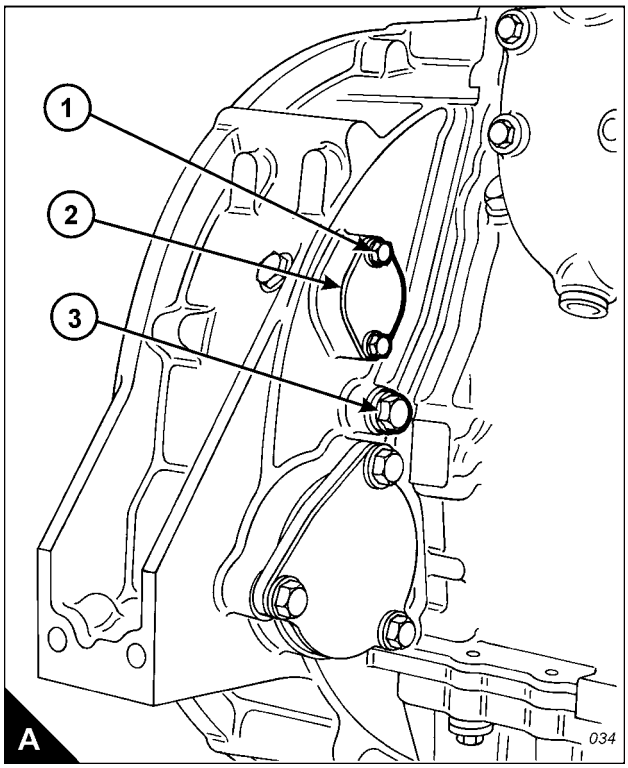
2 Remove the top bolt (A1) from the cover (A2) on the flywheel housing and loosen the other cover bolt to allow the cover to open. The top bolt (A1) is the timing bolt.

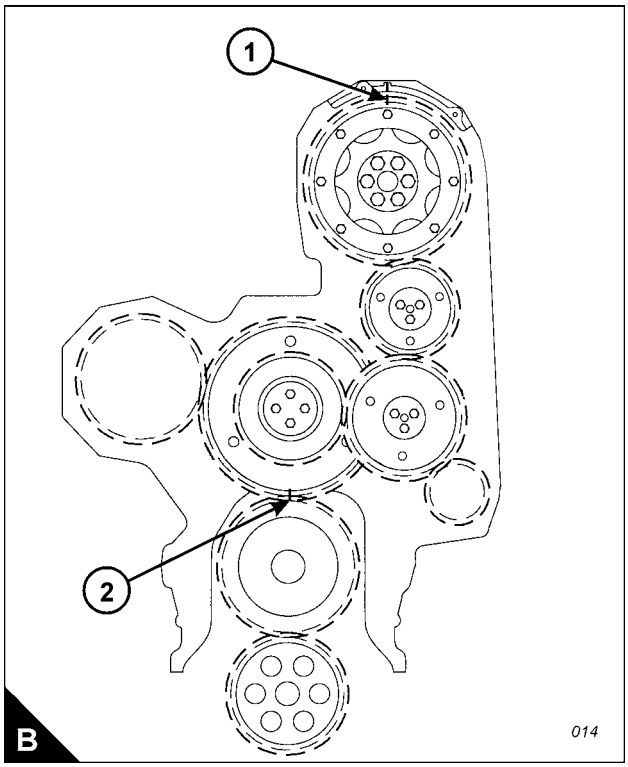
Caution: *If a customer-fitted speed sensor is fitted to the flywheel housing, it must be removed before the engine turning tool can be inserted.*

3 Remove the plug (A3) from the timing bolt location in the flywheel housing and fit the timing bolt.

4 Insert the engine turning tool, CH11148, into the flywheel housing through the aperture behind the cover (A2). Use a $^{1}/_{2}$ inch drive ratchet with the turning tool to rotate the engine flywheel in the normal direction of rotation (anti-clockwise when viewed on the flywheel) until the timing bolt engages with the threaded hole in the flywheel. When the number one piston is at top dead centre on its compression stroke, the mark on the camshaft gear is be aligned with the mark on the gear case (B1). If the mark is not aligned, withdraw the timing bolt, rotate the crankshaft a further 360 degrees in the normal direction of rotation and insert the timing bolt again.

Caution: *If the flywheel is turned past the threaded hole, the flywheel must be turned in the opposite direction for approximately 45 degrees and then back in the normal direction of rotation until the timing bolt engages with the threaded hole. This is to eliminate backlash.*





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5 Remove the rocker lever and rocker shaft assemblies, Operation 3-2. If the camshaft gear (C2) is to be removed, slacken the six retaining bolts before the removal of the rocker lever and rocker shaft assemblies.

6 Remove the camshaft gear (C2), if relevant. Use the guide stud, GE50019. If the gear case is to be removed, the camshaft gear should be removed at this stage.

Caution: *Do not rotate the crankshaft with the camshaft gear or any of the idler gears removed and the rocker shaft assemblies installed. Damage can be caused to the pistons and valves, or to both.*

7 Remove the three bolts and the thrust plate (C3) and remove the adjustable idler. Discard the bolts.

8 Check the condition of the bearing in the gear. Renew the bearing if it is worn or damaged.

9 Remove the three bolts and the thrust plate (C4) and remove the main idler. Discard the bolts.

10 Check the condition of the bearing in the gear. Renew the bearing if it is worn or damaged.

11 Remove the four bolts and the thrust plate (C1) and withdraw the compound idler. Discard the bolts.

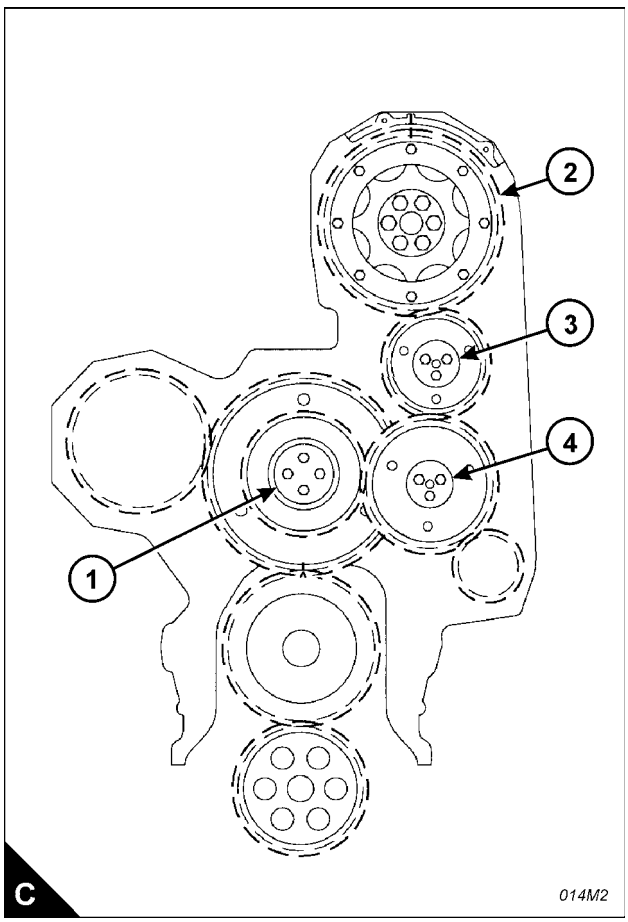
12 Check the condition of the bearing in the gear. Renew the bearing if it is worn or damaged.

Note: If the nuts for the adjustable idler axle are loosened, the backlash for the camshaft gear and main idler gear will have to be adjusted during the assembly operation. Refer to Operation 3-11.

13 Check the condition of the shaft for the adjustable idler. If the bearing diameter of the shaft is worn or damaged, remove the nuts and bolt and renew the assembly. Apply thread lock compound, 21820 117, to the bolt and five studs, fit the bolt and nuts and tighten to a torque of 50 +/- 10 Nm (37 +/- 7 lbf ft).

14 Check the condition of the shaft for the main idler. If the bearing diameter of the shaft is worn or damaged, remove the nuts and bolt and renew the assembly. Apply thread lock compound, 21820 117, to the bolt and five studs, fit the bolt and nuts and tighten to a torque of 50 +/- 10 Nm (37 +/- 7 lbf ft).

15 Check the condition of the shaft for the compound idler. Renew the shaft if the bearing diameter is worn or damaged. If the shaft is removed, renew the five bolts which retain the shaft. Apply thread lock compound, 21820 117, to the bolts and tighten to a torque of 50 +/- 10 Nm (37 +/- 7 lbf ft).



To fit

1 Fit the assembly of the compound idler to its shaft, ensure that the "V" timing mark on the crankshaft is aligned with the marks on the large gear of the compound idler. Fit the thrust plate and fit new bolts. Tighten the bolts to a torque of 28 +/- 7 Nm (21 +/- 5 lbf ft).

2 Fit the main idler gear to the shaft assembly. Fit the thrust plate and fit new bolts. Apply thread lock compound, 21820 117, to the bolts and tighten to a torque of 28 +/- 7 Nm (21 +/- 5 lbf ft).

3 Fit the adjustable idler gear to the shaft assembly. Fit the thrust plate and fit new bolts. Apply thread lock compound, 21820 117, to the bolts and tighten to a torque of 28 +/- 7 Nm (21 +/- 5 lbf ft).

4 Fit the camshaft gear, if it was removed: align the hole in the gear with the dowel pin on the adapter plate. If the timing mark on the gear does not align with the pointer at the top of the gear case, remove the gear and rotate the camshaft until the gear can be installed with the marks aligned. Ensure that the timing marks on the crankshaft gear and compound idler are aligned.

5 Fit the bolts which retain the gear, remove the guide stud and fit the bolt which remains. Tighten the bolts to a torque of 240 +/- 40 Nm (177 +/- 30 lbf ft).

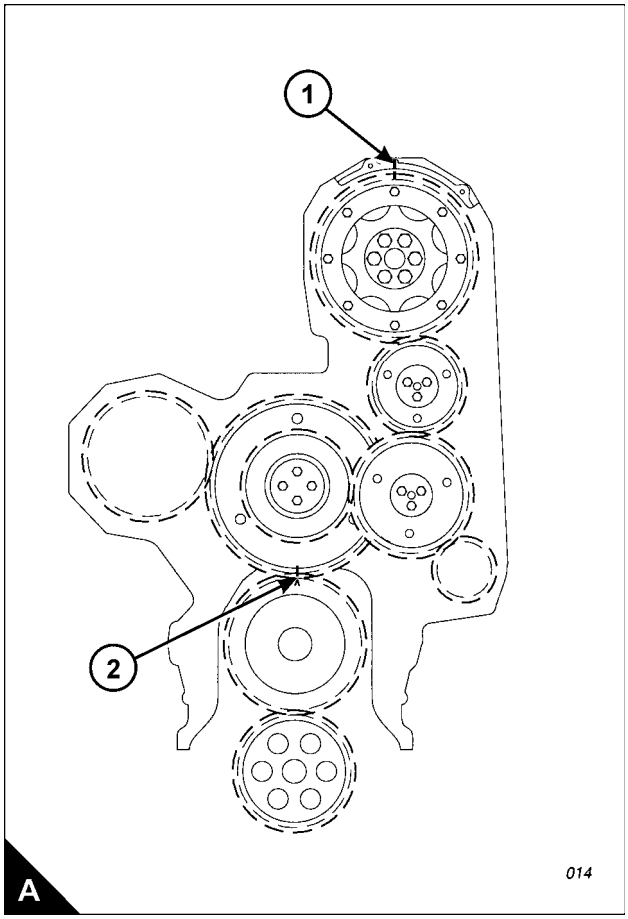
6 Fit the gear case cover, Operation 6-1.

7 Remove the timing bolt from the flywheel and fit the cover and plug.

8 Install the rocker lever and shaft assemblies, Operation 3-2.

How to check the position of the timing gears **Operation 6-3**

Fuel injection timing and the operation of the rocker valves depends on the correct alignment of the timing gears. When the timing mark on the camshaft gear (A1) is aligned with the mark on the gear case, the ‘V’ on the crankshaft must also be aligned exactly with the line (A2) on the idler gear. At this position the piston of cylinder number 1 is at top dead centre (TDC). This can be confirmed by the insertion of the timing bolt into the flywheel as described in Timing gears - To remove and to fit, Operation 6-2.



Gear case

To remove and to fit — Operation 6-4

Special requirements

Consumable products	
Description	**Part number**
Thread lock compound (10 ml)	21820 117

To remove

1 Remove the gear case cover, Operation 6-1.

2 Disconnect the lead and remove camshaft timing sensor from behind the top of the gear case.

3 Disconnect the lead and remove crankshaft timing sensor from behind the bottom of the gear case.

4 Remove the fan drive assembly, Operation 12-6.

5 Remove the coolant pump, Operation 12-13.

6 Remove the crankshaft vibration damper, Operation 5-4.

7 Remove the front engine support, Operation 7-1.

8 Remove the sump, Operation 10-3.

9 Remove the fuel transfer pump, Operation 11-2. If necessary, remove the drive for the fuel transfer pump, Operation 11-4.

10 Remove the timing gears and the camshaft drive gear, Operation 6-2.

11 Remove the bolt and five nuts which retain the axle for the adjustable idler.

12 Remove the bolt and five nuts which retain the axle for the main idler.

13 Remove the three bolts which retain the camshaft front seal assembly. Remove the thrust plate, the adaptor plate and the seal plate. Discard the seals from the seal plate.

14 Attach a suitable hoist to the gear case and remove the mounting bolts.

15 Remove the gear case from the dowels in the crankcase. The weight of the gear case is approximately 62 kg (137 lb).

To fit

1 Clean thoroughly the contact surfaces of the crankcase and gear case.

2 Fit the two dowels, if they have been removed, and ensure that they protrude from the crankcase by 19,1 +/- 0,5 mm (0.75 +/- 0.02 in).

3 Ensure that the front surface of the crankcase is clean and fit a new joint to the crankcase.

4 Ensure that the rear face of the gear case is clean and fit the gear case onto the crankcase. Fit the retaining bolts and tighten to a torque of 50 +/- 10 Nm (37 +/- 7 lbf ft).

5 Check the condition of the shaft for the adjustable idler. If the bearing diameter of the shaft is worn or damaged, renew the assembly. Apply thread lock compound, 21820 117, to the bolt and five studs, fit the bolt and nuts and tighten to a torque of 50 +/- 10 Nm (37 +/- 7 lbf ft).

6 Check the condition of the shaft for the main idler. If the bearing diameter of the shaft is worn or damaged, renew the assembly. Apply thread lock compound, 21820 117, to the bolt and five studs, fit the bolt and nuts and tighten to a torque of 50 +/- 10 Nm (37 +/- 7 lbf ft).

7 Check the condition of the shaft for the compound idler. Renew the shaft if the bearing diameter is worn or damaged. Renew the five bolts which retain the shaft. Apply thread lock compound, 21820 117, to the bolts and tighten to a torque of 50 +/- 10 Nm (37 +/- 7 lbf ft).

8 Fit new ‘O’ ring seals to the camshaft front seal plate. Apply a small amount of engine lubricating oil to the ‘O’ ring seal on the outside of the plate. Fit the seal plate with the face seal against the cylinder head. Insert the adapter plate and fit the thrust plate. Apply thread lock compound, 21820 117, to the three bolts, fit the bolts and tighten.

9 Fit the timing gears, Operation 6-2.

10 Fit the sump, Operation 10-3.

11 Fit a new crankshaft front seal and wear sleeve, Operation 5-2.

12 Fit the front engine support, Operation 7-1.

13 Fit the crankshaft vibration damper, Operation 5-4.

14 Fit the coolant pump, Operation 12-13.

15 Fit the camshaft timing sensor to its location behind the top of the gear case and connect the lead.

16 Fit the crankshaft timing sensor to its location behind the bottom of the gear case and connect the lead.

17 Fit the gear case cover, Operation 6-1.

7

Crankcase and cylinder liners

General information

The crankcase is a single unit casting made from high quality cast iron and comprises the crank chamber and the cylinder block. The crank chamber extends below the centre of the crankshaft to ensure rigidity. The crankshaft is supported in seven bearings secured by removable caps and fitted with thrust washers at the centre bearing. The cylinder block contains a row of six cylinders arranged vertically. Wet-type cylinder liners are used, these are manufactured from cast iron and are induction hardened. A steel spacer plate is fitted to the top face of the crankcase. This improves the strength and durability when compared with conventional designs.

Front engine support

To remove and to fit **Operation 7-1**

To remove

1 Remove the radiator, Operation 12-4.

2 Use a suitable hoist, attached to the front lifting bracket, to support the engine and remove the bolts (A2). which retain the front mounting support (A3) to the base frame.

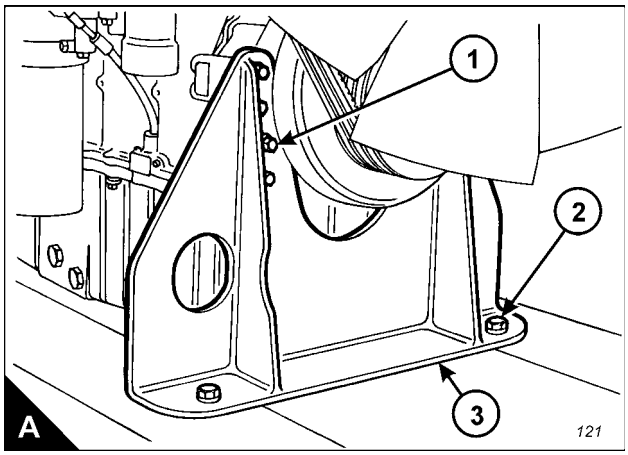
3 Remove the eight bolts and washers (A1) and remove the engine support.

To fit

1 Fit the front engine support to the engine and retain with eight bolts and washers (A1).

2 Attach the engine support to the base frame with the relevant bolts (A2), remove the hoist from the lifting bracket and tighten the bolts.

3 Fit the radiator, Operation 12-4.



Cylinder liners

To remove and to fit **Operation 7-2**

Special requirements

Special tools		Consumable products	
Description	**Part number**	**Description**	**Part number**
Cylinder liner remover	GE50001	Anti-seize compound	CV60890
Cylinder liner installer	GE50000	Anti-seize compound	CV60890

To remove

1 Remove the pistons and connecting rod assemblies, Operation 4-1.

2 Fit covers over the journals of the crankshaft for protection from dirt or water.

3 Use the special tool (A1), GE50001, to remove the cylinder liners (A2). Make a note of the bore position to which each liner is fitted.

To fit

1 Clean the cylinder liners and the liner bores in the crankcase.

2 Install the cylinder liners in the cylinder block without the 'O' ring seals or the filler band. Ensure that the cylinder liners are fitted to their original positions.

3 Check the protrusion of the cylinder liners, Operation 7-3.

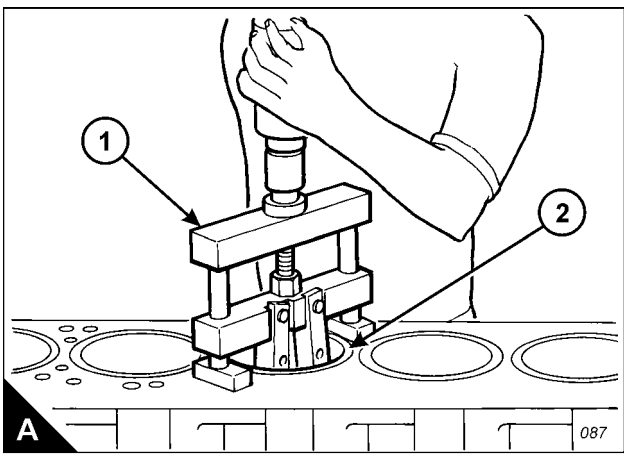
4 Remove the liners and fit new 'O' ring seals.

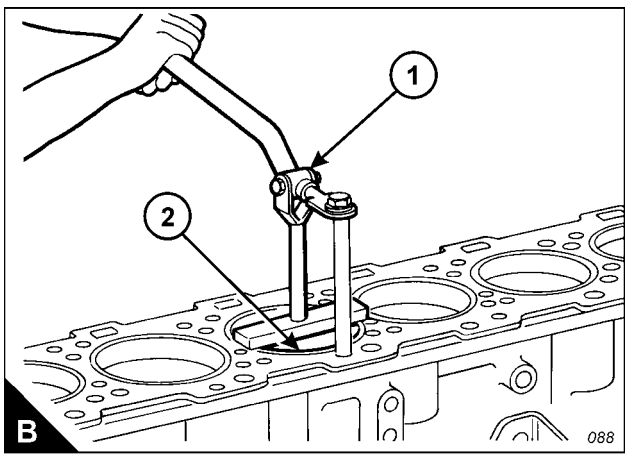
Note: Apply liquid soap and/or clean engine oil immediately before assembly. Do not apply the liquid soap and/or clean engine oil to the seals too early as the seals may swell and become pinched by the liners during installation.

5 When the engine is ready for final assembly, the 'O' ring seals, the cylinder block and the upper filler band must be lubricated before installation. If the lower 'O' ring seals are black in colour, apply liquid soap to them and to the cylinder block, and immerse the upper filler band in clean engine oil. If the lower 'O' rings are brown in colour, apply engine oil to them, to the cylinder block and immerse the upper filler band in clean engine oil.

6 After the engine oil or liquid soap has been applied, immerse the filler band in clean engine oil, then immediately fit the filler band to the groove in the cylinder liner below the liner flange. Immediately install the cylinder liner in the crankcase before expansion of the band occurs. Use the special tool (B1), GE50000, to install the liners (B2). Ensure that the liners are fitted to the correct positions.

7 Fit the pistons and connecting rod assemblies, Operation 4-1.





To check and to adjust the protrusion of the cylinder liners **Operation 7-3**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Clamp bolt	GE50005	Fibre washer	GE50007
Clamp washer	GE50006	Cylinder liner projection tool	GE50002

Note: Cylinder liner protrusion is measured from the top of the cylinder liner to the top of the spacer plate.

1 Ensure that the top face of the cylinder block (A4) is clean. Fit a new spacer plate gasket and fit a clean spacer plate (A3).

2 Fit the cylinder liners to the cylinder block without seals or bands. Ensure that the cylinder liners are fitted to their original positions.

3 Install all of the bolts (A6), GE50005, or the six bolts around the liner (A5) to be checked. A plain washer (A1), GE50006, and a fabric washer (A2), GE50007, must be fitted to each bolt. Tighten the bolts to a torque of 95 Nm (70 lbf ft).

4 Use the special tool, GE50002, to measure the liner protrusion at the four positions shown (B1, B2, B3 and B4) and record the measurements for each cylinder.

5 Add the four readings for each cylinder and divide the sum of the readings by four to obtain the average reading for each cylinder.

The correct specifications for cylinder liner protrusion are:

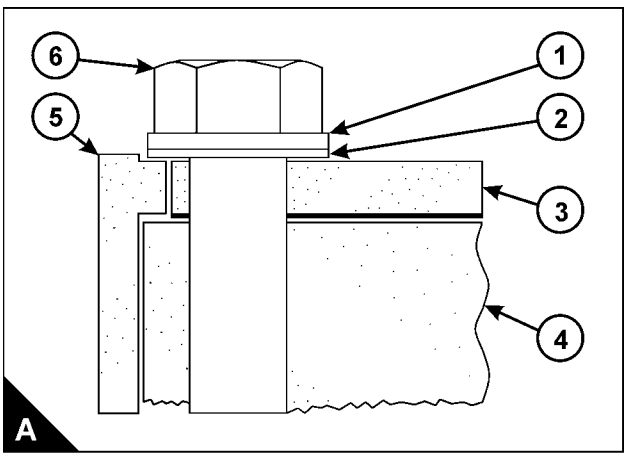
Liner protrusion: 0,025 to 0,152 mm (0.001 to 0.006 in)

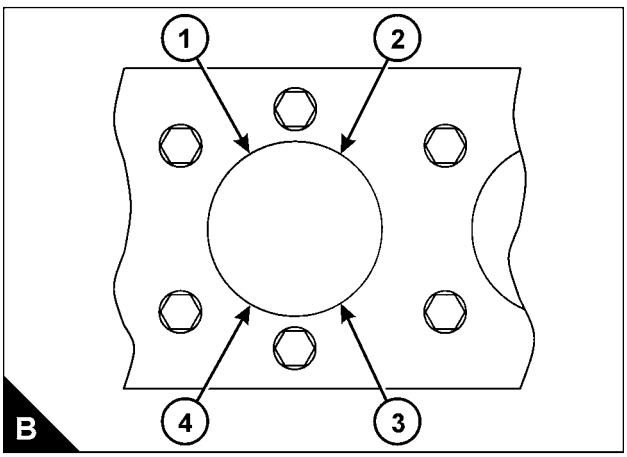
Maximum variation in each liner: 0,051 mm (0.0020 in)

Maximum average variation between adjacent liners: 0,051 mm (0.0020 in)

Maximum variation between all liners: 0,102 mm (0.0040 in)

Note: If the liner protrusion changes around the liner, turn the liner to a new position within the bore. If the liner protrusion is not within the specifications, move the liner to a different bore. Inspect the top face of the cylinder block.





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6 If the liner protrusions are all below the specifications or low in the range, 0,025 mm (0.001 in) or 0,051 mm (0.002 in), try a thinner spacer plate, available from your Perkins dealer. These plates are 0,076 mm (0.003 in) thinner than the original plate and will increase the liner protrusion. Use these spacer plates to compensate for low liner protrusions which are less than the 0,076 mm (0.003 in). Use these spacer plates if inspection of the top face of the cylinder block reveals no measurable damage directly under the liner flanges but the average liner protrusion is less than 0,076 mm (0.003 in).

Caution: *Do not exceed the maximum liner protrusion of 0,152 mm (0.006 in). Excessive liner protrusion will cause the liner flange to crack.*

7 When the liner protrusion is correct, add a temporary mark to the liner and to the spacer plate to assist with the assembly procedure. Remove the bolts and washers, and withdraw the cylinder liners.

8 When the engine is ready for final assembly, the 'O' ring seals, the cylinder block and the upper filler band must be lubricated before installation. If the lower 'O' ring seals are black in colour, apply liquid soap to them and to the cylinder block. Immerse the upper filler band in clean engine oil. If the lower 'O' rings are brown in colour, apply engine oil to them and to the cylinder block. Immerse the upper filler band in clean engine oil.

Note: Apply liquid soap and/or clean engine oil immediately before assembly. Do not apply the liquid soap and/or clean engine oil to the seals too early as the seals may swell and become pinched by the liners during installation.

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8

Engine timing and electronic controls

General information

The electronic control system, used on the 2300 and 2800 Series engines, consists of the Electronic Control Module (ECM) and engine sensors. The ECM, mounted on the left side of the engine, is the computer which controls the engine operating parameters. The software stores the operating maps which define power, engine speed, etc. Electronic unit injectors are fitted to each cylinder. A solenoid on each injector controls the amount of fuel delivered by the injector. The ECM sends a signal to each injector solenoid to provide complete control of the engine. The ECM compares the 'desired speed' with the actual engine speed, obtained from sensors on the crankshaft and camshaft drives, and calculates how much fuel to inject to achieve the desired speed.

The timing of the fuel injection is determined by the ECM after it has received information from the coolant temperature sensor, the air temperature sensor of the inlet manifold and the turbocharger boost pressure sensor. From a signal provided by the engine speed/timing sensor, the ECM determines where top dead centre on cylinder number one is located. The ECM decides when injection should occur relative to top dead centre and provides a signal to the injector at the desired time. The ECM adjusts timing for the best engine performance, fuel economy and white smoke control. Actual or desired timing can be viewed with the service tool.

The ECM controls the amount of fuel injected by varying signals to the injectors. The ECM sends a high voltage signal to energise the solenoids of the fuel injectors. The injectors will pump fuel ONLY if the injector solenoid is energised.

Warning! *The electrical circuit for the fuel injector units operates on 110 volts. Do NOT work on the fuel injector units unless the power supply to the ECM has been disconnected.*

The software inside the ECM sets limits on the amount of fuel that can be injected dependent on the selected rating and the engine operating parameters. The parameters which follow are monitored by the ECM: High coolant temperature, low lubricating oil pressure, overspeed condition, inlet manifold air temperature, fuel temperature and boost pressure.

The electronic system has some ability to diagnose itself. When a diagnostic code is generated, the 'Diagnostics' lamp is illuminated and the exact fault should be determined by use of the service tool. Full information on fault finding the system is given in the relevant Diagnostic Manual.

The ECM communicates with the service tool through the Perkins Data Link (PDL); a connector is normally fitted to the wiring harness to enable the service tool to be connected. A J1939 data link is also available in addition to the Perkins Data Link.

Electronic control module

To remove and to fit **Operation 8-1**

To remove

1 Switch off the engine and disconnect the electrical power supply.

2 Loosen fully the Allen screws from the J1 and J2 connectors (A1 and A4).

3 Remove the two nuts which retain the bar (A6) and the control module (A3), release the ground strap and withdraw the bar and connectors from the control module.

4 Support the control module, remove the two remaining nuts (A2 and A5) and remove the electronic control module from the engine.

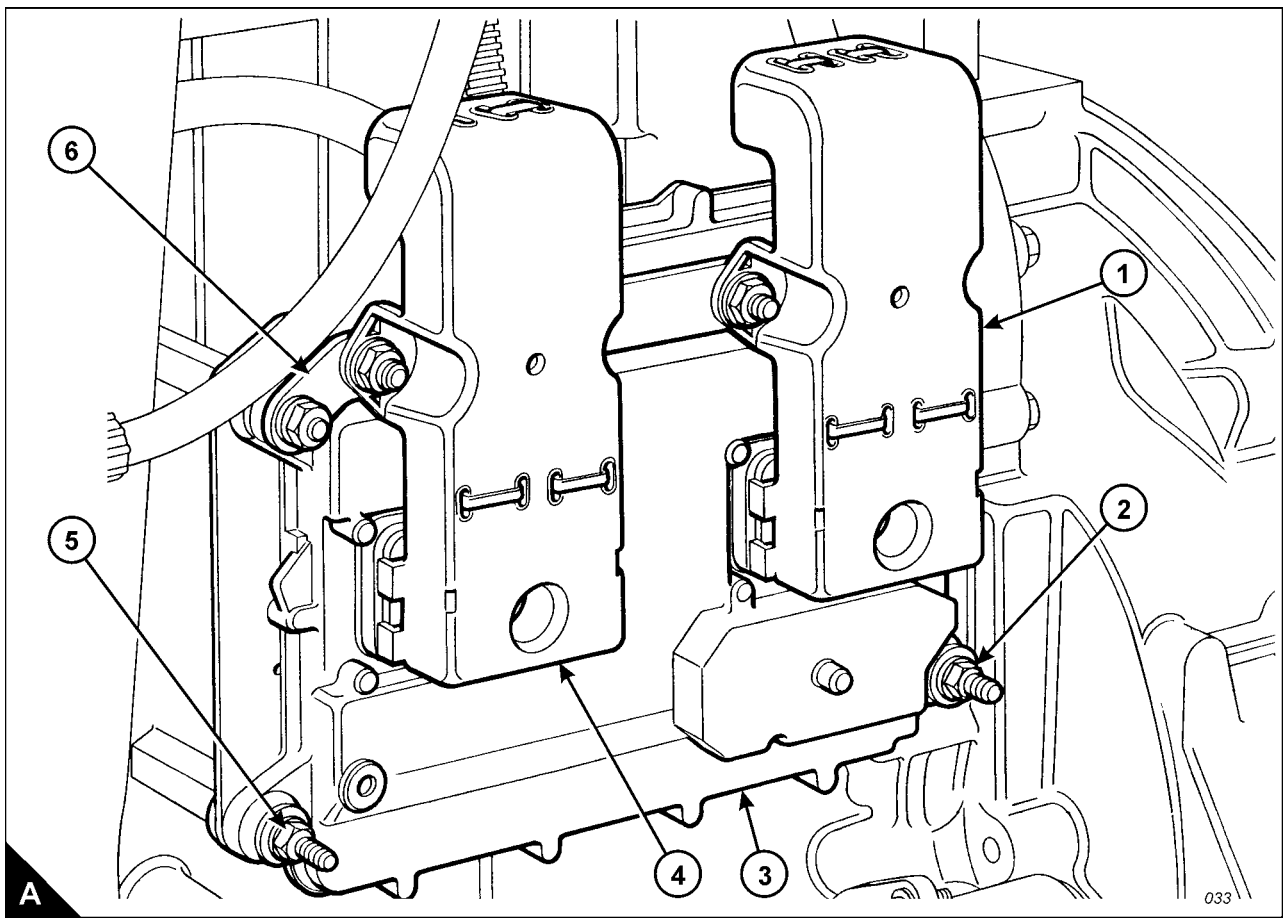
To fit

1 Fit the electronic control module. Retain with four nuts, ensure that the ground strap is fitted correctly.

Note: To avoid damage to the components, use the Allen screws to pull the mating parts of the connectors (A1 and A4) and control module (A3) together. Ensure that the connectors are aligned correctly and are fitted to the correct positions before the Allen screws are tightened.

2 Fit the connectors (A1 and A4) and retain with Allen screws. Tighten the screws to a torque of 3 Nm (2.2 lbf ft). Do NOT overtighten the screws.

3 Connect the electrical power supply.



To check — Operation 8-2

Special requirements

Special tools	
Description	**Part number**
Engine turning tool	CH11148

If it becomes necessary to check the valve/ignition timing position of the engine, use this procedure:

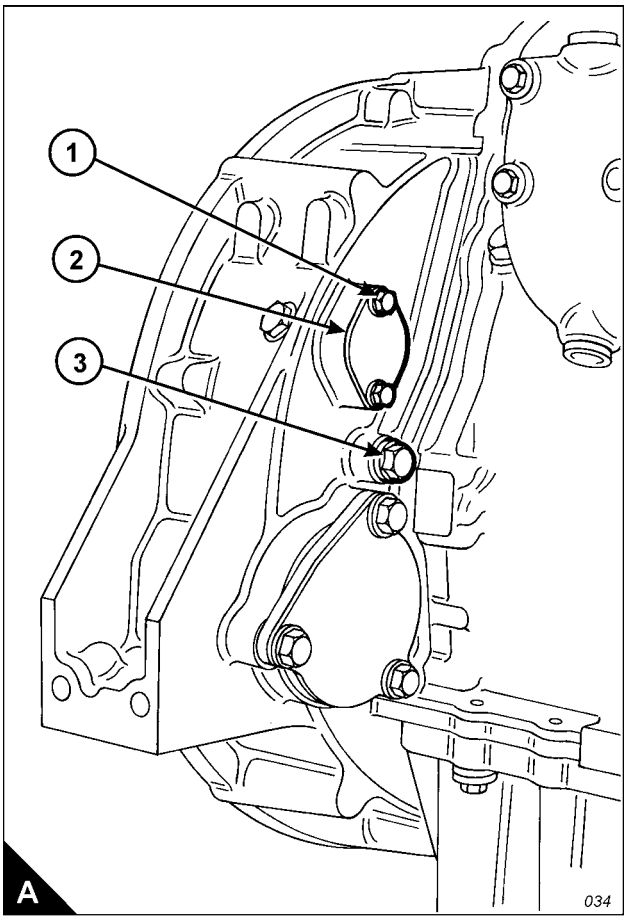
1 With the engine switched off and electrically isolated, remove the rocker cover, Operation 3-1.

2 Remove the cover (A2) from the flywheel housing. The top bolt (A1) is the timing bolt.

Caution: *If a customer-fitted speed sensor is fitted to the flywheel housing, it must be removed before the engine turning tool can be inserted.*

3 Remove the plug (A3) from the timing bolt location in the flywheel housing and fit the timing bolt.

4 Insert the engine turning tool, CH11148, into the flywheel housing through the aperture behind the cover (A2). Use a $^{1}/_{2}$ inch drive ratchet with the turning tool to rotate the engine flywheel in the normal direction of rotation (anti-clockwise when viewed on the flywheel) until the timing bolt engages with the threaded hole in the flywheel. The piston of number 1 cylinder is now at TDC (top dead centre).



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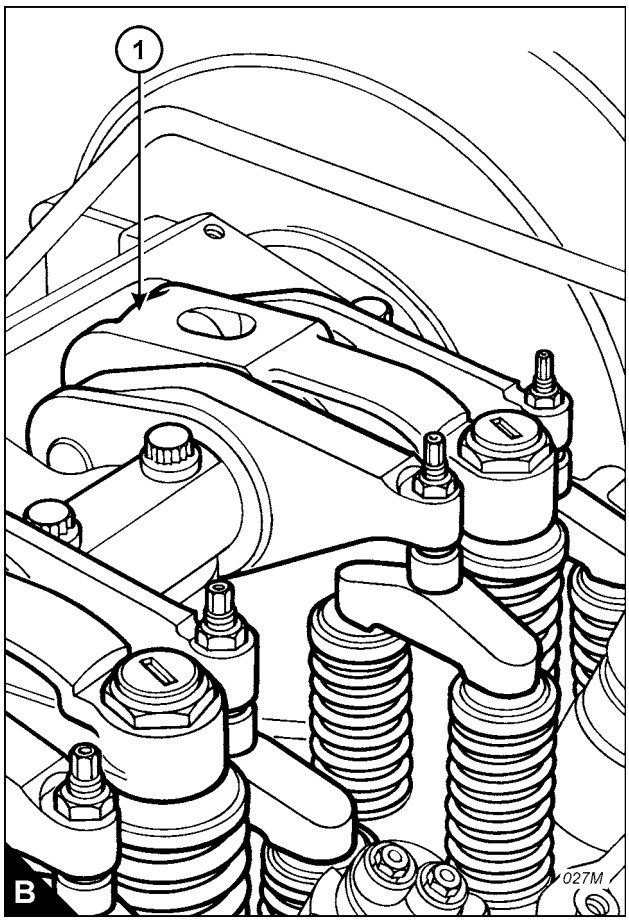
When the number one piston is at TDC on its compression stroke, the valves of number one cylinder will be fully closed, if not, remove the timing bolt, rotate the engine by a further 360 degrees and insert again the timing bolt. The piston of number 1 cylinder is now at TDC on its compression stroke. Withdraw the timing bolt from the flywheel and rotate the engine backwards until the follower of the number one injector rocker lever is in contact with the back of the cam lobe.

5 Attach a plunger clock and set the plunger on the top face of the rocker lever of the number one injector at the position shown (B1). Set the clock to zero.

6 Rotate the engine in the normal direction of rotation until the timing bolt can again enter the hole in the flywheel and check the reading on the plunger clock. The cam lift at this point should be 2,92 +/- 0,25 mm (0.115 +/- 0.010 in).

7 Repeat step 6 to ensure that a consistent reading is obtained.

8 If the reading is not within the limits, adjust the position of the adjustable idler gear to advance or retard the camshaft as necessary. Refer to Operation 3-11.



9

Aspiration system

General information

The induction system of the engine is supplied with air under pressure by a turbocharger. The turbocharger is driven by the energy of the exhaust gas.

Special thermal sleeves manufactured from stainless steel are fitted to the exhaust ports. These reduce the amount of heat transferred to the cooling system and direct the thermal energy to the turbocharger.

The exhaust gas passes through the exhaust manifold and enters the turbine housing of the turbocharger. The pressure of the exhaust gas causes the turbine rotor to rotate, the gas then leaves the engine through the exhaust pipes. Exhaust pipes and exhaust silencers are fitted in accordance with the requirements of the installation. An impeller at the other end of the turbine shaft supplies clean air to the engine at more than atmospheric pressure. The air is drawn through the air cleaner and into the compressor housing which contains the impeller. From the compressor housing the air is forced through the air-to-air charge cooler which is integral with the radiator. The air is cooled as it flows through the charge cooler, this improves the combustion efficiency. From the charge cooler the air is directed through ducts to the cylinder head and enters the cylinders of the engine.

A restriction indicator is fitted next to the casing of the air filter to give a visual indication when the filter element is dirty. The air filter needs no special maintenance, except for the procedures given in the User's Handbook.

The engine breather is an integral part of the rocker cover. If the breather becomes blocked or damaged, the assembly of the rocker cover should be renewed, refer to Operation 3-1.

Exhaust manifold

To remove and to fit — Operation 9-1

Special requirements

Special tools		Consumable products	
Description	**Part number**	**Description**	**Part number**
Pressurizing pump	GE50031	Anti-seize compound	CV60889

To remove

1 Remove the turbocharger, Operation 9-2.

2 Remove the thermostat housing, Operation 12-10.

3 Remove the exhaust shield.

4 Remove the nuts and spacers which retain the exhaust manifold and remove the manifold.

5 Withdraw the sleeves from the cylinder head.

6 Remove the gaskets from the cylinder head.

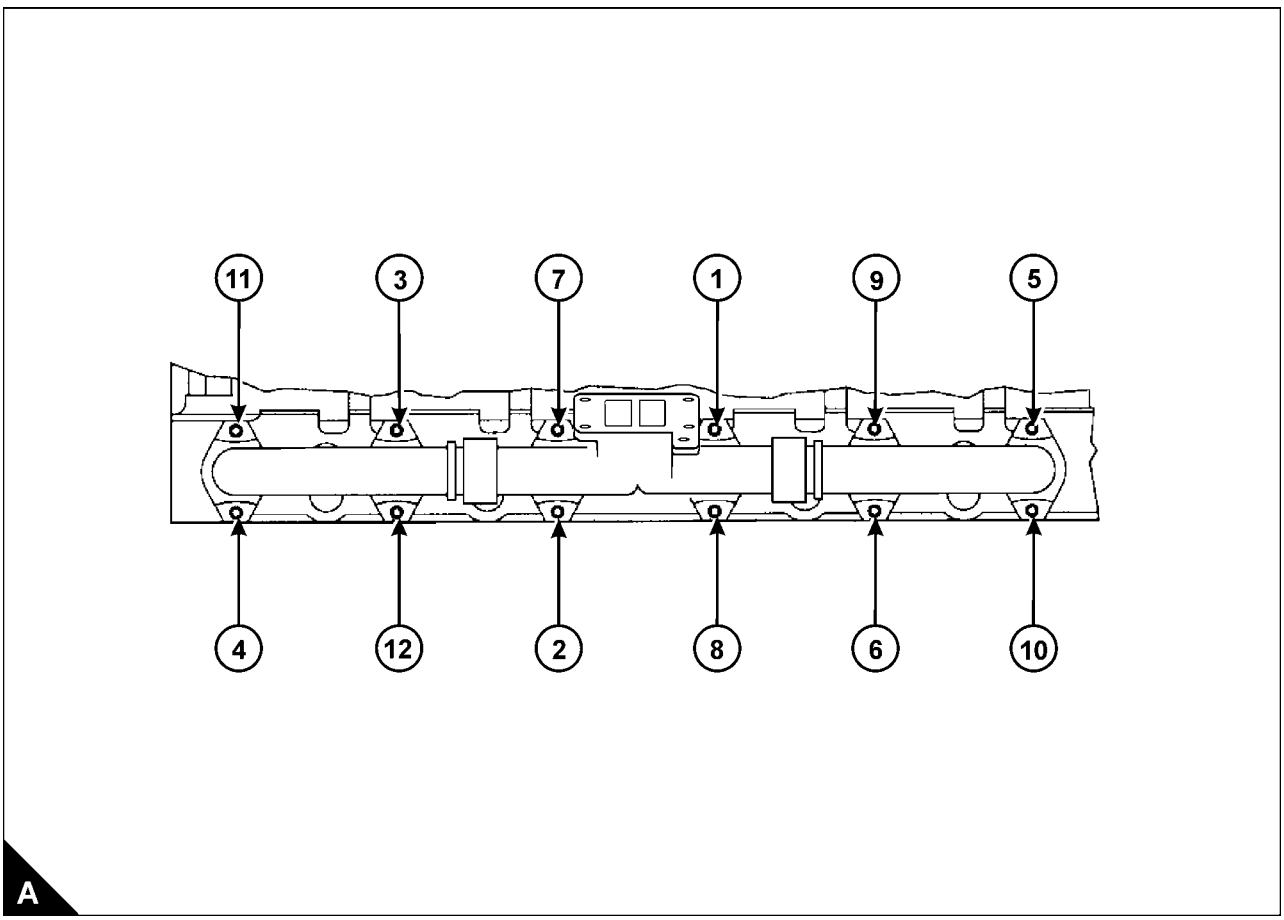
To fit

1 Check the condition of all sleeves, studs and nuts. Renew the components if worn or damaged. Apply anti-seize compound, CV60889, to the studs.

2 Fit new gaskets over the studs and install the sleeves. Fit the exhaust manifold, fit the spacers and the nuts. Tighten the nuts in the sequence shown (A) to a torque of 52 +/- 7 Nm (38 +/- 5 lbf ft).

3 Fit the thermostat housing, Operation 12-10.

4 Fit the turbocharger, Operation 9-2.



Turbocharger

To remove and to fit **Operation 9-2**

To remove

1 Disconnect the exhaust pipe from the turbocharger.

2 Remove the air duct from between the turbocharger and the air cleaner.

3 Disconnect the air duct from between the turbocharger and the charge air cooler.

4 Disconnect the oil feed (A2) and oil drain (A1) pipes.

5 Use a strap and hoist to support the turbocharger, remove the four bolts which retain the turbocharger on the exhaust manifold and remove the turbocharger. Note that the turbocharger weighs approximately 26.5 kg (58 lb).

To fit

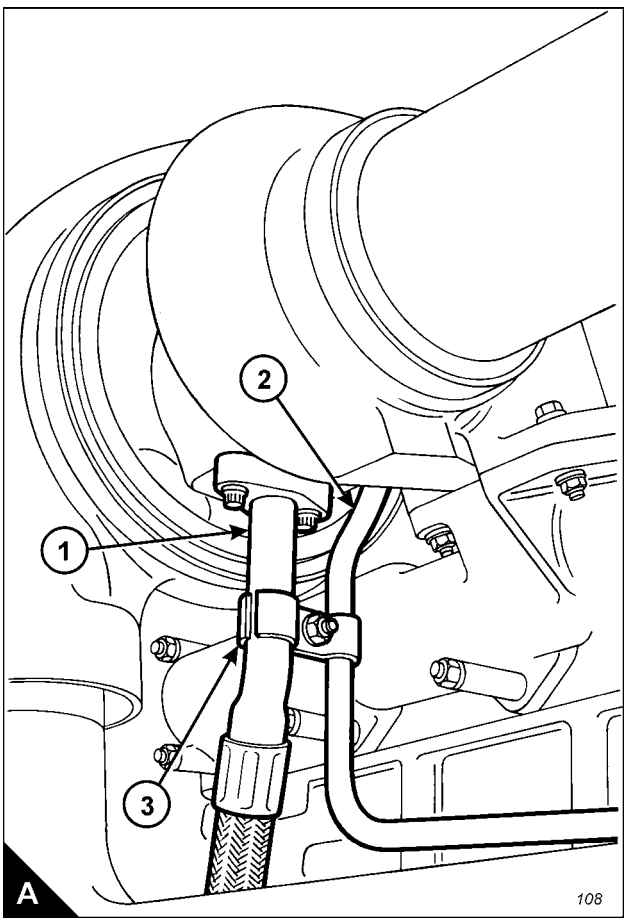
1 Fit the turbocharger to the exhaust manifold. Apply CV60889 anti-seize compound to the bolts. Fit the bolts and tighten them to a torque of 55 +/- 5 Nm (40 +/- 4 lbf ft).

2 Connect the oil feed and oil drain pipes (A2 and A1).

3 Fit the air duct between the turbocharger and the air cleaner.

4 Connect the air duct between the turbocharger and the charge air cooler.

5 Connect the exhaust pipe.



To dismantle and to assemble **Operation 9-3**

To dismantle

1 Remove turbocharger, Operation 9-2.

2 Add temporary alignment marks between the bearing housing and both the compressor housing and the turbine housing to ensure that the parts can be correctly aligned during the assembly operation.

3 Loosen the nuts on the clamps and separate the compressor housing and the turbine housing from the bearing housing.

Caution: *Do not attempt to dismantle the turbocharger bearing housing. Do not remove the compressor wheel. The bearing housing is not serviceable and must be renewed only as a unit.*

4 Check the condition of all components. Renew any worn or damaged components.

To assemble

1 Fit the compressor housing and the turbine housing to the bearing housing and retain with the relevant clamps.

2 Adjust the position of both the compressor and turbine housings until the temporary marks are aligned with those on the bearing housing. Tighten the clamp nuts.

3 Fit the turbocharger, Operation 9-2.

10

Lubrication system

General information

A wet sump type of lubrication system is used on the engine.

The engine is fitted with a lubricating oil pump, of the spur gear type. The drive gear of the lubricating oil pump is driven by a gear on the front of the crankshaft. The oil pump draws oil from the sump through a suction strainer. A pressure relief valve, integral with the oil pump, ensures that a constant pressure is maintained.

Oil leaves the oil pump and is delivered to the main oil gallery in the crankcase. When the engine is warm, the oil passes through the oil cooler and oil filter before it enters the main oil gallery. When the engine is cool, the high viscosity of the oil causes the by-pass valves to open and provide oil directly to the oil filter. To protect the engine, the by-pass valves will also open if there is a restriction in the oil cooler or the oil filter.

A supply of oil is directed to the turbocharger from the oil filter. After lubricating the turbocharger bearings, the oil drains into the crankcase and returns to the sump.

The main oil gallery is parallel to the crankshaft and supplies oil to each of the main bearings and through the main bearings to the crankshaft. The oil in the crankshaft then lubricates the connecting rod bearings. A supply of oil from the main oil gallery is directed to the piston cooling jets which cool the pistons.

An oil passage at the front end of the main oil gallery delivers oil to the cylinder head gallery and has passages which supply the bearings of the drive gears. The teeth of the drive gears are lubricated by spill oil as it returns to the sump.

Small holes in the cylinder head gallery direct oil to the camshaft bearing journals and also to the pedestals for the rocker shafts. From the pedestals the oil passes through the rocker shafts to lubricate the bearings of the valve and unit injector rocker levers. Oil flows through drilled passages in the rocker levers to lubricate the rollers, the valve bridges and the contact surfaces of the actuators for the unit injectors. Other components of the valve assembly are lubricated by splash oil. An aperture at the front of the cylinder head allows oil to drain to the sump.

The full length sump is manufactured from a composite material.

Some engines are fitted with an oil sample valve which enables a small quantity of oil to be drained for testing. Information about the oil sample valve is given in Chapter 15, Auxiliary equipment.

Oil filter and oil filter header

To remove and to fit **Operation 10-1**

To remove

1 Remove the plug (A5) and drain the oil from the oil filter housing.

2 Remove the oil filter housing (A3), and remove the oil filter element.

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

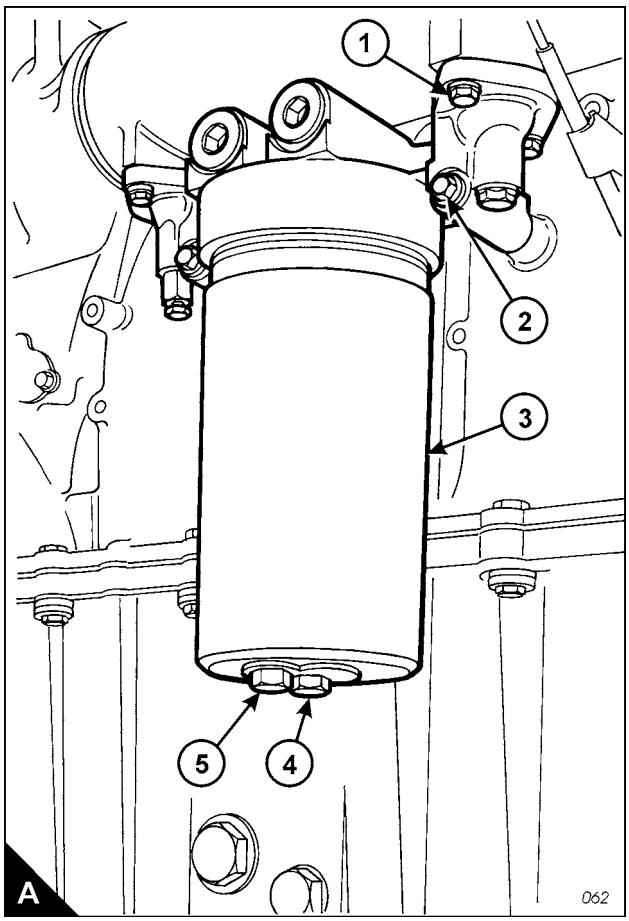
3 Remove the four bolts (A1) which connect the oil filter header to the oil cooler.

4 Remove the two bolts (A2) which retain the oil filter header on the crankcase.

5 Disconnect the turbocharger oil supply pipe from the elbow behind the oil cooler.

6 Remove the four bolts which retain the assembly of the elbow and oil filter header on the crankcase and withdraw the assembly.

7 Remove the four bolts to separate the oil filter header from the elbow. Renew the 'O' ring seals if they are worn or damaged.



To fit

1 Ensure that the 'O' ring seals are fitted to the elbow. Assemble the elbow and oil filter header and retain with four bolts.

2 Ensure that the used gasket material has been removed from the mating faces. Fit the assembly to the crankcase, complete with new gaskets, and retain with four short bolts through the elbow and two long bolts (A2) through the oil filter header.

3 Fit the four bolts (A1) which retain the oil filter header to the oil cooler

4 Connect the turbocharger oil supply pipe and tighten securely.

5 Clean the filter housing (A3) and clean the contact face of the filter head. Clean the drain plug (A2) and fit it to the housing.

Note: If a degreasing agent has been used to clean the housing, a special lubricant, CV60896, must be applied to the threads before the housing is fitted.

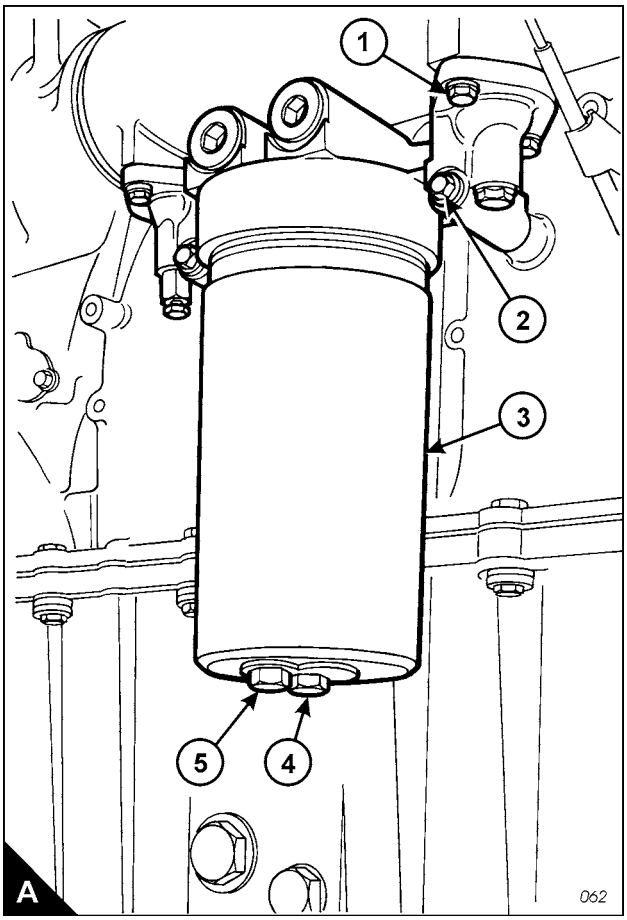
6 Fit a new element into the filter housing, ensure that it engages fully with the guide in the base of the housing. Fit a new 'O' ring seal around the top of the housing.

Caution: *It is important that only genuine Perkins parts are used. The use of incorrect parts could damage the engine.*

7 Fit the housing (A3) onto the filter head and tighten by use of a socket and torque wrench on the hexagon (A1). Tighten the housing to a torque of 90 Nm (66 lbf ft). Do NOT overtighten. Ensure that the drain plug is tightened securely.

8 Check the amount of engine oil in the sump. If necessary, add more oil of the correct grade and specification. Refer to the User's Handbook.

9 Run the engine and check for leaks. Check again the amount of engine oil in the sump. If necessary, add more oil of the correct grade and specification.



Oil filter header

To dismantle and to assemble **Operation 10-2**

To dismantle

1 Remove the two plugs (A5 and A6) which retain the by-pass valves in the oil filter header (A1).

2 Remove the spring (A3) and the plunger (A2) for the oil cooler by-pass valve. Remove the spring (A8) and plunger (A9) for the oil filter by-pass valve. Add temporary marks to the two springs and plungers to assist during assembly.

3 Remove the two small plugs and the adaptor.

To assemble

Inspect the 'O' ring seals fitted to all plugs and renew them if necessary.

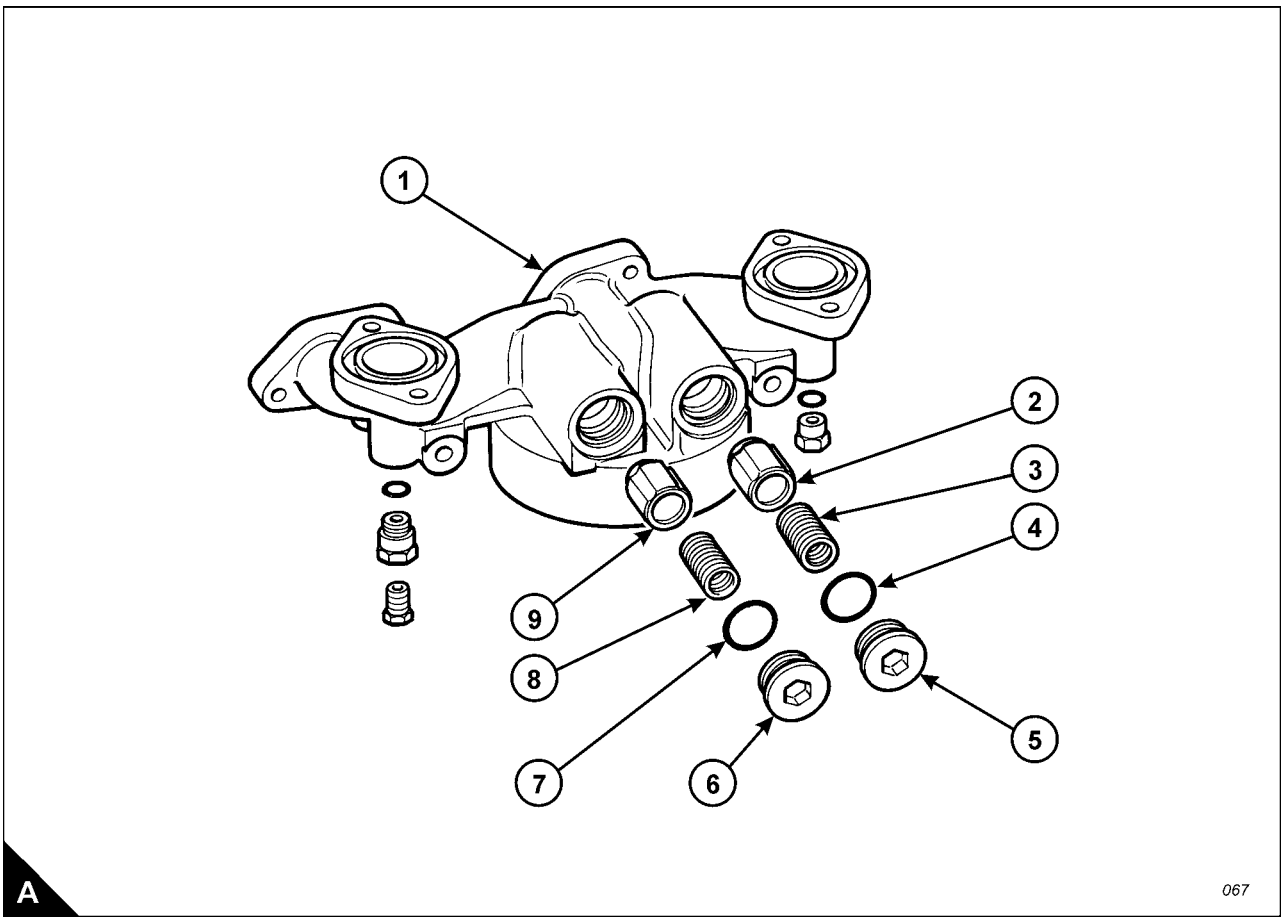
Note: Ensure that the plungers and springs are fitted to their original locations.

1 Fit the plunger (A9) and spring (A8) to the oil filter header.

2 Fit the plunger (A2) and spring (A3) to the oil filter header.

3 Fit the plugs (A5 and A6). Tighten each plug to 100 +/- 15 Nm (74 +/- 11 lbf ft).

4 Fit the adaptor and the two small plugs. Tighten each of them to 25 +/- 5 Nm (18 +/- 4 lbf ft).



Sump

To remove and to fit — Operation 10-3

Special requirements

Consumable products	
Description	**Part number**
RTV silicone sealant	CV60888

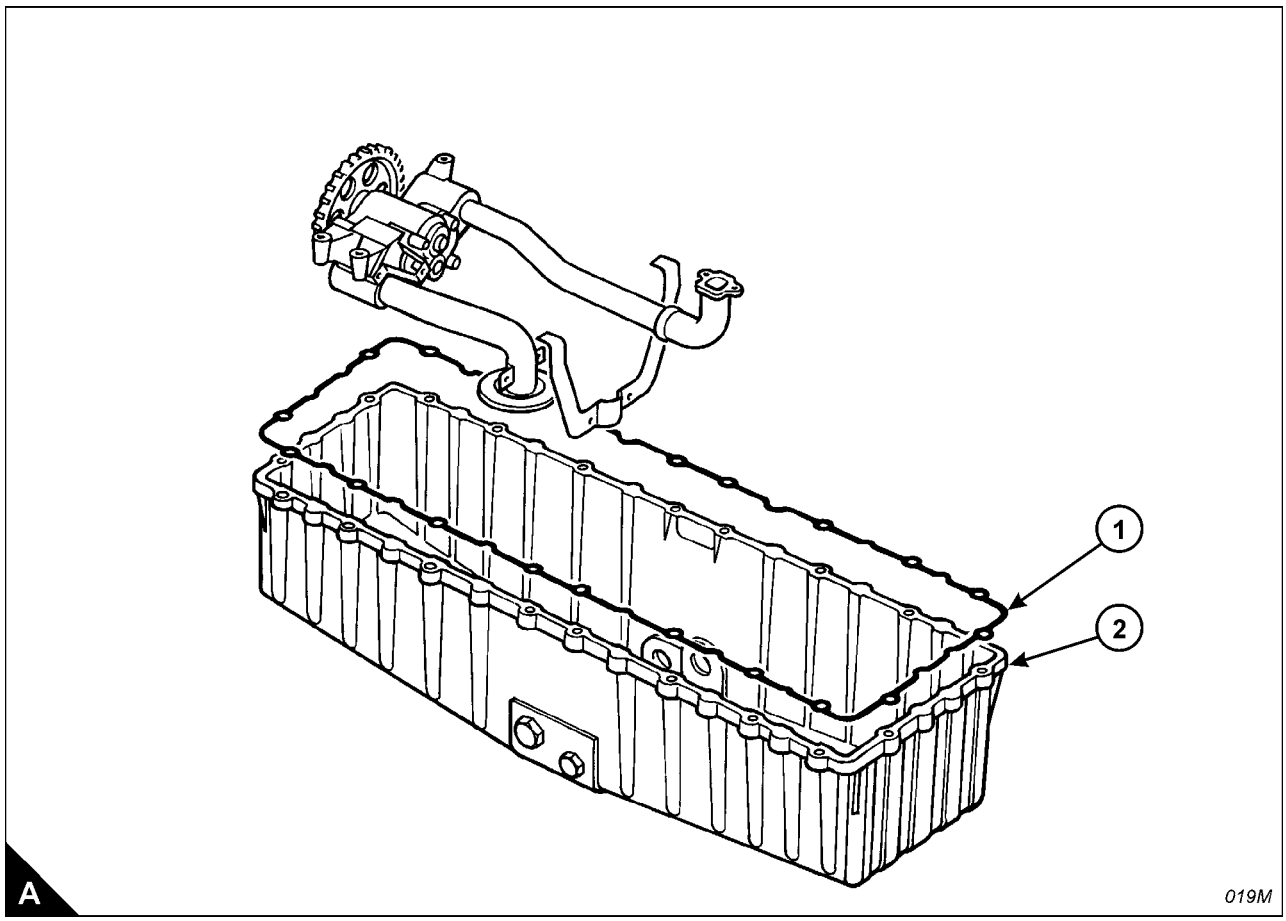
To remove

Warning! *Hot oil and components can cause personal injury. Do not allow hot oil or components to contact the skin.*

1 Drain the oil from the sump (A2).

2 Loosen the bolts which retain the sump on the engine. Do not remove the bolts fully, allow them to be retained by the seal (A1).

3 Remove the sump.



To fit

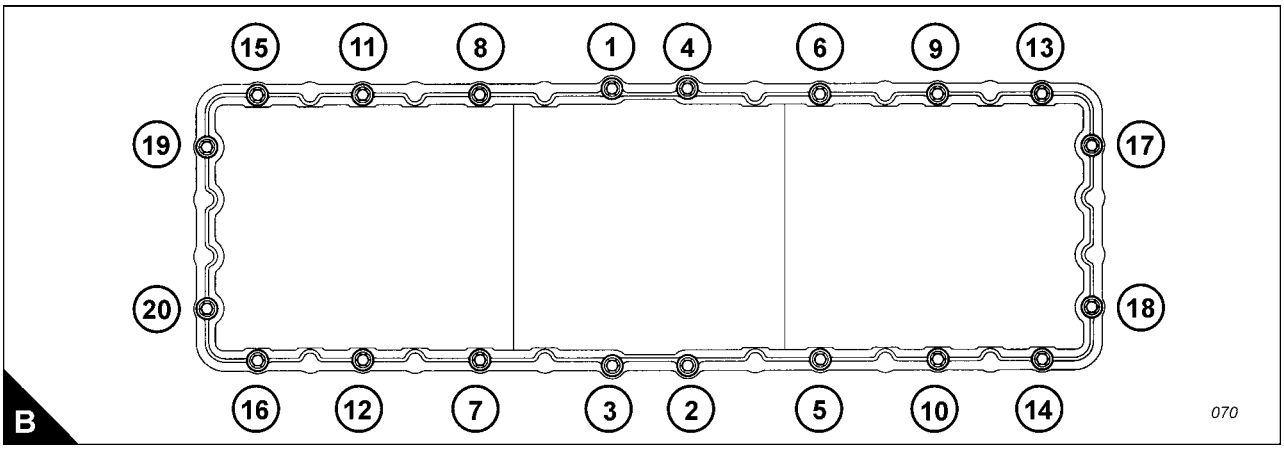
1 Examine the sump seal and renew if necessary. Ensure that the machined surface of the sump is clean before a new seal is fitted.

2 Clean the bottom face of the crankcase and also the bottom faces of the flywheel housing and the gear case.

3 Apply a bead of RTV silicone sealant, CV60888, at the four positions where the edge of the flywheel housing and gear case joints will be in contact with the sump seal. The bead must cover completely the exposed edge of the joints.

4 Fit the sump and tighten the bolts to a torque of 30 Nm (22 lbf ft); use the sequence shown (B).

5 Fill the engine to the correct level with oil of the correct grade and specification. Refer to the User's Handbook.



Oil pump

To remove and to fit — **Operation 10-4**

To remove

1 Remove the sump, Operation 10-3.

2 Remove the oil supply tube (A3) and the strainer and tube (A2).

3 Remove the bolts and remove the oil pump (A4).

Note: If the oil pump is to be dismantled, slacken the bolt which retains the drive gear (A1) before the pump is removed from the engine.

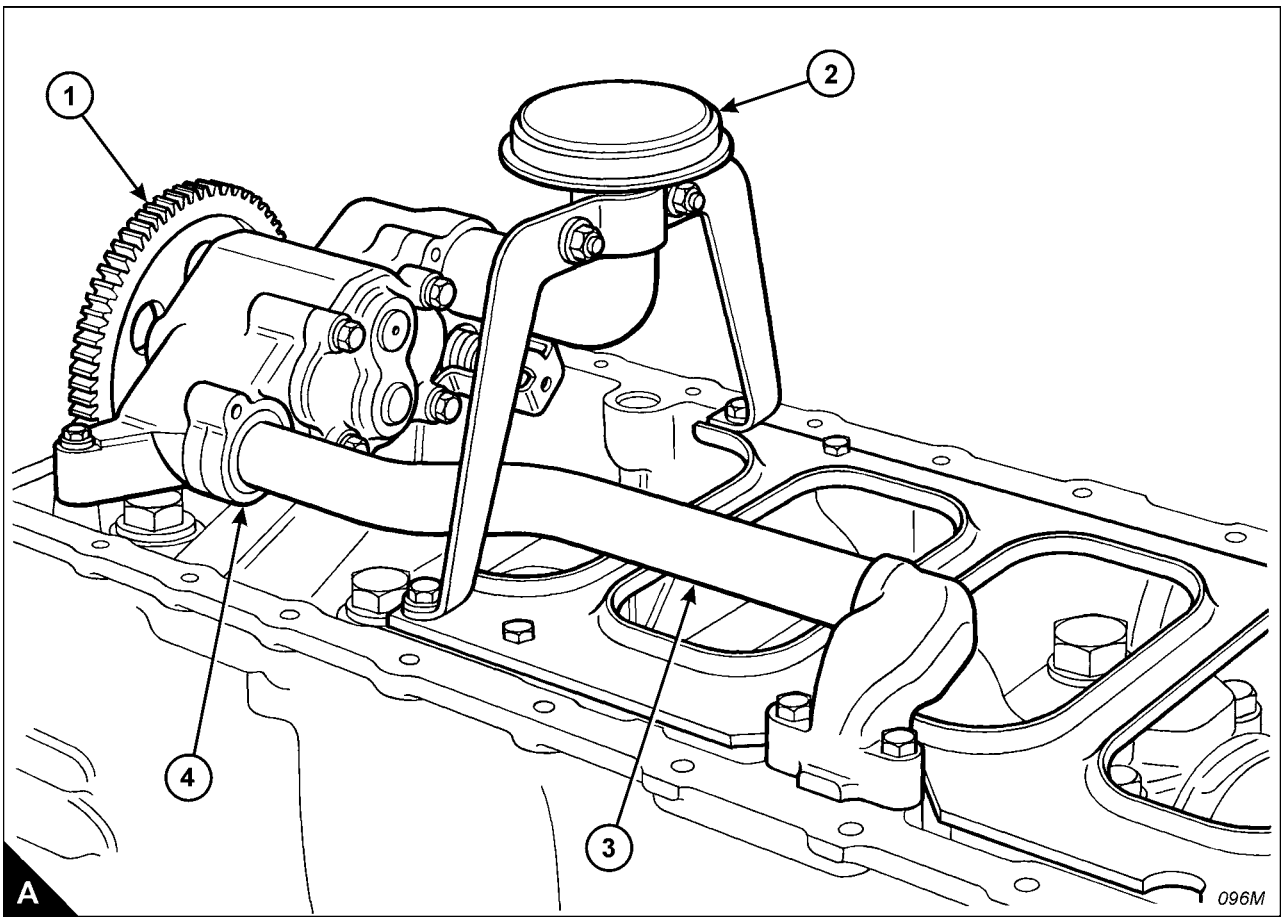
To fit

1 Fit the oil pump to the crankcase.

2 Apply clean engine oil to the 'O' ring seals of the tubes.

3 Install oil supply tube (A3) and strainer and tube (A2).

4 Fit the sump, Operation 10-3.



To dismantle and to assemble **Operation 10-5**

To dismantle

1 Remove the bolt and washer which retain the gear on the shaft.

2 Use a suitable gear puller to remove drive gear (A1) from the shaft. Remove the key from the shaft.

3 Remove retainer (A5) for the by-pass valve.

4 Remove the spring (A4) and the by-pass valve (A3).

5 Remove the cover (A6) from the pump body (A2).

6 Remove the idler gear and drive gear from pump body.

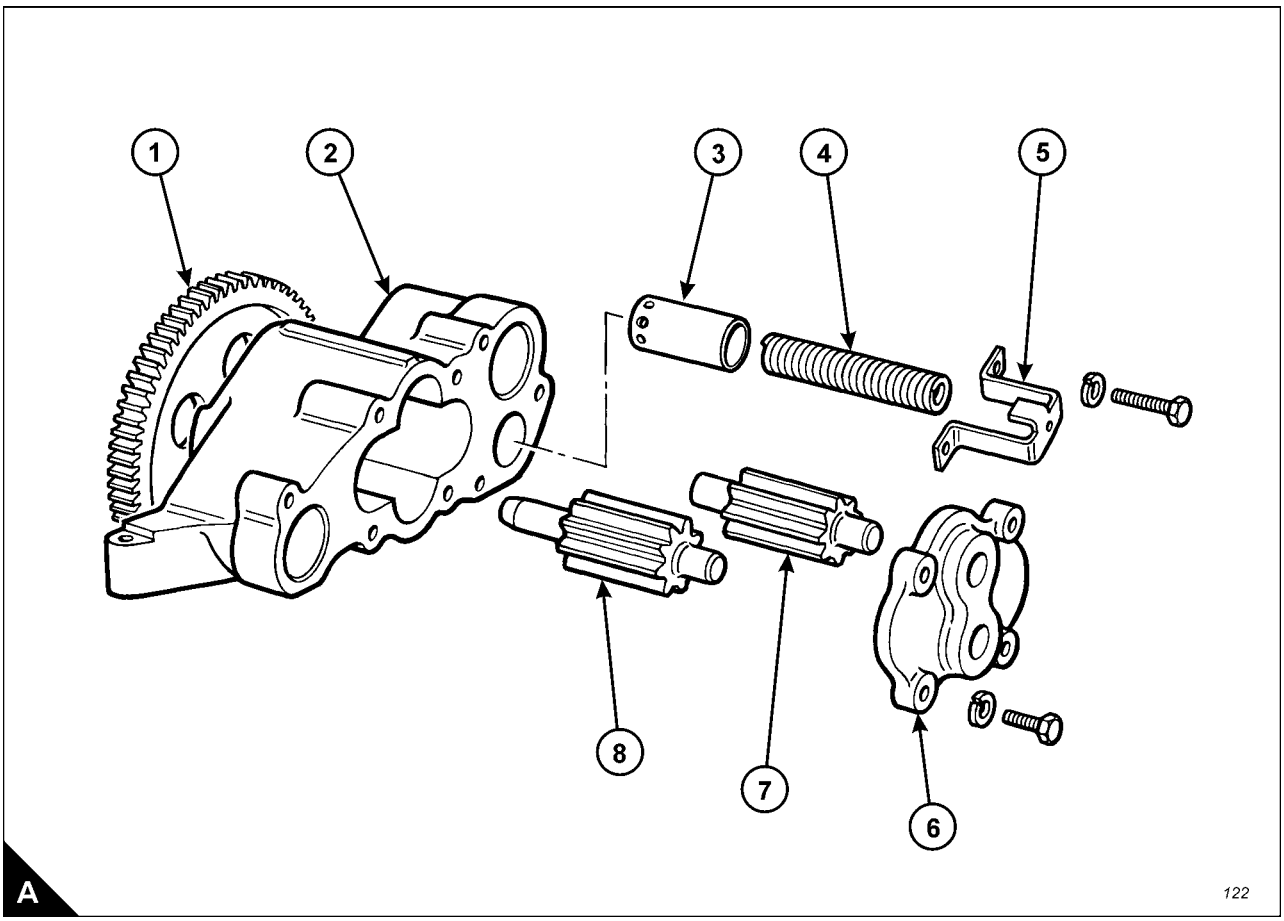
To assemble

1 Apply clean engine oil to the idler gear and drive gear and install the gears in the oil pump body.

2 Fit the by-pass valve, the spring and the retainer to the pump body (A2).

3 Fit the key to the shaft.

4 Fit the drive gear (A1) to the shaft. Install the washer and bolt which retain the gear. Tighten the bolt to a torque of 55 +/- 10 Nm (41 +/- 7 lbf ft). Ensure that the oil pump turns freely after assembly.



11

Fuel system

General information

The fuel supply circuit used on the 2300 and 2800 Series engines is a conventional design for engines fitted with unit injectors. A fuel transfer pump, driven by the timing gears of the engine, is fitted behind the gear case on the left side of the engine. The fuel transfer pump draws fuel from the fuel tank. The fuel is filtered by the primary fuel filter before it enters the transfer pump. From the transfer pump, the fuel is filtered by the secondary fuel filter and is then supplied to the fuel gallery in the cylinder head. The fuel injectors draw fuel from the gallery and return the spill fuel to the same gallery. A pressure relief valve ensures that the pressure in the gallery is maintained and any excess fuel is returned to the fuel tank.

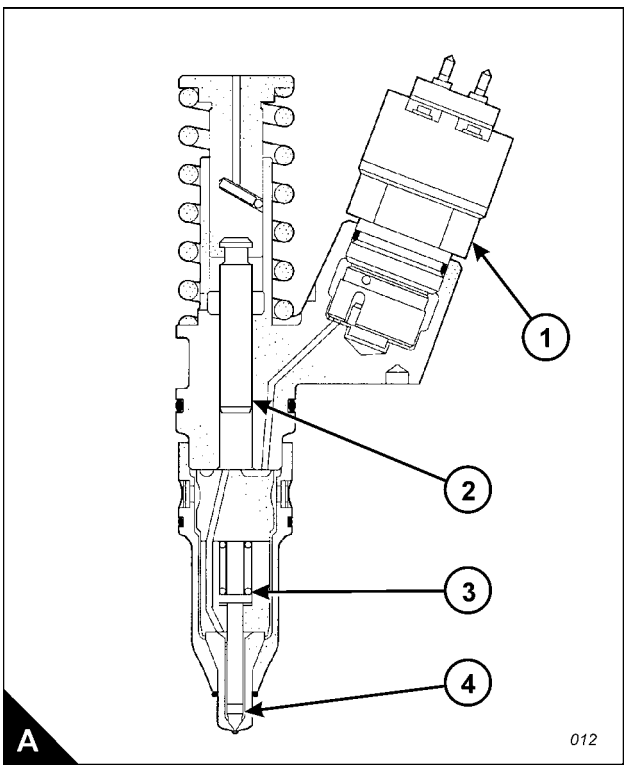
Each unit injector is operated, through a rocker lever, by a lobe of the camshaft. This provides the force required to pressurize the fuel in the injector. The camshaft has three lobes for each cylinder, the other two lobes operate the inlet and exhaust valves. The unit injectors are fitted with a solenoid (A1) which is electronically controlled by the ECM (engine control module).

Low pressure fuel circulates through the body of the unit injector and excess fuel is returned to the fuel gallery through a spill port. When the solenoid of the unit injector is activated by a signal from the ECM, it closes the escape route for the fuel and the pressure increases in the injector tip (A4).

Injection begins when the pressure in the tip reaches 34464 kPa (5,000 lb/in^2). At this pressure the force applied by the spring (A3) is not sufficient to keep the nozzle closed. As the plunger (A2) moves through its full stroke, the pressure increases. When the correct amount of fuel has been injected, the ECM de-energises the solenoid. This opens the spill port and the reduction in pressure allows the spring (A3) to close the injector nozzle. The high-pressure fuel which passes through the spill port returns to the fuel gallery.

During maintenance of the fuel system, clean thoroughly each component before it is removed or dismantled and fit suitable caps and plugs to all unions immediately after they have been disconnected.

Operations for the unit injectors and the injector sleeves are given in Chapter 3 Cylinder head assembly.



Fuel priming pump

To remove and to fit **Operation 11-1**

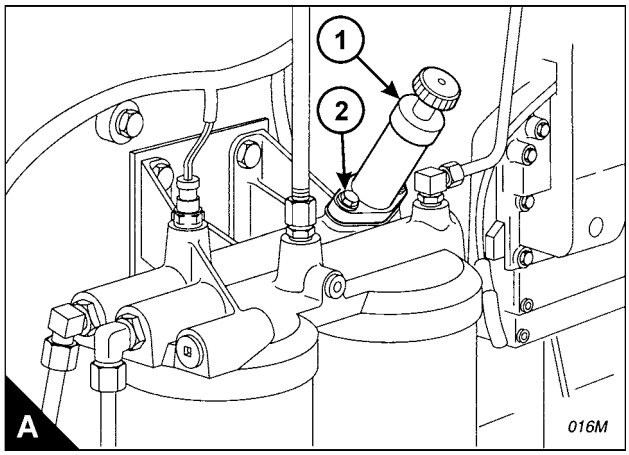
To remove‘

1 Remove two bolts (A2) and remove fuel priming pump (A1).

To fit

1 Inspect the gasket of the fuel priming pump; fit a new gasket if necessary.

2 Fit the fuel priming pump (A1) and retain with the two bolts (A2).



Fuel transfer pump

To remove and to fit — **Operation 11-2**

To remove

1 Disconnect the fuel pipes from the fuel transfer pump (A2).

2 Use plugs or caps to seal temporarily all openings to prevent contamination of the fuel system.

3 Remove the bolts (A1) and withdraw the fuel transfer pump.

To fit

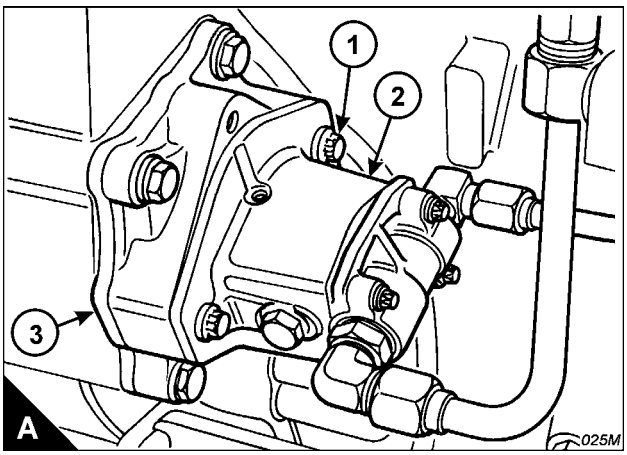
1 Check the condition of the 'O' ring seal on the fuel transfer pump, renew the seal if it is worn or damaged.

2 Ensure that the 'O' ring seal is fitted correctly to the fuel transfer pump. Apply a small amount of clean engine oil to the seal.

3 Fit the fuel transfer pump (A2) and retain with two bolts (A1).

4 Remove the plugs or caps from the fuel pipe openings and connect the fuel pipes.

5 Eliminate air from the fuel system, Operation 11-6.



To test **Operation 11-3**

Use a suitable test rig and diesel fuel to test the fuel transfer pump.

1 Run the pump at 2940 rev/min. The flow at 650 kPa (94 lb/in^2) must be 4,5 litres/min (1.0 UK gall/min).

2 Run the pump at 840 rev/min. The flow at 550 kPa (80 lb/in^2) must be 3,0 litres/min (0.66 UK gall/min).

3 Run the pump at 100 rev/min with the inlet to the atmosphere for 10 seconds. The pump must maintain a vacuum of 60 kPa (9 lb/in^2) for 30 seconds when the inlet is blocked.

If the pump cannot achieve the figures given above, it must be renewed.

Drive for the fuel transfer pump

To remove and to fit **Operation 11-4**

To remove

1 Remove the fuel transfer pump (A2), Operation 11-2.

2 Remove four bolts and washers (A1) and withdraw the assembly of the pump drive and housing (A3) from the gear case.

3 Remove the three bolts from the housing (B1) and remove the assembly of the bearings and gear (B2) from the housing.

4 Remove the 'O' ring seal (B3) from the housing.

5 Inspect all components, renew any which are worn or damaged.

To fit

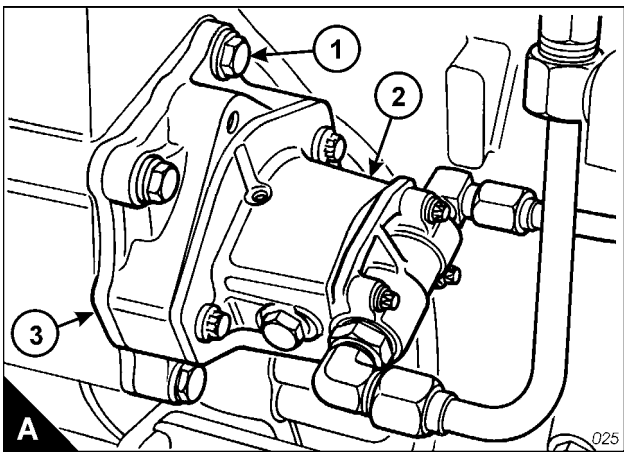
1 Fit the assembly of the bearings and gear (B2) into the pump drive housing (B1).

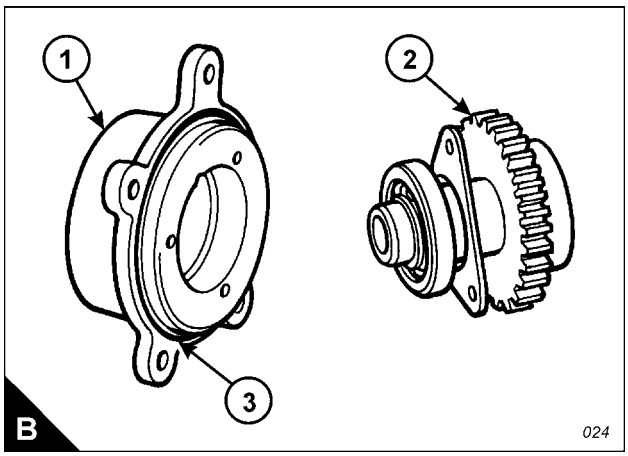
2 Retain the gear and bearings in the housing with the three bolts.

3 Fit a new 'O' ring seal (B3) to the housing.

4 Insert carefully the assembly of the pump drive and pump drive housing into the gear case. Retain with four bolts and washers.

5 Fit the fuel transfer pump, Operation 11-2.





Fuel filter header

To remove and to fit **Operation 11-5**

To remove

1 Remove the fuel priming pump (A2), Operation 11-1.

2 Disconnect the fuel pipes (A1, A3, A4 and A5). Fit plugs or caps to all openings to prevent contamination of the fuel system.

3 Remove the filter housings and elements from the fuel filter header.

Warning! *Discard the used filter elements and 'O' ring seals in a safe place and in accordance with local regulations.*

4 Remove the bolts which retain the filter header on the crankcase.

To fit

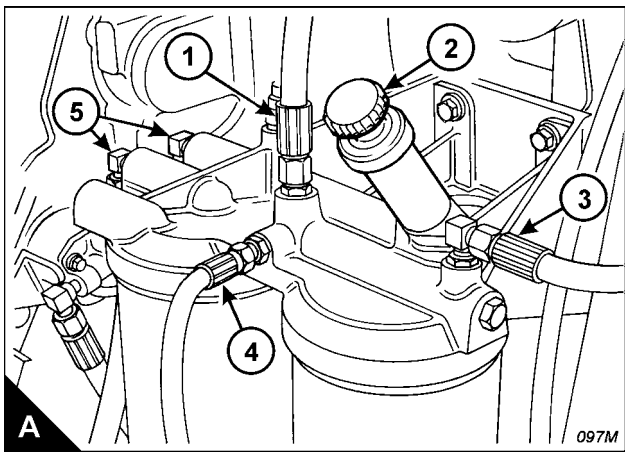
1 Fit the filter header to the crankcase.

2 Remove any plugs or caps and connect the fuel pipes (A1, A3, A4 and A5).

3 Renew the fuel filter elements in the primary and secondary fuel filter canisters. Use the procedures given in the User's Handbook, TSD3449E.

4 Fit the fuel priming pump, Operation 11-1.

5 Eliminate air from the fuel system, Operation 11-6.



How to eliminate air from the fuel system — **Operation 11-6**

This procedure is used normally when the engine runs out of fuel.

1 Loosen the union of the fuel return pipe (A1). Unlock and operate the hand priming pump (A2) until fuel, free from air, flows from the union; this procedure will require many strokes of the pump. Use a cloth or a container to collect the excess fuel.

2 Tighten the union (A1). Operate the hand priming pump until a strong pressure is felt on the pump. Push the priming pump plunger inward. Tighten the plunger by hand and continue immediately with the next stage.

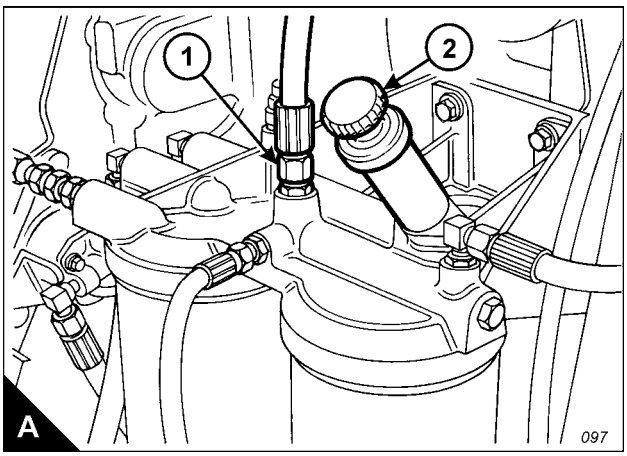
3 Start the engine.

Caution: *Do not crank the engine continuously for more than 30 seconds. Allow the starter motor to cool for two minutes before the engine is cranked again.*

4 If the engine will not start, allow the starter motor to cool for 2 minutes. Repeat steps 1 and 2 to start the engine. Continue to eliminate air from the fuel system if:

- The engine starts, but runs unevenly.
- The engine starts, but continues to misfire or smoke.

5 Run the engine with no load until it runs smoothly.



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12

Cooling system

General information

A pressurised coolant system is used on the engine. This allows the system to operate at a temperature higher than the boiling point of water and prevents cavitation in the coolant pump.

In normal operation, the coolant pump directs most of the coolant through the oil cooler and into the cylinder block. The coolant circulates around the cylinder liners and is then directed into the cylinder head where it flows around the valves and passages for the exhaust gases. The coolant leaves the cylinder head at the front end and enters the thermostat housing.

When the engine is cold, the thermostats are closed and the coolant flow is directed back to the coolant pump. When the engine is at normal operating temperature, the thermostats open and the flow is directed to the top of the radiator. The coolant flows from the top to the bottom of the radiator and then returns to the coolant pump.

Only the approved coolant mixture should be used in the engine. Refer to the User’s Handbook.

Cooling system

To inspect — Operation 12-1

Inspect visually the cooling system before any tests are performed.

Notes:

- Inspect the coolant pump seals. A small amount of leakage of coolant across the surface of the face seal in the water pump is normal. Its purpose is to provide lubrication for the seal.
- There is a hole in the water pump body to allow coolant to drain. Small amounts of coolant might be seen to leak intermittently from the drain hole during the engine operation cycle.
- Signs of a small leakage through the drain hole are not an indication that the pump is faulty. Coolant stains or intermittent drops of coolant from the hole, indicate normal operation of the pump.

1 Check the coolant level in the cooling system.

Warning! *On a hot engine release the filler cap carefully as the system will be under pressure.*

2 Check for leaks in the system.

3 Ensure that the air flow through the radiator is not restricted. Check for bent fins in the radiator and also for large deposits of dirt or debris.

4 Inspect the drive belts for the fan.

5 Check for damage to the fan blades.

6 Check for air or combustion gas in the cooling system.

7 Inspect the filler cap and check the surface which the filler cap seals against. This surface must be clean.

Special requirements

Special tools	
Description	**Part number**
Pressurizing pump	GE50031

Use the procedure which follows to check for leakage of the cooling system.

Warning! *On a hot engine release the filler cap carefully as the system will be under pressure. Cooling system conditioner contains alkali. Avoid contact with skin and eyes.*

1 When the engine is cool, loosen the filler cap slowly to relieve any pressure, then remove the filler cap from the radiator.

2 Ensure that the coolant is at the correct level.

3 Attach the pressurizing pump, GE50031, to the radiator and apply pressure until the reading on the gauge is 20 kPa (3 lb/in^2) more than the pressure given on the filler cap.

4 Check the radiator for leakage.

5 Check all connection points and hoses for leakage.

The cooling system is free from leaks if you do NOT see any external leakage and the reading remains constant for at least five minutes. If the reading on the gauge goes down and there is no external leakage, the cooling system must be leaking internally. Make repairs as necessary.

Coolant filler cap

To test **Operation 12-3**

Special requirements

Special tools	
Description	**Part number**
Pressurizing pump	GE50031

Use the procedure which follows to check the operation of the coolant filler cap.

Warning! *On a hot engine release the filler cap carefully as the system will be under pressure. Cooling system conditioner contains alkali. Avoid contact with skin and eyes.*

1 When the engine is cool, loosen the filler cap slowly to relieve any pressure, then remove the filler cap from the radiator.

2 Carefully inspect the filler cap. Check for damage to the seals and to the sealing surface. Examine the filler cap, the seal and the surface for seal, ensure that they are free from deposits. Any deposits or other material that is found on these items must be removed.

3 Check the opening pressure for the filler cap as follows: fit the filler cap to the pressurizing pump, GE50031.

4 Apply pressure and check the gauge for the exact pressure which opens the filler cap.

5 Compare the reading on the gauge with the correct pressure which should open the filler cap, this figure is given on the filler cap.

6 Renew the filler cap if it is defective.

Radiator

To remove and to fit — Operation 12-4

To remove

1 Drain the coolant into a suitable container.
2 Remove the air duct from between the charge air cooler and the air inlet elbow.
3 Remove the coolant pipe from between the thermostat housing and the top of the radiator.
4 Remove the fan guards.
5 Remove the air duct from between the turbocharger and the base of the charge air cooler.
6 Remove the coolant pipe from between the coolant pump elbow and the radiator.
7 Remove fasteners which retain the radiator to its base frame.

To fit

1 Fit the radiator to its base frame.
2 Fit the coolant pipe between the coolant pump elbow and the radiator.
3 Fit the air duct between the turbocharger and the base of the charge air cooler.
4 Fit the fan guards.
5 Fit the coolant pipe between the thermostat housing and the top of the radiator.
6 Fit the air duct between the charge air cooler and the air inlet elbow.
7 Fill the radiator with the correct coolant mixture. Refer to the User’s Handbook.
8 Run the engine until it reaches the normal temperature of operation and check for leaks.

Fan

To remove and to fit **Operation 12-5**

To remove

1 Switch off the engine and disconnect the electrical power supply.

2 Remove the fan guards.

Caution: *Take care during the removal of the fan; ensure that the radiator does not become damaged.*

3 Remove the bolts which retain the fan on the hub and remove the fan.

To fit

1 Fit the fan to the hub and retain with the six bolts.

2 Fit the fan guards.

3 Connect the electrical power supply.

Fan drive assembly

To remove and to fit **Operation 12-6**

To remove

1 Remove the fan, Operation 12-5.

2 Remove the hub (A1).

3 Loosen the adjustment bolts to release the tension on the alternator belt. Remove the belt and the alternator (A3).

4 Release the tension on the fan drive belts and remove the belts.

5 Remove the two bolts and cap which retain the pulley (A2) and withdraw the pulley complete with bearing.

6 Remove the two nuts and two bolts which retain the fan bearing housing (A4) and remove the housing.

To fit

1 Fit the fan bearing housing (A4).

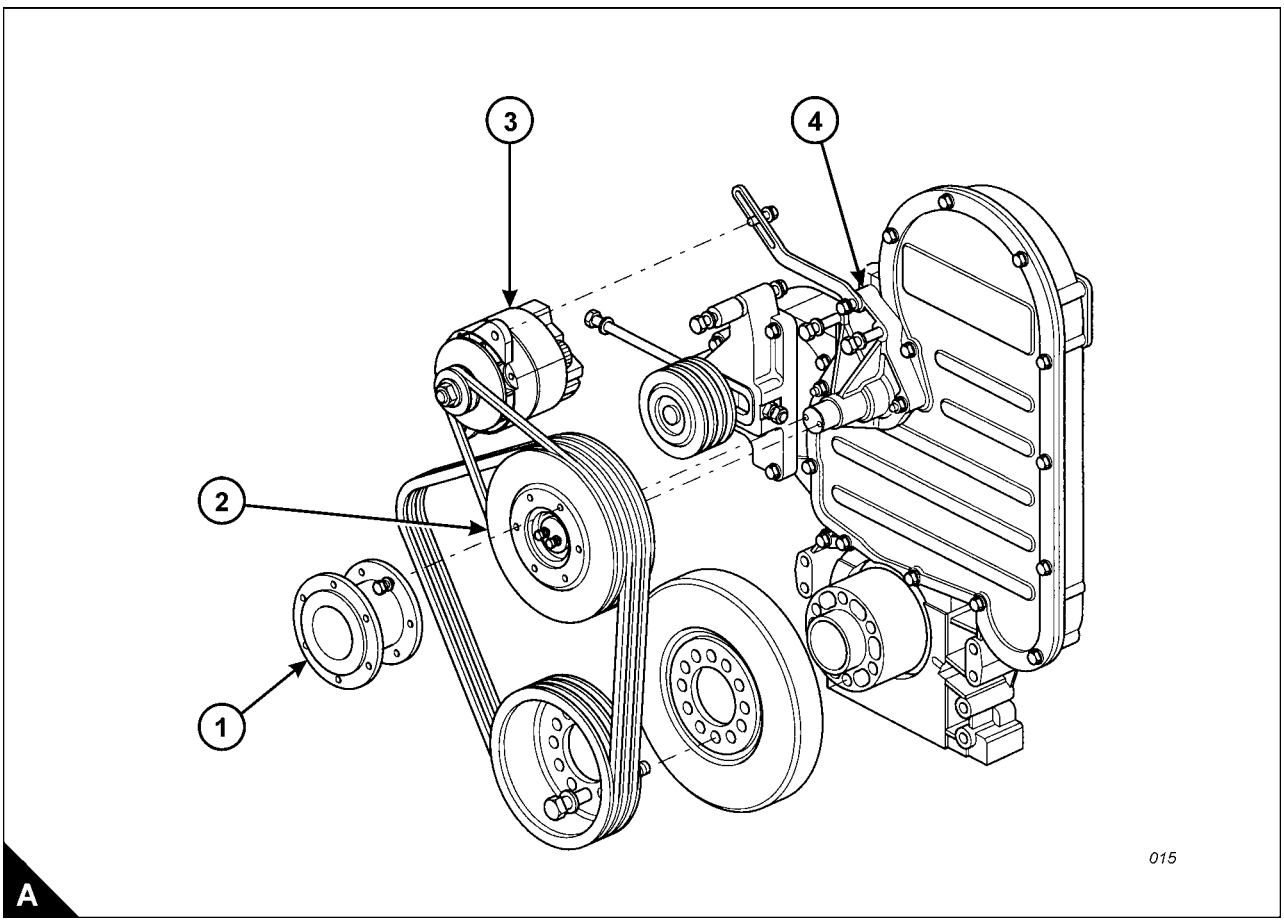
2 Fit the pulley (A2) and retain with the cap and two bolts. Tighten the bolts to a torque of 24 +/- 6 Nm (18 +/- 4 lbf ft).

3 Fit the fan drive belts and adjust the tension as given in Operation 12-7.

4 Fit the alternator (A3), fit the alternator belt and adjust the tension as given in Operation 14-3.

5 Fit the hub (A1).

6 Fit the fan, Operation 12-5.



Fan drive belts

To check and to adjust the tension — Operation 12-7

1 Remove the fan guards.

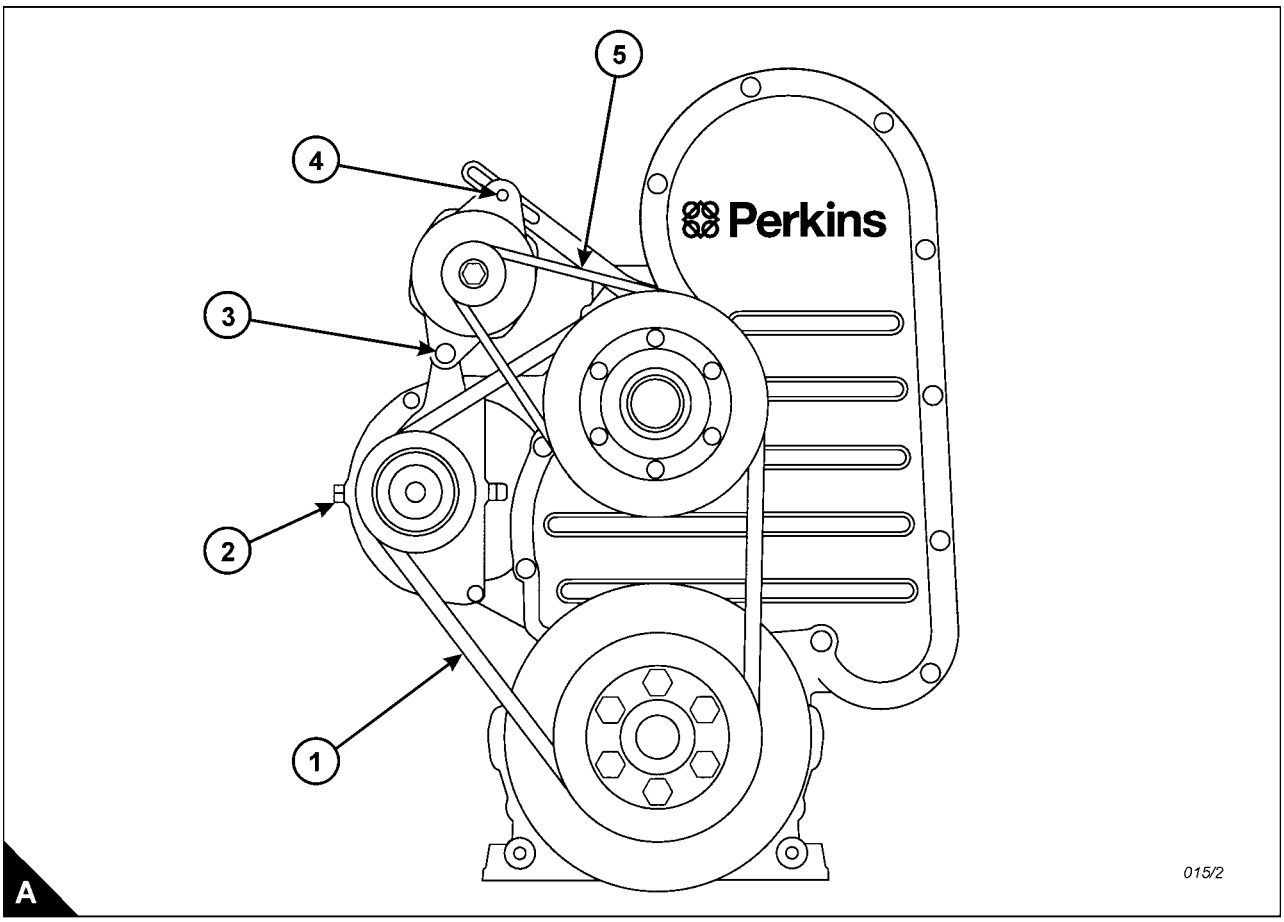
2 Use a Borroughs belt tension gauge to check the tension at the position shown (A1). It should be 800 N, which is equivalent to 4,0 mm of movement when a force of 33 N is applied. To adjust the tension, proceed as follows:

3 Loosen the lock nuts on the adjustment bolt (A2), loosen the large lock nut on the belt tensioner and turn the adjustment bolt (A2) until the correct tension is obtained. Tighten the large lock nut and check the tension of the belts again. If the tension is correct, slacken the adjustment bolt (A2) just enough to release its tension, then tighten its lock nuts.

4 Fit the fan guards and run the engine for 15 minutes. Remove the guards and check again the tension.

5 For new fan belts, set the tension to 868 N, which is equivalent to 4,0 mm of movement when a force of 35,7 N is applied. After the engine has been run for 15 minutes, check the tension and adjust it to 800 N; equivalent to 4,0 mm of movement when a force of 33 N is applied.

6 When the correct tension is obtained, fit the fan guards.



To renew **Operation 12-8**

1 Remove the fan, Operation 12-5.

2 Loosen the belt tensioner and remove the old belts. Ensure that the grooves of the pulley are free from grease and dirt and fit a new set of belts.

3 Fit the fan and tighten the bolts securely. Adjust the fan belts to the correct tension, as given in Operation 12-7.

Engine oil cooler

To remove and to fit **Operation 12-9**

To remove

1 Drain the coolant from the engine.

2 Use a tray to collect any oil which may spill from the oil cooler during its removal.

3 Make temporary marks on the coolant duct (A2) and the oil cooler (A1) for correct alignment during assembly. Remove the four bolts (A3) which retain the coolant duct (A2) and carefully separate the duct from the oil cooler.

4 Remove the four bolts which retain the oil cooler (B1) on the oil filter header (B3).

5 Withdrawn the oil cooler from the elbow (B2), take care not to damage the seal.

6 Remove the 'O' ring seal from the elbow (B2).

Note: The matrix is not removable from the housing.

To fit

1 Clean the core tubes of the oil cooler with a 3,81 mm (0.150 in) diameter rod.

2 Check the condition of the 'O' ring seals used on the oil cooler and the oil filter header. Renew any 'O' ring seal which appears to be worn or damaged. Apply clean engine oil to the seals before they are fitted.

3 Ensure that the 'O' ring seals are fitted to the oil filter header.

4 Fit the 'O' ring seal over the elbow (B2). Apply clean engine oil on the seal.

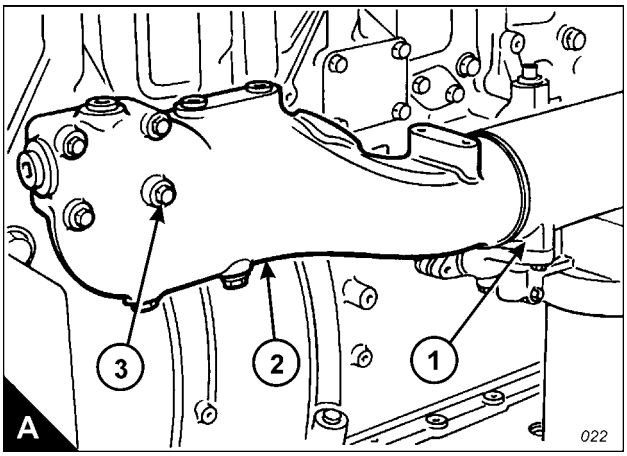
5 Align the oil cooler with the elbow and slide the oil cooler over the elbow. Fit the four bolts which retain the oil cooler on the oil filter header.

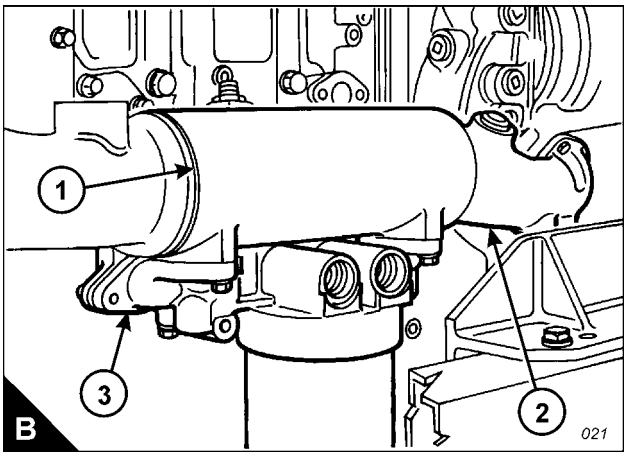
6 Fit an 'O' ring seal to the coolant duct (A2) and fit the duct to the oil cooler. Fit the four bolts.

7 Fill the cooling system with the correct coolant mixture. Refer to the User's Handbook.

8 Check the amount of lubricating oil in the sump. Add lubricating oil of the correct grade, if necessary. Refer to the User's Handbook.

9 Clean away any oil or coolant which has been spilled.





Thermostats and thermostat housing

To remove and to fit **Operation 12-10**

To remove

1 Drain the coolant until the level is below the thermostat housing (A1).

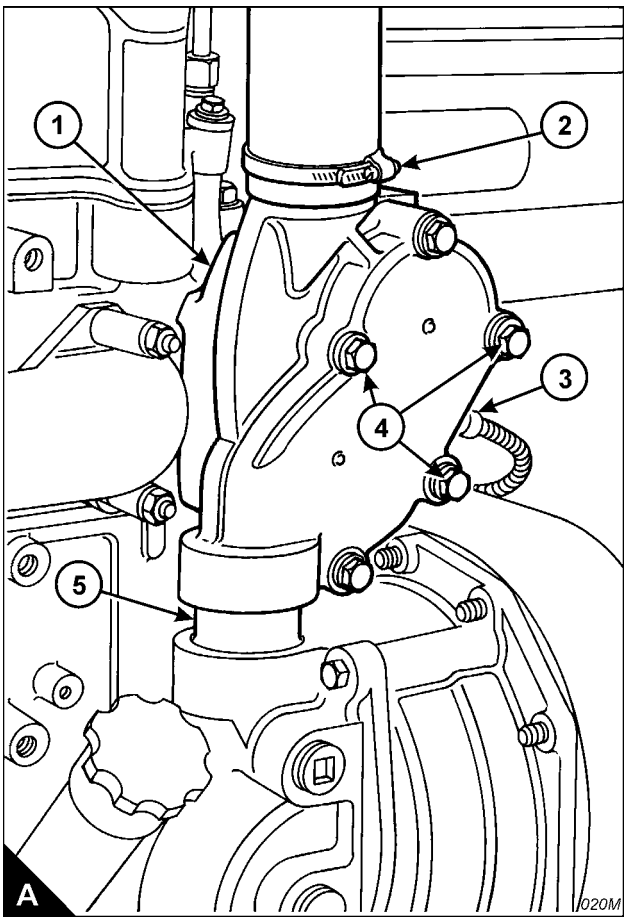
2 Disconnect the cable (A3) from the coolant temperature sensor.

3 Release the hose clips (A2) and disconnect the pipe and hose from the top of the unit.

4 If the thermostats are to be removed, loosen all five bolts of the thermostat housing; then remove fully the three bolts (A4) which retain the thermostat housing on the cylinder head. If the thermostat housing is to be removed without access to the thermostats, do not loosen the five bolts; remove only the three retaining bolts (A4).

5 Lift carefully the assembly to separate it from the coolant bobbin (A5) at its base.

Note: If relevant, remove the two short bolts which remain, separate the two halves of the assembly and remove the thermostats.



To fit

Note: If the thermostat housing has not been dismantled, continue from step 3.

1 Clean thoroughly both parts of the assembly and check the condition of the lip-type seals. Renew the seals if they are worn or damaged.

2 Fit the new thermostats. Ensure that the new thermostats are fitted correctly. Fit a new 'O' ring type seal to the groove in the thermostat housing, assemble the two halves of the unit and retain with the two short bolts.

3 Ensure that the mating face on the cylinder head is clean. Fit new seals to the coolant bobbin (A5) which fits into the base of the unit and lubricate the seals with a small amount of rubber lubricant. Fit a new 'O' ring seal to the groove in the mating face of the housing and fit the assembly over the coolant bobbin. Fit the three bolts (A4) which retain the thermostat housing on the cylinder head and tighten all five bolts to a torque of 47 +/- 9 Nm (35 +/- 7 lbf ft).

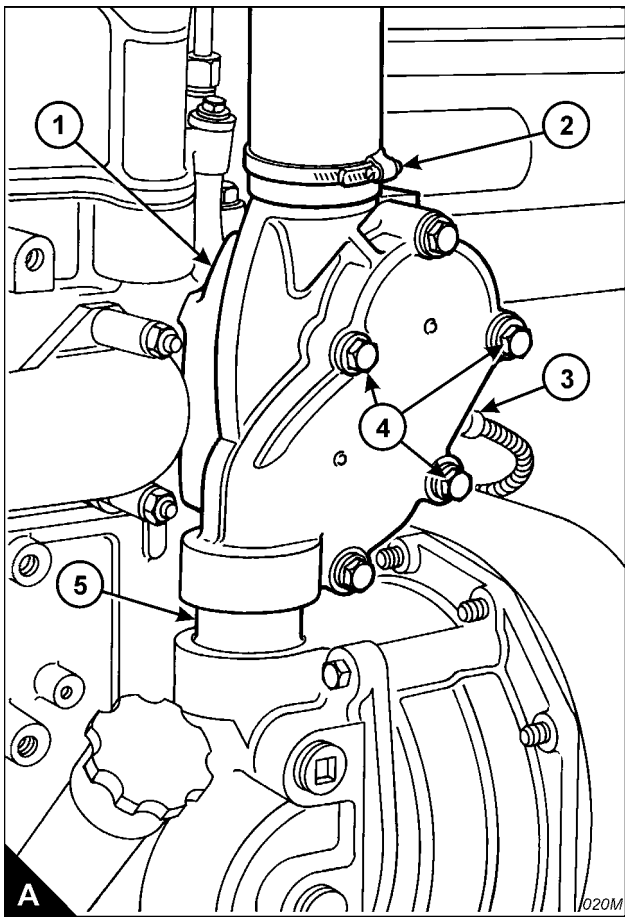
4 Connect the hose to the top of the housing and tighten the hose clip.

5 Connect the cable (A3) to the coolant temperature sensor.

6 Fill the coolant system to the correct level with the approved coolant mixture.

7 Operate the engine until it reaches the normal temperature of operation and check for leaks. Stop the engine, check the coolant level and, if necessary, add extra coolant.

Warning! *Take care during removal of the filler cap as the coolant system will be under pressure.*



To test the thermostats **Operation 12-11**

1 Remove the thermostats from the engine.

Warning! *Use care during this operation to avoid serious injury from the hot water.*

2 Heat water in a suitable container until the temperature is 98 °C (208 °F). Stir the water to ensure that the temperature is consistent within the container.

3 Suspend the thermostat in the container of water. The thermostat must be below the surface of the water and it must be away from the sides and the bottom of the container.

4 Ensure that the water is maintained at the correct temperature for ten minutes.

5 After ten minutes, remove the thermostat. Immediately check the distance that the thermostat has opened. It must be a minimum of 10,4 mm (0.41 in). If the distance is less, renew the thermostat.

Coolant temperature sensor

To test **Operation 12-12**

Special requirements

Special tools	
Description	**Part number**
Thermometer	GE50032

Check the accuracy of the coolant temperature sensor (A2) if one of these conditions exist:

The engine runs at a temperature that is too hot, but a normal temperature is indicated. A loss of coolant is found.

The engine runs at a normal temperature, but a hot temperature is indicated. No loss of coolant is found.

Note: The coolant temperature can be read on the display screen of the electronic service tool.

Warning! *On a hot engine release the filler cap carefully as the system will be under pressure.*

1 When the engine is cool, release the coolant filler cap to relieve any pressure.

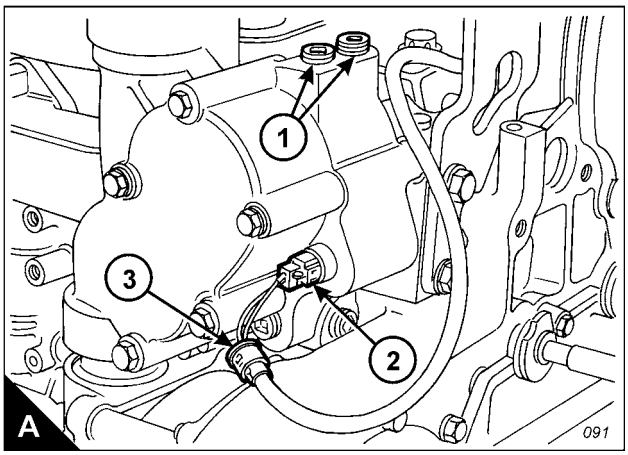
2 Remove one of the two plugs (A1) and install the special thermometer, GE50032. A temperature indicator of known accuracy can also be used for this test. Tighten again the coolant filler cap.

3 Start the engine and run the engine until the temperature reaches the desired range according to the test thermometer. If necessary, place a cover over part of the radiator to cause a restriction of the coolant flow. The reading on the coolant temperature indicator should agree with the test thermometer within the tolerance range of the coolant temperature indicator.

Pointer position	Test thermometer °C	Test thermometer °F
1	65 to 77	150 to 170
2	99 to 103	210 to 218

Caution: *If a cover was used over part of the radiator ensure that is removed on completion of the test.*

4 If the temperature sensor is renewed, do not attempt to disconnect the leads from the unit. Disconnect the unit at the connection shown (A3).



Coolant pump

To remove and to fit — Operation 12-13

To remove

1 Drain the coolant from the engine into a suitable container for storage or disposal.

2 Remove the thermostat housing, Operation 12-10.

3 Remove the oil cooler, Operation 12-9.

4 Remove four bolts (A1) and the elbow (A2).

5 Check the condition of the 'O' ring seal (B1), discard the seal if it is worn or damaged. Remove the bolts from the gear case cover and the coolant pump and remove the coolant pump.

To fit

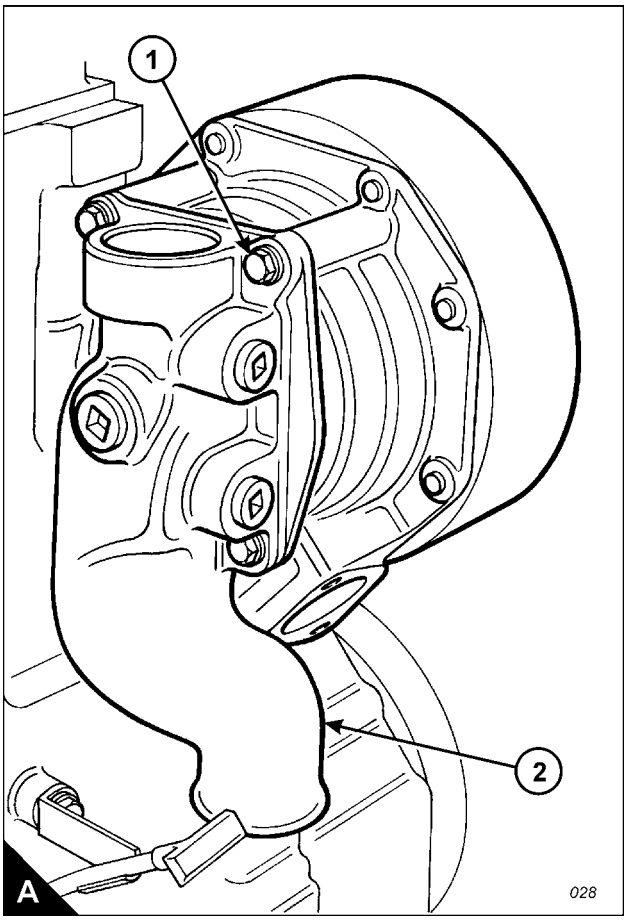
1 Fit the coolant pump to the gear case, ensure that the gear engages correctly. Tighten the bolts.

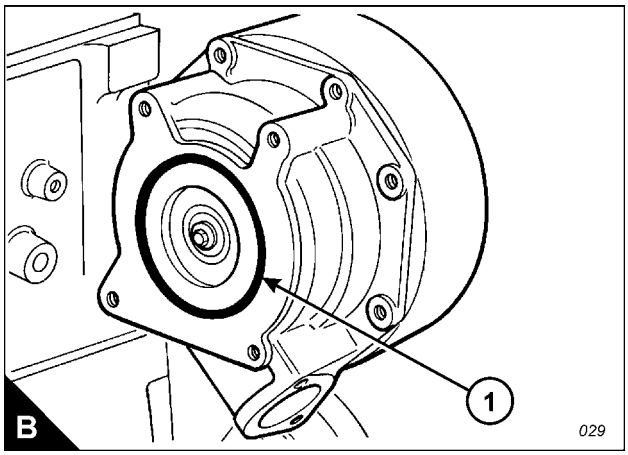
2 If necessary, fit a new 'O' ring seal (B1). Fit the elbow (A2) and retain with four bolts (A1).

3 Fit the oil cooler, Operation 12-9.

4 Fit the thermostat housing, Operation 12-10.

5 Fill the coolant system to the correct level with the specified coolant mixture. Refer to the User's Handbook for the correct procedure.





To dismantle and to assemble **Operation 12-14**

Notes:

- The coolant pump seal can be renewed without removal of the coolant pump from the engine.
- Intermittent leakage of a small amount of coolant from the hole in the coolant pump housing is not an indication of a coolant pump seal failure. This is required to provide lubrication for the seal. Renew the coolant pump seal only if a large amount of leakage or a constant flow of coolant is observed draining from the coolant pump housing.
- Service exchange coolant pumps can be obtained from your Perkins dealer.

To dismantle

1 Remove the bolt (A15) and washer (A14). Use a suitable puller to remove the impeller (A11) from the shaft (A16). Ensure that the impeller does not become damaged during this operation.

2 Remove the spring and seal (A13) from the shaft.

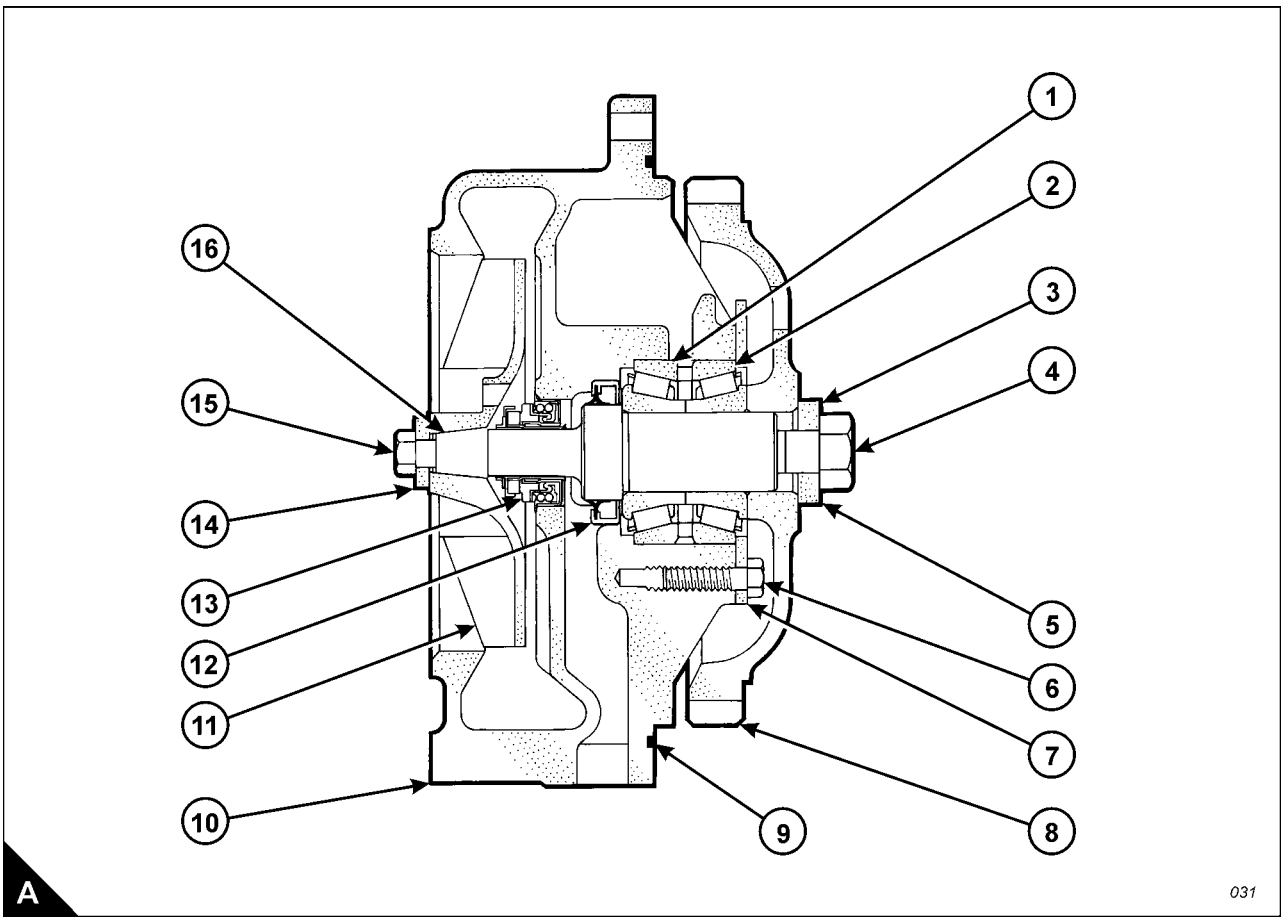
Note: The coolant pumps of certain engines may not have a spring fitted at this position.

3 Remove the four bolts (A6) from the retainer (A7) and remove the 'O' ring seal (A9) from the housing (A10).

4 Remove the gear and shaft assembly (A8). Remove the bolt (A4) and retainers (A3 and A7) from the shaft assembly.

5 Use a press to remove the shaft (A16) from the gear. Remove the bearing (A1), the spacer if fitted, and second bearing (A12) from the shaft.

6 Remove the lip-type seal (A12) from the housing.



To assemble

1 Ensure that the shaft and the seal counter bore in the pump housing are clean.

2 Fit the bearing (A1), the spacer if relevant, and the second bearing (A2) to the shaft (A16).

3 Fit the retainer (A7) and gear (A8) to the shaft assembly. Fit the second retainer (A3) and the bolt (A4).

4 Fit a new lip-type seal (A12) into the housing (A10). The seal must be fitted with the lip toward the inside of the housing. Apply a small amount of clean engine oil to the lip of the seal.

5 Fit a new 'O' ring seal (A9) to the housing.

6 Install the gear and shaft assembly in the housing. Fit the bolts (A6) which hold the retainer (A7) to the housing.

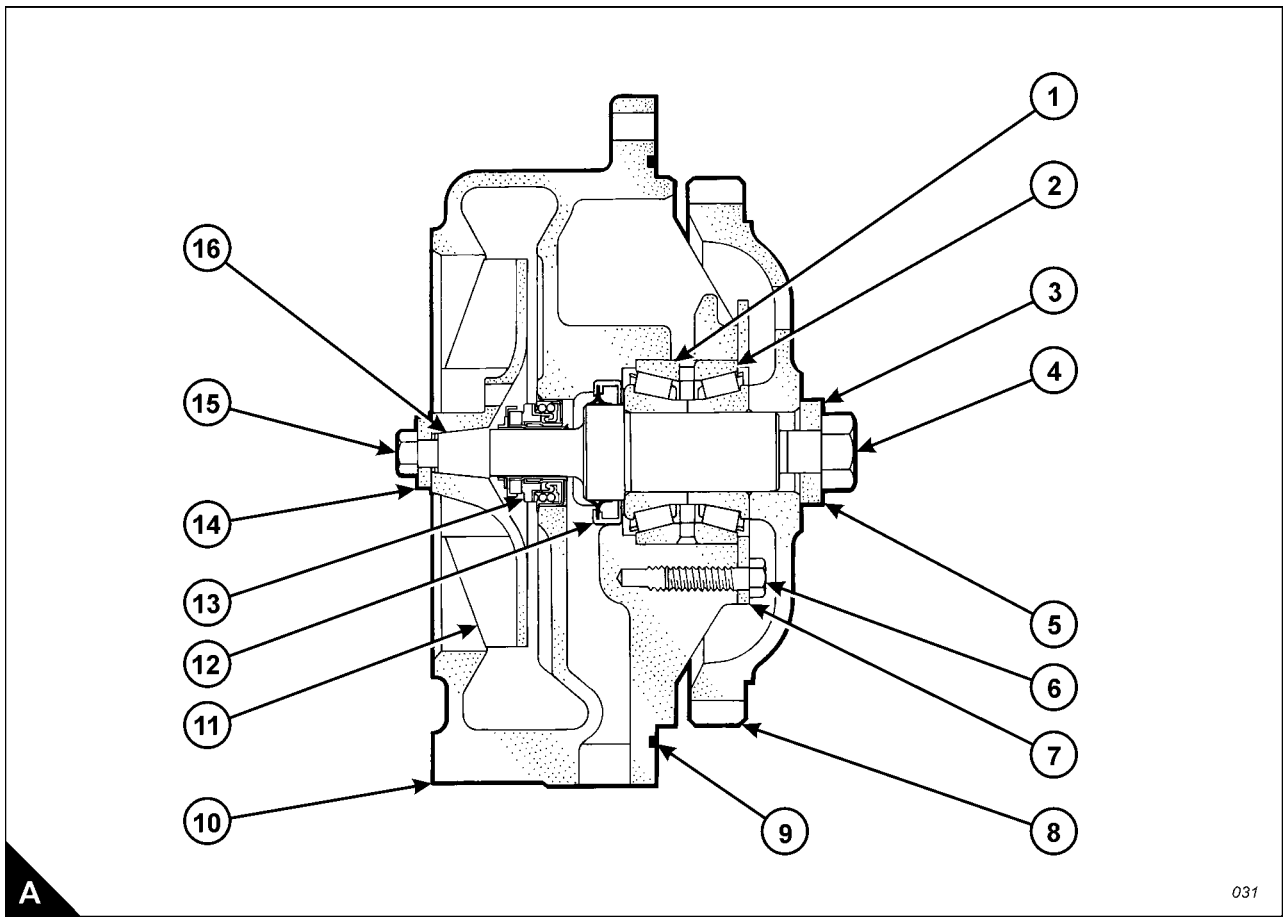
Caution: *Do not allow grease or oil to contact the faces of the seal. Do not stretch the seal during installation.*

Note: The carbon seal assembly (A13) must rotate with the coolant pump shaft when it is installed. Use clean water as a lubricant for assistance during installation.

7 Separate the spring from the seal assembly (A13). Use hand pressure to install the seal on the shaft (A16). Push the seal onto the shaft until the seal faces make light contact. Fit the spring to the shaft.

8 Fit the impeller (A11) to the shaft and retain with the washer (A14) and bolt (A15). Tighten the bolt to a torque of 39 +/- 3 Nm (28 +/- 2 lbf ft).

9 Fit the coolant pump, Operation 12-13.



To test the pressure of the coolant pump **Operation 12-15**

Special requirements

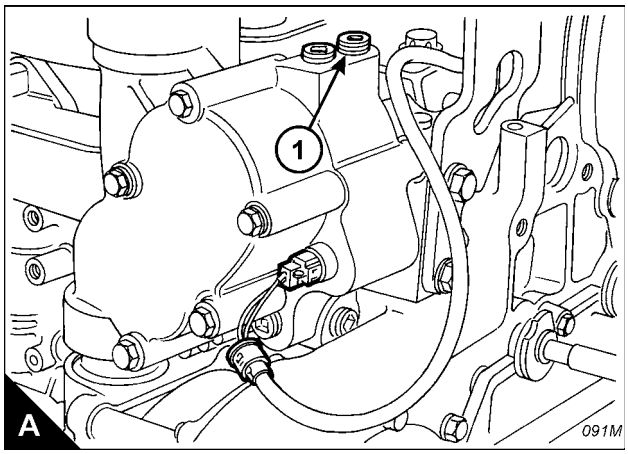
Special tools	
Description	**Part number**
Pressure gauge	GE50033

1 To check that the coolant pump is operating correctly, the outlet pressure can be measured.

2 Remove the plug (A1) from the coolant manifold and connect the pressure gauge, GE50033, to the port.

3 Start the engine and run the engine until the normal temperature of operation is obtained.

4 Make a note of the reading on the pressure gauge. The pressure supplied by the coolant pump should be 112 +/- 12 kPa (16 +/- 2 lbf/in^2).



13

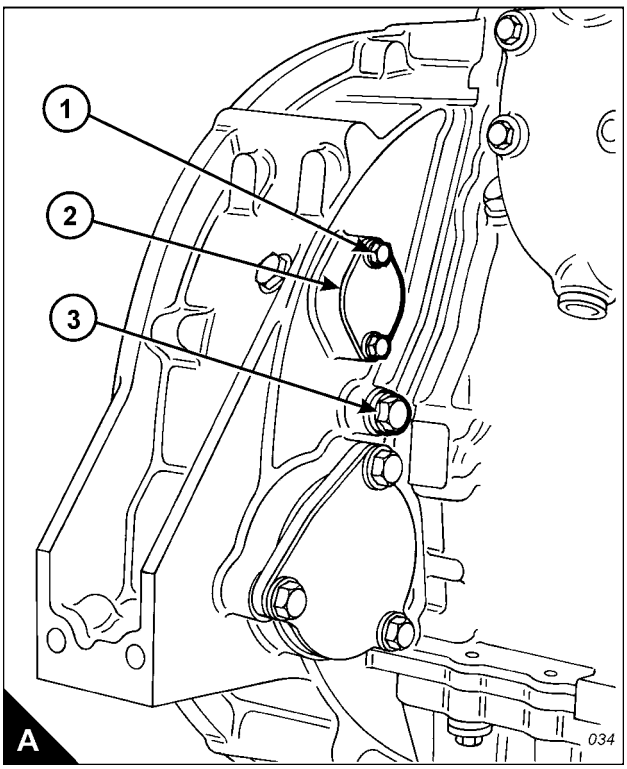
Flywheel and housing

General information

The steel flywheel is fitted with a hardened starter ring. The flywheel is fastened securely to the rear face of the crankshaft by a clamp ring and 12 bolts.

A dowel ensures that, when the flywheel is fitted, the timing marks on the flywheel are in the correct relationship to the crankshaft.

The flywheel housing is located on the crankcase by two dowels and is retained by 24 bolts and washers. The electric starter motor is mounted on the left side of the flywheel housing and a facility is provided on the right side for setting the engine to the correct timing position for the purposes of checking and adjustment. The cover (A1) can be removed for the insertion of the engine barring tool and the plug (A3) is removed for insertion of the timing bolt (A1). The engine barring tool can be used to rotate the engine until the timing bolt can be inserted in the flywheel. When the timing bolt can be inserted, dependent on the stroke, the piston of either number one or number six cylinder will be at top dead centre.



Flywheel

To remove and to fit — Operation 13-1

To remove

1 Remove two of the flywheel bolts from horizontally opposite sides of the flywheel and insert two suitable guide studs.

2 Remove the bolts which remain and withdraw the flywheel from the crankshaft. Fit a suitable sling through the centre of the flywheel and support the weight with a hoist. The weight of the flywheel is approximately 56 kg (123 lb).

3 Remove the flywheel and remove the guide studs.

4 Remove the gear ring from the flywheel if necessary.

To fit

1 If the gear ring has been removed, heat the ring in an oven to a maximum temperature of 315 °C (600 °F) and fit it to the flywheel. Ensure that the gear ring is fully seated on the flywheel.

Note: The gear ring must be fitted with the chamfer on the gear teeth toward the starter motor pinion.

2 Fit suitable guide studs to bolt holes at horizontally opposite sides of the flywheel. Ensure that the dowel is fitted in the end of the crankshaft.

3 Attach a sling to the flywheel and use a hoist to locate the flywheel on the guide studs. Ensure and that the flywheel is correctly aligned with the dowel.

4 Remove the sling and slide the flywheel up to the crankshaft.

5 Apply clean engine oil to the threads of the bolts which retain the flywheel and fit 10 of the bolts. Remove the guide studs and fit the two bolts which remain. Tighten the bolts to a torque of 270 Nm (200 lbf ft).

Flywheel housing

To remove and to fit — Operation 13-2

Special requirements

Consumable products	
Description	**Part number**
Liquid gasket	CH10879

To remove

1 Remove the flywheel, Operation 13-1.

2 Remove the crankshaft rear seal and wear sleeve, Operation 5-3.

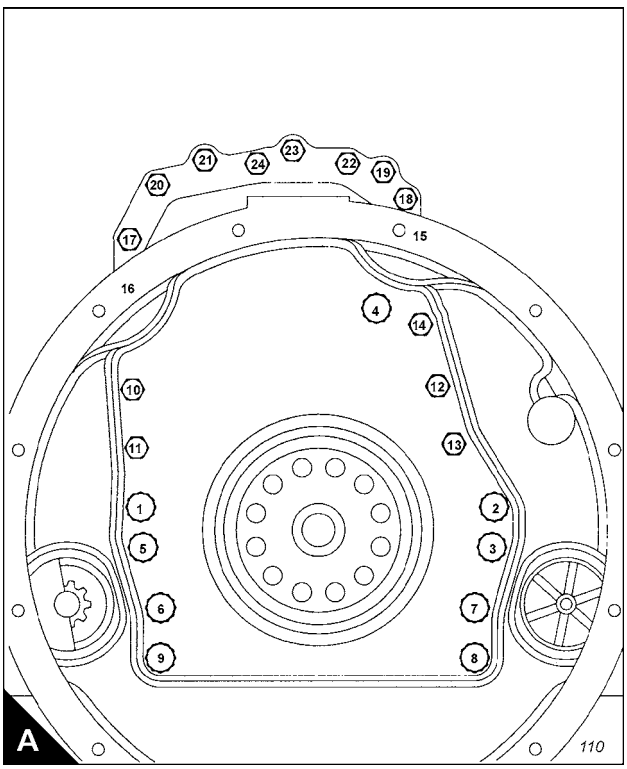
3 Remove the starter motor, Operation 14-1.

4 Remove the sump, Operation 10-3.

5 Use a suitable hoist to support the flywheel housing and remove the bolts (A1 to A24) which retain it.

Note: The bolts which retain the flywheel housing are of two different sizes. Make a note of their positions to ensure that they are fitted correctly.

6 Remove the flywheel housing from the dowels in the crankcase. The weight of the flywheel housing is approximately 83 kg (183 lb).



To fit

1 Clean thoroughly the contact surfaces of the crankcase and flywheel housing.

2 Fit the two dowels (B2 and B3) if they have been removed from the crankcase. They must protrude from the crankcase by 19,1 +/- 0,5 mm (0.75 +/- 0.02 in).

3 Apply a bead of liquid gasket, CH10879, to the area shown (B1).

4 Attach a suitable hoist and fit the flywheel housing to the crankcase. Fit the bolts which retain the housing but do not tighten at this stage.

5 Tighten the flywheel housing bolts as follows:

a. Tighten bolts A1 to A9, in numerical sequence, to a torque of 100 +/- 20 Nm (74 +/- 15 lbf ft).

b. Tighten bolts A10 to A24, in numerical sequence, to a torque of 40 +/- 10 Nm (30 +/- 7 lbf ft).

c. Tighten bolts A1 to A9, in numerical sequence, to a torque of 135 +/- 20 Nm (100 +/- 15 lbf ft).

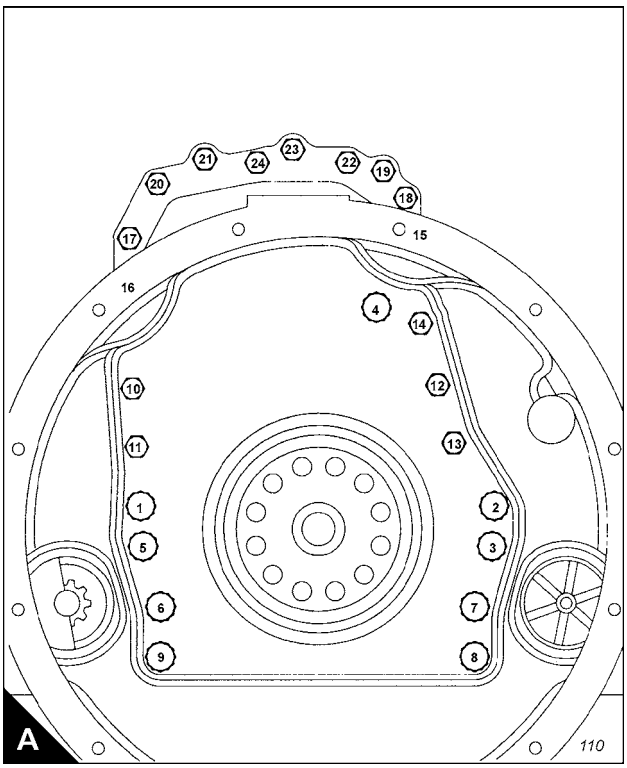
d. Tighten bolts A10 to A24, in numerical sequence, to a torque of 55 +/- 10 Nm (40 +/- 7 lbf ft).

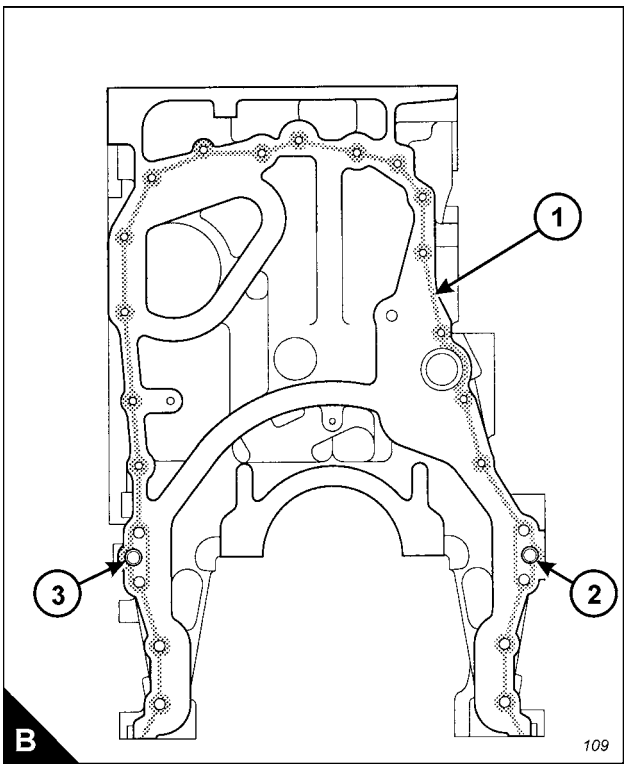
6 Fit the sump, Operation 10-3.

7 Fit the starter motor, Operation 14-1.

8 Fit a new crankshaft rear seal and wear sleeve, Operation 5-3.

9 Fit the flywheel, Operation 13-1.





14

Electrical equipment

General information

This section includes the components which form part of the battery charging circuit and the engine starting circuit: the alternator and starter motor.

A brush-type alternator is fitted at the front of the engine. The alternator unit is driven by a single belt from the fan pulley. The output, 24 volts/70 amps, is controlled by an integral regulator.

The 24 volt starter motor is mounted on the flywheel housing and, when operated, rotates the engine flywheel at a speed that is fast enough to start the engine. When the engine start button is operated, a solenoid, mounted on the starter motor, engages the starter pinion with the ring gear of the flywheel. The circuit which operates the starter motor is completed when the pinion is fully engaged. When the circuit between the battery and the starter motor is complete, the pinion will rotate the engine flywheel. A clutch provides protection for the starter motor so that the engine cannot turn the starter motor too fast. When the start button is released, the pinion is withdrawn from the ring gear.

Starter motor

To remove and to fit **Operation 14-1**

To remove

Note: To assist with the assembly operation, identify and mark the positions of all wiring before it is disconnected.

1 Disconnect the batteries before any service work is attempted.

2 Disconnect the wiring loom from the starter motor assembly (A2).

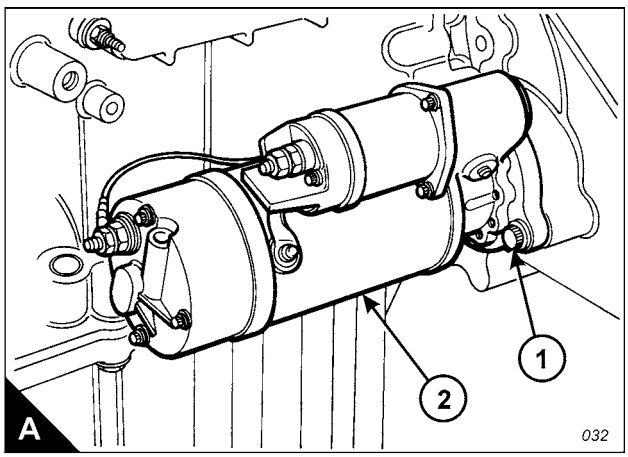
3 Fasten a hoist to the starter motor. Remove the three bolts (A1) which retain the starter motor on the flywheel housing, then withdraw the starter motor from the housing. The weight of the starter motor is 32 kg (70 lb).

To fit

1 Use a hoist to support the starter motor. Fit the starter motor to the flywheel housing. Retain with three bolts.

2 Connect the wiring loom to the starter motor. If the engine earth strap is connected to the starter motor, tighten the nut which retains the earth strap to a torque of 30,5 +/- 3,5 Nm (22.5 +/- 2.5 lbf ft).

3 Connect the batteries.



Alternator

To remove and to fit **Operation 14-2**

To remove

Note: To assist with the assembly operation, identify and mark the positions of all wiring before it is disconnected.

1 Disconnect the batteries before any service work is attempted.

2 Remove the access panel in the fan guard.

3 Loosen the alternator pivot bolt (A3), the adjustment link bolt which is behind the fan pulley and the adjustment bolt (A4). Move the alternator to release the drive belt and remove the drive belt from the alternator pulley.

4 Disconnect the wiring loom from the alternator.

5 Remove the bolts (A3 and A4) and remove the alternator.

To fit

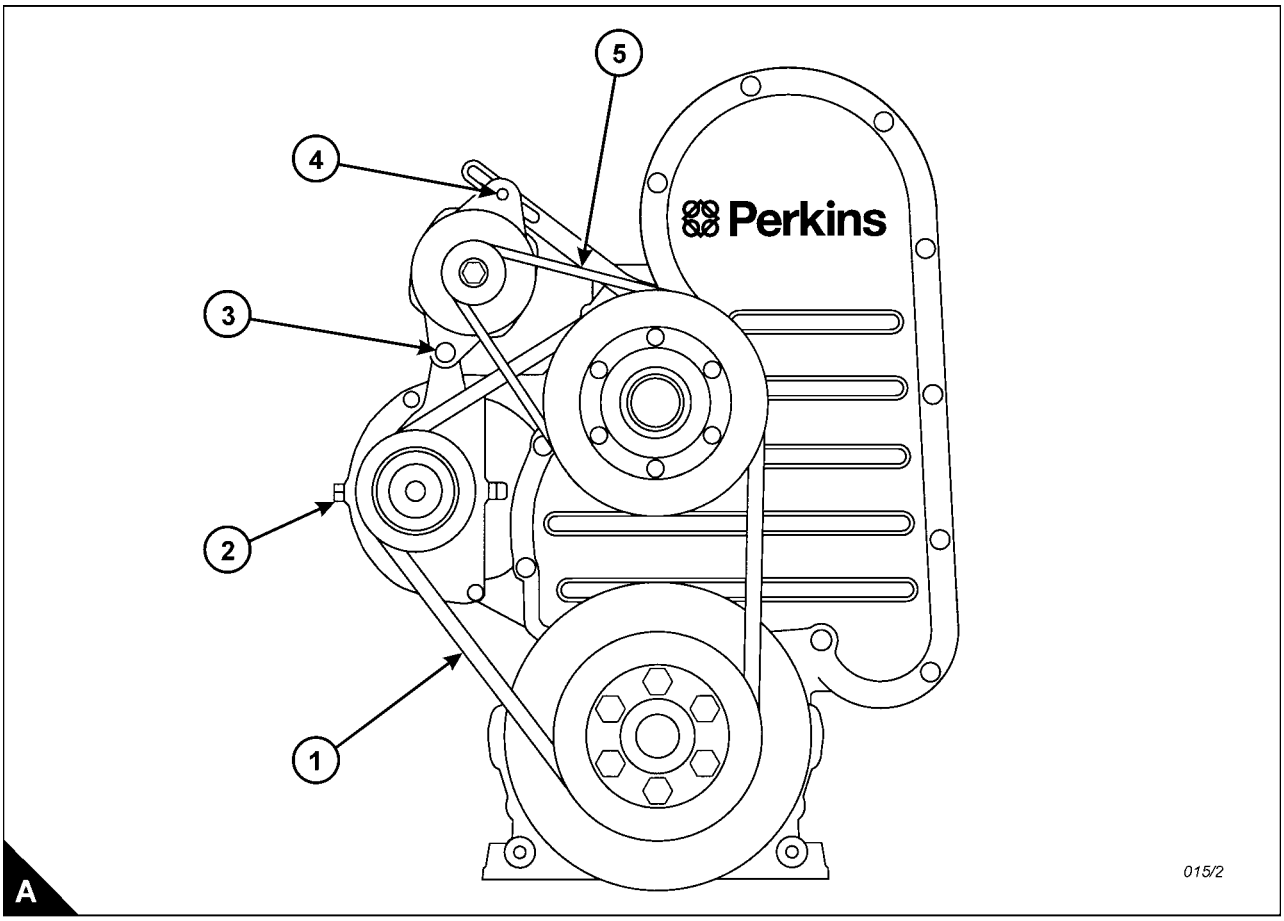
1 Fit the alternator and retain with the pivot bolt (A3) and the adjustment link bolt (A4). Do not tighten the bolts at this stage.

2 Fit the alternator drive belt over the alternator pulley and set the tension as given in Operation 14-3.

3 Connect the wiring loom to the alternator.

4 Fit the access panel to the fan guard.

5 Connect the batteries.



To check and to adjust the tension of the alternator belt **Operation 14-3**

1 Remove the access panel in the fan guard and proceed as follows.

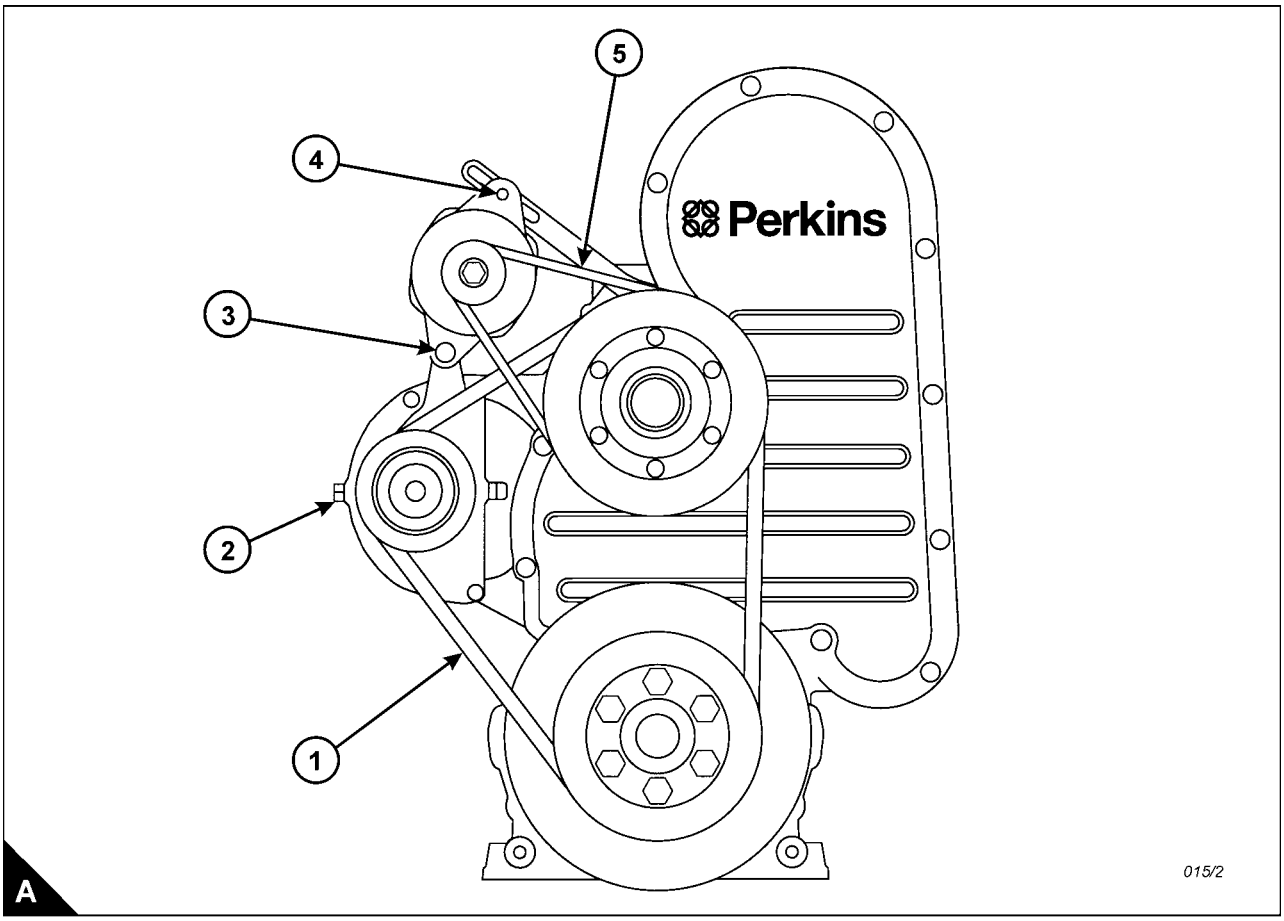
2 Use a Borroughs belt tension gauge to check the tension at the position shown (A5). It should be 267 N, which is equivalent to 2,5 mm of movement when a force of 11,3 N is applied. To adjust the tension, proceed as follows.

3 Loosen the alternator pivot bolt (A3), the adjustment link bolt which is behind the fan pulley and the adjustment bolt (A4). Move the alternator to obtain the correct belt tension and tighten the bolts.

4 Fit the access panel to the fan guard and run the engine for 15 minutes. Remove the access panel and check again the tension.

5 If a new alternator belt is fitted, set the tension to 400 N, which is equivalent to 2,5 mm of movement when a force of 16,6 N is applied. After the engine has been run for 15 minutes, check the tension and adjust it to 267 N; equivalent to 2,5 mm of movement when a force of 11,3 N is applied.

6 When the correct tension is obtained, fit the access panel to the fan guard.



To renew the alternator belt **Operation 14-4**

1 Remove the fan, Operation 12-5.

2 Loosen the adjustment bolts to release the tension on the alternator belt and remove the old belt. Check that the pulley grooves are clean and fit a new belt.

3 Fit the fan, Operation 12-5.

4 Adjust the alternator belt to the correct tension, Operation 14-3.

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15

Auxiliary equipment

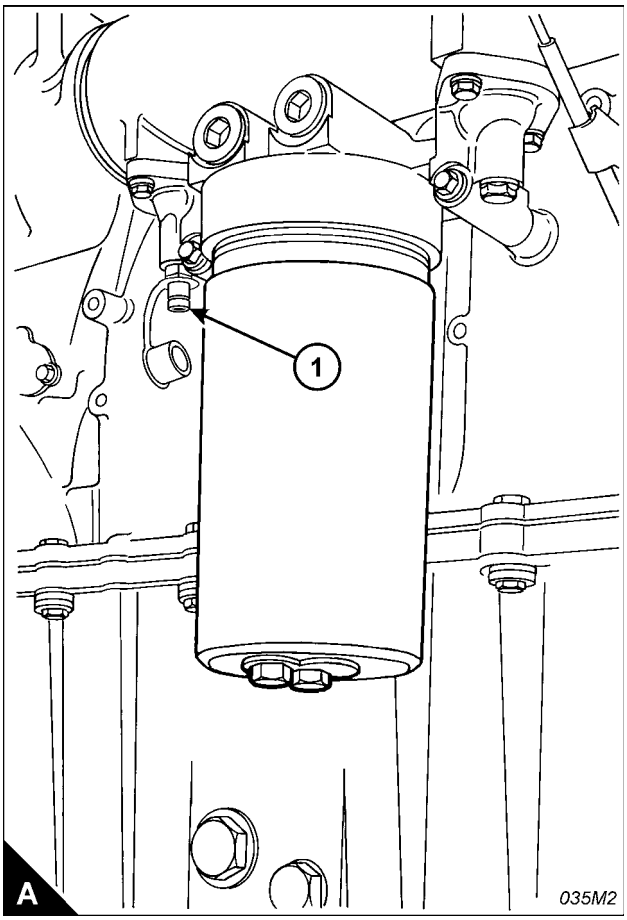
General information

Some engines are fitted with an oil sample valve. The valve enables a small quantity of oil to be drained for testing. Details about further auxiliary equipment are not available at the time of print.

Oil sample valve

Warning! *The 'O' ring fitted to the oil sample valve contains 'VITON', see the safety precautions for "Viton seals" on page 4.*

Note: Some engines have an oil sample valve (A1) fitted to the oil filter head. The oil sample valve is supplied with an 'O' ring seal already fitted in a recess at the top of the threaded section. If the oil sample valve has been removed, ensure that the 'O' ring is in place. Screw the oil sample valve into its boss on the filter head and apply a torque of 24 +/- 2 Nm (17 +/-1 lbf ft); ensure that the torque is applied to that part of the sample valve which is in contact with the oil filter head. Fit the eye of the dust cover strap into the recess close to the top of the valve, then fit the cover over the valve.



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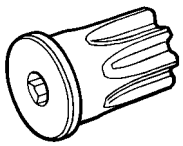
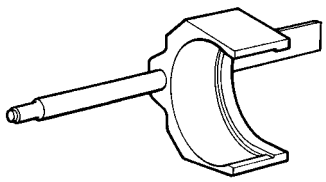
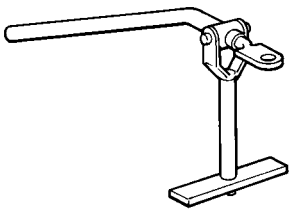
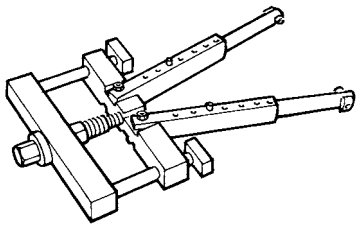
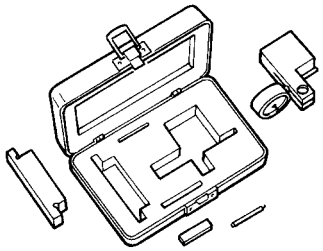
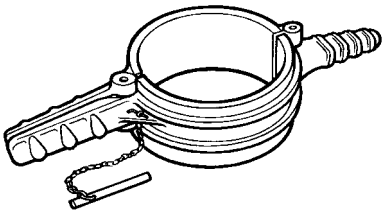
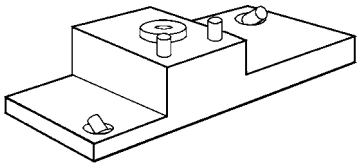
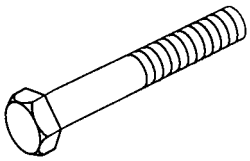
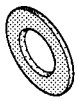
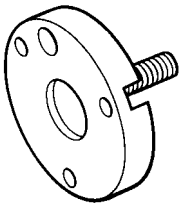
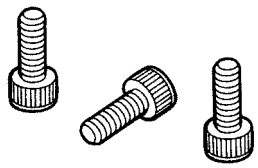
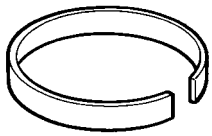
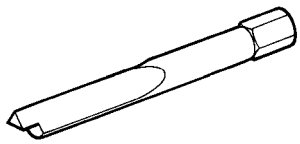
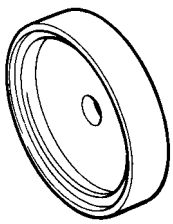
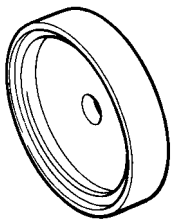
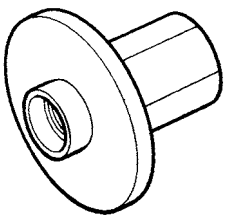
16

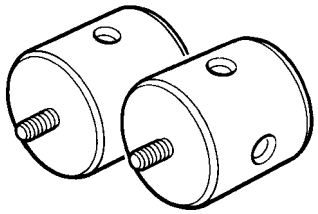
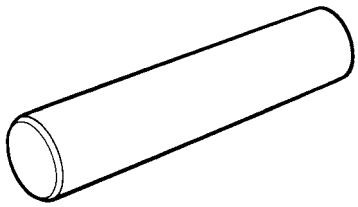
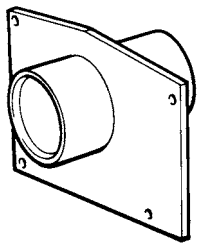
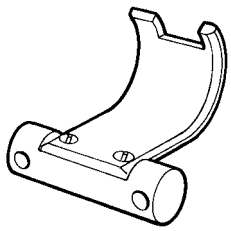
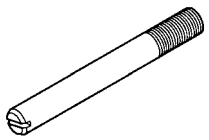
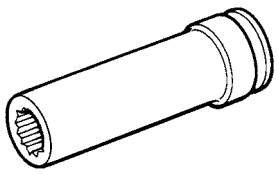
Special tools

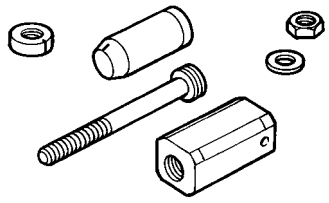
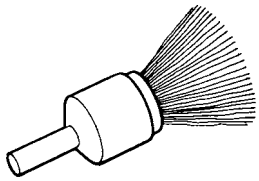
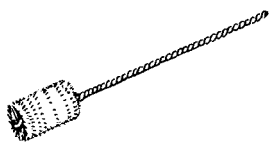
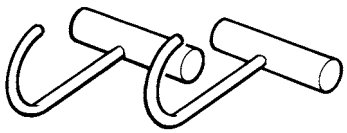
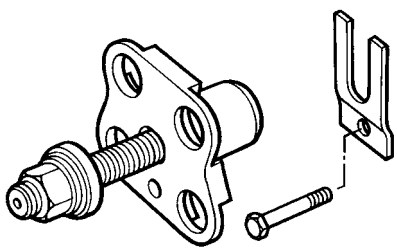
List of special tools

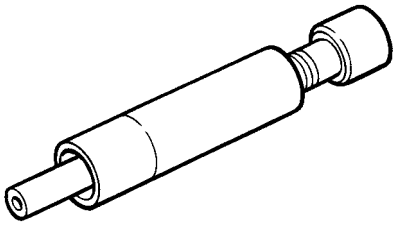
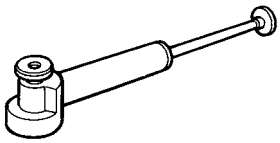
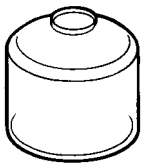
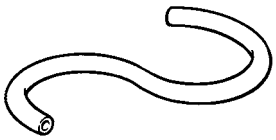
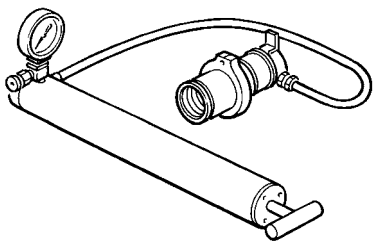
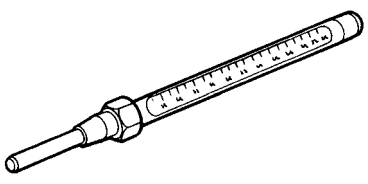
Tool number	Description	Illustration
CH11148	Engine turning tool	
CH11149	Setting gauge, fuel injector	
GE50000	Installer, cylinder liner	
GE50001	Remover, cylinder liner	
GE50002	Height tool, cylinder liner projection	

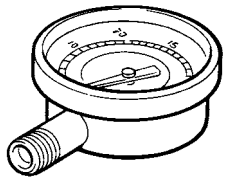
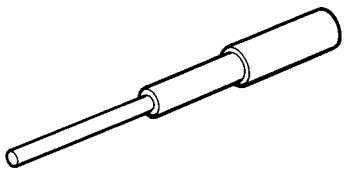
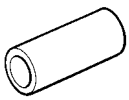
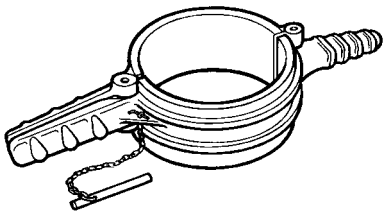
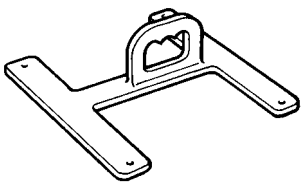
Tool number	Description	Illustration
GE50003	Piston ring compressor	
GE50004	Alignment tool, piston cooling jets	
GE50005	Clamp bolt, cylinder liner (26 required)	
GE50006	Washer (26 required)	
GE50007	Fibre washer (26 required)	
GE50008	Locator, crankshaft seal	

Tool number	Description	Illustration
GE50009	Bolt, crankshaft seal installer (use with GE50008)	
GE50010	Distorter protection ring (use with GE50008)	
GE50011	Distorter tool (use with GE50008)	
GE50012	Installer, front crankshaft seal (use with GE50008)	
GE50013	Installer, rear crankshaft seal (use with GE50008)	
GE50014	Nut (use with GE50008)	

Tool number	Description	Illustration
GE50015	Pilot, camshaft guide	
GE50016	Alignment sleeve, camshaft guide	
GE50017	Guide, camshaft	
GE50018	Cradle, camshaft	
GE50019	Guide stud, camshaft gear	
GE50020	Impact socket	

Tool number	Description	Illustration
GE50021	Remover/installer, injector sleeve	
GE50022	Brush, large bore	
GE50023	Brush, small tapered	
GE50024	Brush, small bore	
GE50025	Lifting hook, camshaft	
GE50026	Compressor, valve spring	

Tool number	Description	Illustration
GE50027	Installer, valve guide seal	
GE50028	Vacuum pump	
GE50029	Vacuum pump bottle	
GE50030	Vacuum pump tube	
GE50031	Pressurising pump, coolant system	
GE50032	Thermometer, coolant temperature	

Tool number	Description	Illustration
GE50033	Pressure gauge	
GE50043	Remover/installer, valve guide	
GE50044	Sleeve, valve guide	
GE50045	Piston ring compressor	
VP12712	Lift bracket, cylinder head	

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