
Perkins 2000 Series

All 2000 diesel models

USER'S HANDBOOK

Six cylinder diesel engines for industrial applications

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This publication is divided into six chapters:

- 1 General information**
- 2 Engine views**
- 3 Operation instructions**
- 4 Preventive maintenance**
- 5 Engine fluids**
- 6 Fault diagnosis**

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1

General information

Introduction

The new range of industrial engines is the latest development from Perkins Engines Company Limited, a world leader in the design and manufacture of high performance diesel engines.

More than fifty years of diesel production experience, together with the use of the latest technology, have been used in the manufacture of your engine to give you reliable and economic power.

To ensure that you use the correct information for your specific engine type, refer to "Engine identification" on page 8.

Danger is indicated in the text by two methods:

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

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

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

Safety precautions

These safety precautions are important.

Reference must also be made to the local regulations in the country of operation.

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

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

- Do not operate the engine if a safety guard has been removed.
- Do not remove the filler cap of the cooling system while the engine is hot and while the coolant is under pressure, because dangerous hot coolant can be discharged.
- Do not use salt water or any other coolant which can cause corrosion in the closed coolant circuit.
- Do not allow sparks or fire near the batteries (especially when the batteries are on charge) because the gases from the electrolyte are highly flammable. The battery fluid is dangerous to the skin and especially to the eyes.
- Disconnect the battery terminals before a repair is made to the electrical system.
- Only one person must control the engine.
- 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 in a safe place to prevent contamination.
- Ensure that the control lever of the transmission drive is in the 'out-of-drive' position before the engine is started.
- 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.
- Fuel and oil pipes **must** be inspected for cracks or damage before they are fitted to the engine.
- Fit only genuine Perkins parts.

How to care for your engine

This handbook has been written to assist you to maintain and operate your engine correctly.

To obtain the best performance and the longest life from your engine, you must ensure that the maintenance operations are done at the intervals given in "Preventive maintenance periods" on page 21. If the engine is operated in a very dusty environment or other adverse conditions, certain maintenance intervals will have to be reduced. Renew the filter elements and the lubricating oil regularly to ensure that the inside of your engine remains clean.

Ensure that all adjustments and repairs are done by personnel who have had the correct training. Perkins distributors have this type of personnel available. You can also obtain parts and service from your Perkins distributor.

The left and right sides of the engine are as seen from the rear (flywheel) end.

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

Engine preservation

Storage

When the engine is not in use, temporarily or for a longer period, it must be protected from corrosion. The amount and the type of treatment to prevent corrosion during storage is according to the length of the period of storage. When necessary, there must also be protection from frost.

If the engine is fitted with a composite sump, and to avoid possible damage, it must not be allowed to rest on its sump.

All new and reconditioned engines which leave the Factory have been inhibited to Perkins Engines standards. An engine may be in storage, under a cover and in dry conditions, for a maximum period of 12 months from the date it left the Factory, without the need for it to be inhibited again.

After a period of 12 months of storage, the engine must be inspected thoroughly and must be again inhibited.

Short period storage

- Up to seven days

No treatment is necessary.

- Up to three months

Each week, operate the engine until the normal temperature of operation is reached. If the engine cannot be operated, turn the crankshaft by hand, in the normal direction of rotation (anti-clockwise as seen on the flywheel), a minimum of three revolutions.

Long period storage

If it is necessary to put an engine into storage for a period of between three and twelve months, use this procedure:

1 Remove the thermostat from its housing and carefully clean it. Apply a silicone grease, such as MS4, to the valve stems of the thermostat and operate the valves by hand to ensure that the grease enters the glands. Fit the thermostat to its housing.

2 Operate the engine until the normal temperature of operation is reached. Stop the engine and drain immediately the lubricating oil from the sump and from the canisters of the oil filter (see the '**Note**' below about canisters).

3 Fill the canisters of the oil filter with PX4 corrosion inhibitor and fit the canisters to the filter head (see "How to renew the canisters of the oil filter" on page 31).

4 Fill the sump, to the normal oil level, with PX4 corrosion inhibitor and, once again, run the engine until the normal temperature of operation is reached.

5 Stop the engine, disconnect the fuel supply pipe and connect the pipe to a supply of PX4 corrosion inhibitor. Start the engine, while it is still hot, and operate the engine, with no load, for ten minutes. Stop the engine.

6 Disconnect the supply of PX4 corrosion inhibitor from the fuel system and seal the end of the pipe. Drain the fuel filters.

Note: The canisters of the oil filters and the fuel filters are designed so that when fitted upside down, the lubricating oil or fuel does not drain from the canister, when the engine is stopped.

To drain a canister, hold it over a suitable container, insert a small tool into one of the inlet openings and carefully press open the rubber, non-return seal. During this operation, do not damage the rubber seal or the element of the filter.

Fasten a label, at a position where it will be seen, to indicate that the fuel system has been disconnected.

7 Remove the fuel injectors and put them in a container of PX4 corrosion inhibitor.

Continued

8 Set the fuel control lever to the NO FUEL position, remove the rocker covers and disconnect the air filter(s).
9 Turn the engine by the use of the starter and, at the same time, spray PX4 corrosion inhibitor into the manifolds until an emission of vapour is seen from each opening for the fuel injectors. Connect the air inlet pipes. Connect the air filter(s).

10 Spray 40 cc of PX4 corrosion inhibitor into each cylinder, through the openings for the fuel injectors. Fit the fuel injectors.

Caution: *The engine must NOT be turned after this operation and a label must be fitted to this effect.*

11 Spray PX4 corrosion inhibitor around the valves and around the rocker assemblies. Fit the rocker covers.

12 Drain the PX4 corrosion inhibitor from the sump of the engine and from the oil filter canisters. Fit a **NO OIL** label to the oil filler cap.

13 Drain the cooling system and fill with the recommended coolant mixture (see "Coolant" on page 53).

Caution: *The mixture must NOT contain less than 50% inhibited ethylene glycol or propylene glycol, and may contain up to 90% by volume.*

14 Wait for 15 minutes, then drain completely the coolant mixture. Fit a **NO COOLANT** label to the filler cap of the radiator.

15 Disconnect the exhaust pipe at the turbocharger outlet, or at the junction of the manifolds if the engine has a normal aspiration system. Inject two grammes of VPI 260 powder and fit a blanking plug. Do NOT connect the exhaust pipe.

16 Inject two grammes of VPI 260 powder into the turbocharger, if relevant.

17 Disconnect the air ducts between the air filter(s) and the turbocharger and inject two grammes of VPI 260 powder into the air ducts.

18 Inject two grammes of VPI 260 powder into each paper element type air filter. Other types of air cleaners may be sprayed inside with PX4 corrosion inhibitor. Fit the air ducts.

19 Spray Crodafluid PM47 onto areas of the engine and auxiliary equipment which are not protected by paint. Ensure that the fuel control linkage is sprayed with Crodafluid PM47.

Caution: *Do NOT spray PM47 into the vent holes of the alternator.*

20 Cover, completely, the alternator and the starter motor in mouldable wax wrapping, and seal with adhesive tape.

21 Seal the air filter inlets, the crankcase breather and all other openings with mouldable wax wrapping and adhesive tape.

22 Remove all drive belts, apply French chalk to the belts and put them in a sealed plastic bag. Fasten the bag to the engine.

23 Fasten to the engine a label which indicates:

- That the exhaust system has been sealed.
- The dates when the corrosion inhibitors were applied to the engine and when the corrosion inhibitors must be applied again.

If the engine is to remain in storage for more than one year, the above procedure must be repeated at the end of each period of twelve months.

Removal from storage

To prepare the engine for use, after it has been in storage, refer to Chapter 3, Operation instructions. The information given applies to new engines and to those engines which have been removed from storage.

Approved products for engine preservation

Component	Product	Manufacturer
Thermostat	MS4 silicone grease	Ambersil Limited Whitney Road Basingstoke Hampshire
Lubrication system	PX4 corrosion inhibitor	Croda Chemicals Limited Churchill Road Doncaster Yorkshire
Fuel system	PX4 corrosion inhibitor	Croda Chemicals Limited
Valves and rocker assemblies	PX4 corrosion inhibitor	Croda Chemicals Limited
Cooling system	Inhibited ethylene glycol or Inhibited propylene glycol	Various
Induction/exhaust systems	PX4 corrosion inhibitor VPI 260 powder	Croda Chemicals Limited Shell Chemicals Limited Stanlow Terminal Ellesmere Port Cheshire
Engine and auxiliaries - outer casing	Crodafluid PM47 Mouldable wax wrapping	Croda Chemicals Limited Carrs Paper Limited Shirley Solihull West Midlands

Parts and Service

Introduction

If problems occur with your engine or with the components fitted to it, your Perkins distributor can make the necessary repairs. Your Perkins distributor will ensure that only the correct parts are fitted and that the work is done correctly.

Certain components can be supplied by your Perkins distributor through the Perkins Exchange Component Programme. These will enable you to reduce the cost of certain repairs.

Service literature

Workshop manuals and other service publications are available from your Perkins distributor at a nominal cost.

Training

A four day course on the service and the overhaul of the 2000 Series range of engines is available at the Factory. For details, apply to: The Customer Training Centre, Perkins Engines Company Limited, Shrewsbury, SY1 3NX, England.

Service Bulletins

Service procedures and engine design are checked continuously at Perkins Engines. As a result of this development work, it may become necessary to alter the information in manuals and other service publications. Between revisions of the literature, all relevant personnel are provided with full details of changes as they occur. The information is produced as a Service Bulletin; these are supplied to distributors for distribution as necessary.

Engine identification

The engine number is stamped on the data plate which is fastened to the right side of the crankcase (A1).

For early engines a typical engine number is **8D26113U 71813P**, which consists of these codes:

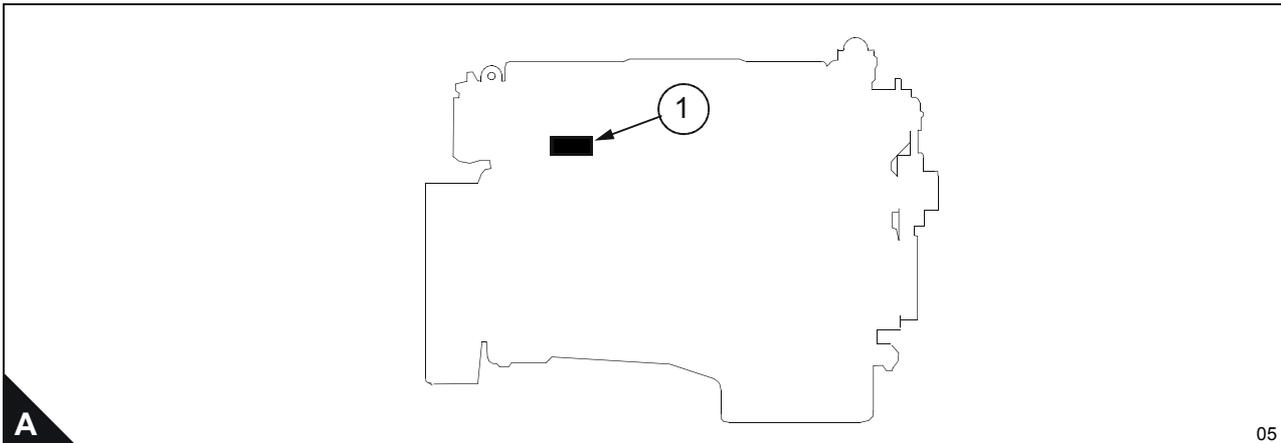
8D	Engine family
26113	Engine number
U	Country of origin
71813	Build line number
P	Year of manufacture

Engines made after August 1994, have a new engine number system. For these engines, a typical number is: **SGH 06 0002 U 0059 C**, which consists of these codes:

SG	Engine application
H	Engine type
06	Number of engine cylinders
0002	Engine specification number
U	Country of manufacture
0059	Build line number
C	Year of manufacture

Units such as the fuel injection pump and turbochargers have their own data plates.

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



Engine data**General**

Number of cylinders	6	
Cylinder arrangement	In-line	
Cycle	Four stroke	
Induction system		
165 kW (221 bhp) to 257 kW (345 bhp) versions 229 kW (307 bhp) to 368 kW (494 bhp) versions	Turbocharged	
Combustion system	Turbocharged and charge cooled	
Nominal bore	Direct injection	
Stroke	130,17 mm (5.125 in)	
Compression ratio	152,4 mm (6.000 in)	
Cubic capacity	15.9:1 nominal (except TTAG - 15:1)	
Firing order	12,17 litres (742.64 in ³)	
No. 1 cylinder is at front (fan end)	1, 4, 2, 6, 3, 5	
Tappet clearances (cold)		
Inlet	0,25 mm (0.010 in)	
Exhaust	0,50 mm (0.020 in)	
Direction of rotation	Anti-clockwise: view on flywheel	
Injection timing	As stamped on engine data plate	
Dry weight of engine (approximate)	Engine only:	Typical electropak
TG1, TG1A, TG2, TG2A	1118 kg (2465 lb)	1180 kg (2601 lb)
TAG, TAG2	1231 kg (2714 lb)	1365 kg (3009 lb)
TWG, TWG2	1138 kg (2509 lb)	1216 kg (2681 lb)
TTAG	1325 kg (2921 lb)	1459 kg (3217 lb)
Cooling system		
Capacity of coolant system		
(does not include radiator)	24,4 litres (4.5 UK gallons)	
Coolant system pressure	Maximum 70 kN/m ² (10 lbf/in ²) to suit installation	
Temperature (normal)		
(At sea level)	78 to 95 °C (172 to 203 °F)	
Thermostat	Three-element wax capsule type with radiator by-pass	

Continued

Fuel system

Type Low-pressure supply to fuel injection pump with through flow return to tank

Fuel injection pump

165 kW (221 bhp) to
257 kW (345 bhp) gross

S3000 with 12 mm lower helix elements (damper plates fitted to variable speed engines over 300 bhp only). Boost control device fitted to 300 bhp engines only. Automatic selection of excess fuel and retarded timing for starting. The engine is retarded by 6°.

229 kW (307 bhp) to
368 kW (494 bhp) gross

S7100 with 12 mm lower helix elements and snubber valves. Boost control device fitted. Automatic selection of excess fuel and retarded timing for starting. The engine is retarded by 6°.

Governor All speed, integral with fuel injection pump or electric (depending on requirements)

Lift pump Single acting

Fuel supply pressure 103 to 207 kN/m² (15 to 30 lbf/ft²)

Fuel injectors Low spring type, opening pressure 240 bar

Main fuel filter Single screw-on type canister

Lubrication system

Type Wet sump

Capacity of lubricating oil sump

Max. mark on dipstick 25 litres (5.5 UK gallons)

Max. mark on dipstick
(composite sump) 36 litres (7.9 UK gallons)

Lubricating oil pressure

Normal load conditions 350 to 480 kN/m² (50 to 70 lbf/in²)

Minimum at rated speed 207 kN/m² (30 lbf/in²) ⁽¹⁾

Pressure relief valve Spring loaded plunger in body of oil pump

Oil-to-coolant heat exchanger Single unit, tube stack type with partial by-pass for coolant

Filters Two screw-on type canisters with integral by-pass valves

(1) Important for the protection of the turbocharger bearings

Induction/exhaust system**Aspiration**

TG, TAG and TWG Pressure charged by a single turbocharger

TTAG Pressure charged by two turbochargers connected in series

Air charge cooler

TG Not fitted

TAG and TTAG Air-to-air type, integral with radiator

TWG Air-to-coolant type, integral with induction manifold

Cold start aids Optional - Start Pilot or Fleetguard

Electrical equipment

Alternator Belt driven unit, 24 volt, 40 amp

Starter motor Single, 24 volt - flange-mounted

Stop control Electrical, 24 volt

Auxiliary equipment

Air compressor (if fitted) Single cylinder, flange mounted

2

Engine views

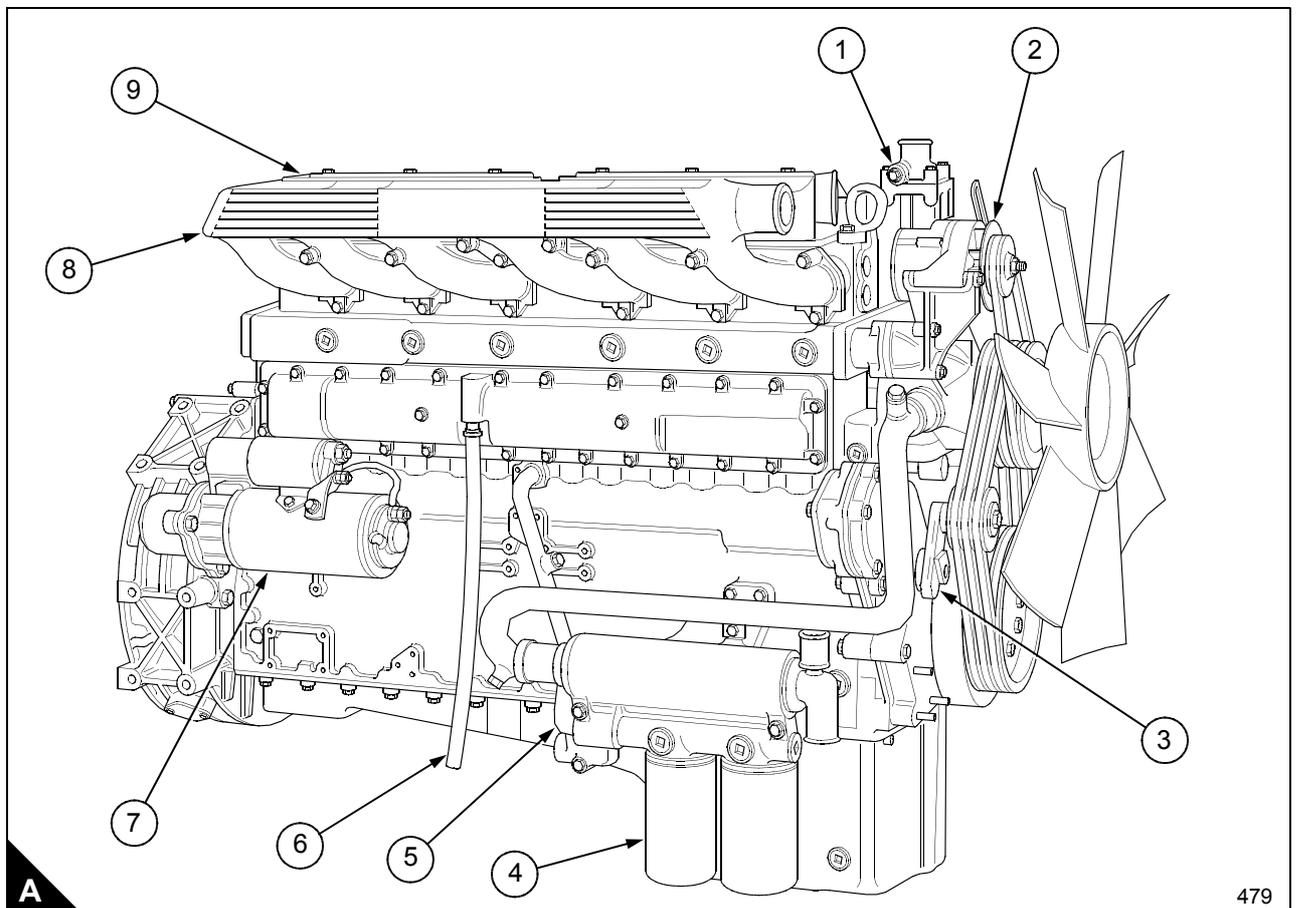
Introduction

Perkins engines are built for specific applications and the views which follow do not necessarily match your engine specification.

Location of engine parts

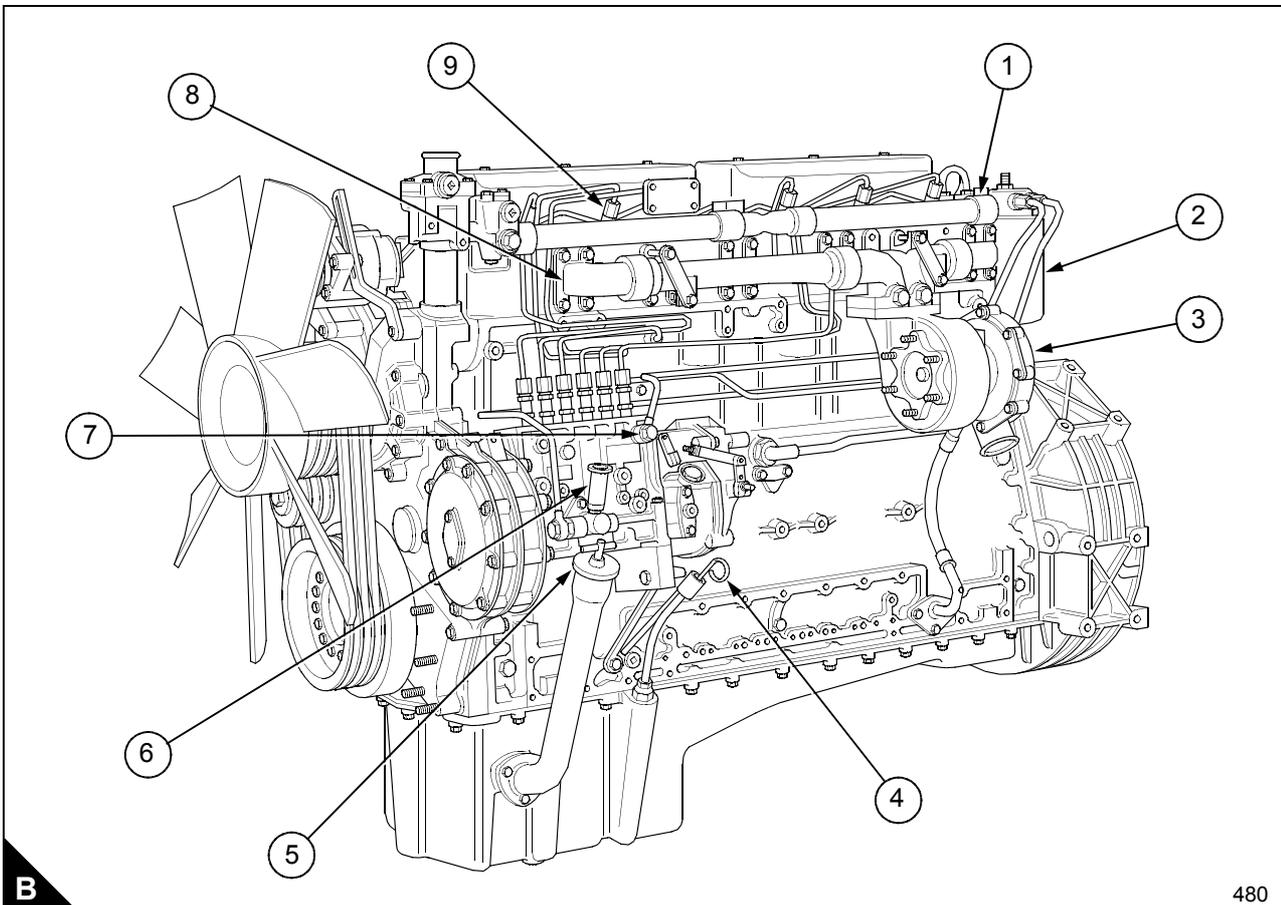
Front and left side view of a 2000 Series engine (A)

- | | |
|---|------------------------------------|
| 1 Thermostat housing | 6 Breather pipe |
| 2 Alternator | 7 Starter motor |
| 3 Belt tensioner | 8 Air charge cooler/inlet manifold |
| 4 Canisters of the lubricating oil filter | 9 Rocker cover |
| 5 Oil cooler | |



Front and right side view of a 2000 Series engine (B)

- | | |
|---|-----------------------------|
| 1 Coolant pipe | 6 Fuel lift pump |
| 2 Fuel filter canister | 7 Relief valve for the fuel |
| 3 Turbocharger | 8 Exhaust manifold |
| 4 Dipstick and tube | 9 Fuel injector |
| 5 Filler cap for the engine lubricating oil | |

**B**

480

3

Operation instructions

How to prepare a new or an overhauled engine

Every new engine supplied by Perkins Engines Company Limited, Shrewsbury, is run-in before it leaves the factory.

- 1 Check that all protection covers and blanking plugs have been removed.
- 2 Fit all components which were removed for storage or for transport.
- 3 Ensure that the drain plugs for the coolant and for the lubricating oil are securely fitted.
- 4 Where necessary, connect the remote control linkages, the pressure gauge pipes, the air inlet pipes and the wiring loom.
- 5 Connect the fuel pipes.
- 6 Connect the exhaust pipes.
- 7 Fill the fuel tank/s with the correct grade of fuel (see "Diesel fuel" on page 53).
- 8 Fill the cooling system with the approved coolant mixture (see "Coolant mixture" on page 53).
- 9 Fill the sump to the 'H' mark on the dipstick with the correct grade of lubricating oil (see "Lubricating oil" on page 54).
- 10 Remove the plug from the right side of the fuel injection pump and fill the fuel injection pump and governor with clean engine lubricating oil, of the correct grade, until the level of the oil reaches the hole for the plug. Fit the plug and tighten securely.
- 11 Add oil to the turbocharger, or to the two turbochargers if relevant, as follows: Clean the area around the blanking plug at the top of the turbocharger bearing housing. Remove the plug and insert 0,2 litre ($\frac{1}{3}$ pint) of engine lubricating oil of the correct grade. Fit the plug.
- 12 Eliminate air from the fuel system (see page 41).
- 13 Lubricate all of the control linkages and check the linkages for free movement.
- 14 Ensure that the stop control is in the STOP position and that the lever of the speed control is in the IDLE position. Press the start button for 10 seconds and wait for 10 seconds, then press it for 20 seconds and wait for 20 seconds. Oil pressure **must** be indicated on the gauge.

Normal start procedures

Service checks before a new or an overhauled engine, or an engine which has been in storage, is started

If an engine has been in storage for a period of more than one month or if the fuel injection pump or turbocharger has been removed, lubricating oil must be added to the fuel injection pump, to the governor of the fuel injection pump and to the turbocharger. Refer to steps 10 and 11 of "How to prepare a new or an overhauled engine" on page 15. Use clean engine oil of the same grade and specification as that already in the system.

Service checks each day before the first engine start:

- 1 Check that the level of the coolant is just at the bottom of the filler extension in the radiator. Fill, if necessary, to the correct level with the approved coolant mixture. Find the reason for large losses of coolant.
- 2 Check the engine oil level. With the engine stopped the oil level must be at the 'H' mark on the dipstick. If necessary, add oil of the same grade and specification as that already in the system. Do **not** add more oil than is necessary.
- 3 Check the level in the fuel tank. Open the fuel valve, if one is fitted.

How to start the engine

Perform the daily service checks then proceed as follows:

Move the stop control lever to the RUN position.

- 1 Move the speed control lever to the maximum speed position.
- 2 Press the start switch and release it when the engine starts.
- 3 Move the speed control lever to the idle position.

How to start the engine in low ambient temperatures

In addition to the use of cold starting aids as given below, efficient starts in low temperatures require the use of a suitable engine lubricating oil of the correct viscosity and also a good battery.

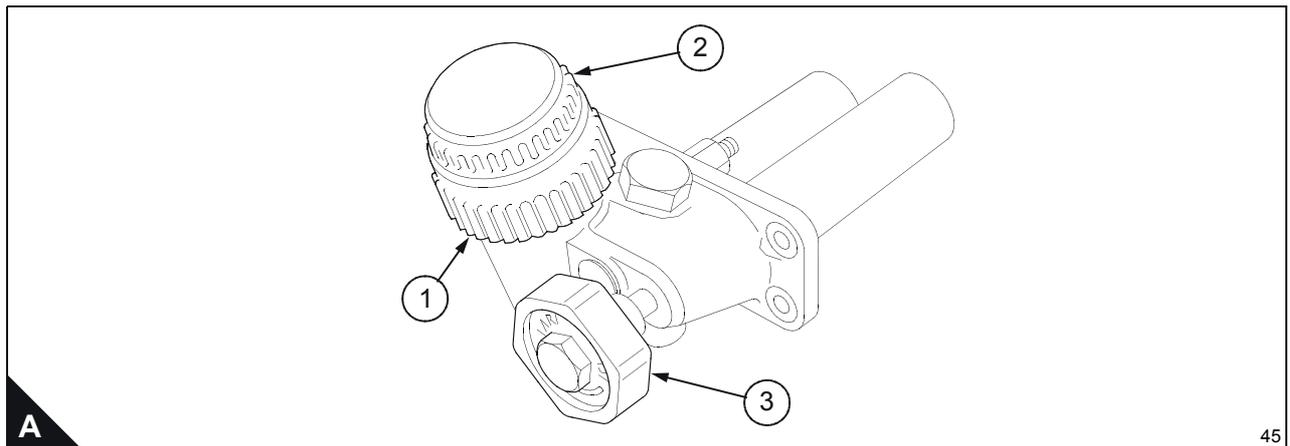
If a cold engine is started in a temperature of 10 °C, it will increase speed immediately to the maximum engine speed. At -30 °C (-22 °F), 20 minutes may elapse before the engine speed increases from the minimum of 450 rev/min at which the engine will continue to run, to the maximum engine speed.

Variable speed engines have an automatic excess fuel device which is fitted within the fuel injection pump and operates when the lever for the speed control is moved to the maximum speed position. The excess fuel device works as a starting aid when ambient temperatures are below 0 °C.

Engines which drive generators are fitted with manual excess fuel levers.

'Start Pilot' systems

- 1 **'ER' system.** Remove the cap (A1) of the capsule chamber and pull the plunger (A2) fully out. Insert a fluid capsule into the chamber, fit the cap and push the plunger fully in to make a hole in the capsule.
- 2 After a short delay, when the capsule is empty, repeat the operation with two or three more capsules according to the adverse ambient temperature. Then operate the pump (A3) for three double strokes while the start switch is operated.
- 3 **'Viso-F' system.** Use the canister to fill the reservoir to the MAX mark. Then operate the pump for three double strokes.
- 4 Move the lever for the speed control away from the IDLE position and operate the start switch. Continue to operate the pump. Do not turn the engine continuously at cranking speed for more than 20 seconds. If the engine does not start, there must be a short delay before the start switch and the pump are operated again.
- 5 When the engine starts and runs, release the start switch and continue to operate the pump until the engine speed increases. Then return the lever of the speed control to the IDLE position.



'Fleetguard' system

This system consists of an expendable screw-on type canister which contains 710 cc of ether under pressure. The ether is supplied to the engine by a remotely operated priming valve. Each operation of the priming valve causes the atomisation and injection of 6 cc of ether into the inlet manifold.

- 1 Move the lever for the speed control away from the IDLE position and operate the start switch.
- 2 When the engine turns, pull the control knob to operate the priming valve for two seconds and then release it. This action causes ether to be discharged for three seconds into the inlet manifold.
- 3 According to the adverse ambient temperature, repeat the operation of the priming valve until the engine starts and runs. Release the start switch but continue to repeat the operation of the priming valve until the engine speed increases. Then return the lever of the speed control to the IDLE position.
- 4 Do not turn the engine continuously at cranking speed for more than 20 seconds. If the engine does not start, there must be an interval of 20 seconds before steps 1 to 3 are repeated.

How to run the engine

The precautions which follow will help to ensure a long and fault-free life for the engine:

- 1 Do not operate the engine at high speeds and loads until the coolant has reached a minimum temperature of 78 °C (172 °F).
- 2 Do not allow the engine to run at idle speed, or without load, for prolonged periods.
- 3 Do not exceed the maximum rated speed of the engine.
- 4 Never allow an engine to continue to run if the oil pressure is below 207 kN/m² (30 lbf/in²) at the rated speed.
- 5 Fill the fuel tank/s at the end of each day to prevent condensation and to allow sediment to fall to the bottom of the tank.

How to stop the engine

- 1 Operate the engine for 3 minutes at idle speed with no load to allow the turbocharger to reduce speed and temperature.
- 2 Move the switches for the engine protection devices to their OFF positions.
- 3 Move the stop control or switch to the STOP position and release it after the engine has stopped.

Running-in after a repair

Every new or reconditioned engine which is supplied by Perkins Engines has been given a period of running-in before it leaves the Factory and it needs no special process when it is put into service.

When a 'Short engine' or a 'Long engine' has been installed, or when a partial overhaul has needed new cylinder liners and new piston rings, the Operator is advised that the procedure, given below, should be applied before the engine is run at full load.

- 1 Run the engine **without** a load until the normal temperature is reached.
- 2 During a period of three to four hours, increase **gradually** the load on the engine until the final conditions of the full load are reached.

Make frequent checks of:

- Oil pressure.
- Coolant temperature.
- Pipes and connections for leaks.

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4

Preventive maintenance

Preventive maintenance periods

These preventive maintenance periods apply to average conditions of operation. Check the periods given by the manufacturer of the equipment in which the engine is installed. If necessary, use the shorter periods. When the operation of the engine must conform to the local regulations, these periods and procedures may need to be adapted to ensure correct operation of the engine.

The service intervals can be reduced for operation in adverse conditions. The intervals must not be extended unless Perkins Engines Company Limited have approved the changes as indicated in the Perkins Warranty.

It is good preventive maintenance to check for leakage and loose fasteners at each service. These maintenance periods apply only to engines that are operated with fuel and lubricating oil which conform to the specifications given in this handbook.

Schedule for engines in normal use

The preventive maintenance operations must be applied at the interval (hours or months) which occurs first.

- | | | | |
|----------|----------------------------|----------|-------------------|
| A | Every 10 hours or daily | D | Every 2000 hours |
| B | At pre-delivery inspection | E | Every 10000 hours |
| C | Every 400 hours | | |

A	B	C	D	E	Operation
●	●				Check the restriction indicator for the air filter and, when necessary, renew the filter element
●	●				Check the pressure of the lubricating oil at the gauge, if fitted
●	●				Check the level of the lubricating oil
●	●				Check the amount of coolant
●					Drain all water/sediment from the primary fuel filter
	●	●			Check the condition and the tension of all drive belts
		●			Renew the lubricating oil
		●			Renew the canisters of the lubricating oil filter
		●			Renew the rotor of the by-pass filter for the lubricating oil, if fitted
		●			Renew the canister of the main fuel filter
		●			Check the specific gravity and the pH value of the coolant
		●			Ensure that the nuts which retain the turbocharger(s) are tightened securely
			●		Ensure that the fuel injectors are checked and corrected, or renewed if necessary ⁽¹⁾
			●		Ensure that the tappet clearances are checked, and adjusted if necessary ⁽¹⁾
			●		Loosen and tighten the bolts and the nuts of the cylinder heads to the correct torque only in accordance with the instructions given in "How to tighten the bolts of the cylinder head" on page 50. See the 'Note' at the beginning of this operation.
				●	Ensure that the turbocharger(s), the coolant pump, the alternator, and the starter motor are checked ⁽¹⁾
				●	Ensure that the belt tensioner pulley, the engine damper, and the air compressor (if fitted) are checked ⁽¹⁾
				●	Engine overhaul
					- Intermediate 8 000 to 10 000 hours
					- Full 16 000 to 20 000 hours
					Use the instructions given in the Workshop Manual

⁽¹⁾ By a person who has had the correct training.

In addition to the operations listed above, the operations listed below must be applied at 12 month intervals:

- Drain and flush the coolant system and renew the coolant mixture.
- Check that the intercooler and the radiator are clean and free from debris.

Schedule for engines in intermittent use

For engines which are in use for a total of less than 400 hours in every twelve months, the schedule below must be used:

The preventive maintenance operations must be applied at the interval (hours or months) which occurs first.

- A Every month
- B Every 200 hours or 12 months
- C Every 1000 hours or 24 months

A	B	C	Operation
●			Check the amount of coolant
●			Check the level of the lubricating oil
●			Check the restriction indicator for the air filter and, when necessary, renew the filter element
●			Drain all water/sediment from the primary fuel filter
●			Start and run the engine until normal temperature of operation is reached. If the engine has not been run for more than a month, add oil to the turbocharger(s) before the engine is started, see "How to prepare a new or an overhauled engine" on page 15
	●		Check the condition and the tension of all drive belts
	●		Renew the lubricating oil
	●		Renew the canisters of the lubricating oil filter
			Renew the rotor of the by-pass filter for the lubricating oil, if fitted
	●		Renew the canister of the main fuel filter
		●	Ensure that the fuel injectors are checked and corrected, or renewed if necessary ⁽¹⁾
		●	Ensure that the tappet clearances are checked, and adjusted if necessary ⁽¹⁾

(1) By a person who has had the correct training.

In addition to the operations listed above, the operations listed below must be applied at 12 month intervals:

- Check the coolant pump, drain and flush the coolant system and renew the coolant mixture.
- Check the turbocharger(s) and give it/them a service if necessary ⁽¹⁾. Ensure that the nuts which retain the turbocharger(s) are tightened securely.
- Ensure that the alternator and the starter motor are checked, and corrected if necessary ⁽¹⁾.
- Ensure that the belt tensioner pulley, the engine damper and the air compressor (if fitted) are checked ⁽¹⁾.
- Check that the intercooler and the radiator are clean and free from debris.

How to check the coolant level

Remove the filler cap from the radiator and check that the level of the coolant mixture just touches the bottom of the filler tube inside the radiator, or as given in the equipment manufacturer's manual. If necessary, add coolant until the level of the coolant reaches the filler tube. Fit the filler cap.

For radiators which have a short filler tube: check that the level of the coolant mixture is 76mm (3 in) below the top of the filler tube. If necessary, add coolant until the level is correct. Fit the filler cap.

Caution: *If coolant is added to the system during the service, it must consist of the same original mixture as used to fill the system.*

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

How to check the lubricating oil level

At the periods given in the service schedule, use the dipstick to check the amount of lubricating oil in the sump.

Stop the engine and check that the oil level is at the H mark on the dipstick. If necessary, put more oil into the sump. The oil must be of the same grade and specification as that which is already in the system.

Caution: *Do not overfill.*

Air filter

The air filter (A) is a 14 inch dry type unit which is fitted with a restriction indicator which gives a visual warning when the filter needs a service.

When the red warning indicator is seen through the clear panel to have reached the 'service level' mark after the engine has stopped, the element of the air filter must be cleaned or renewed.

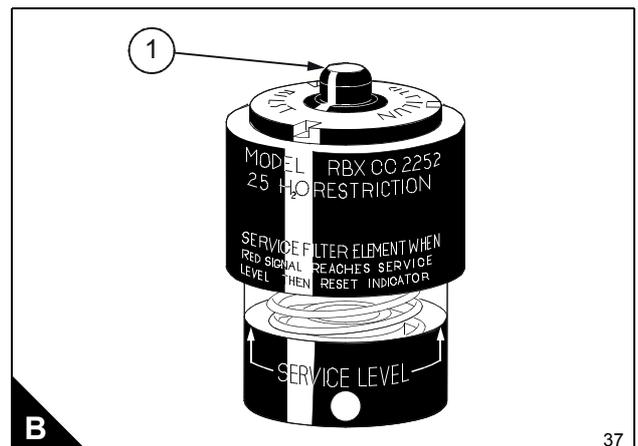
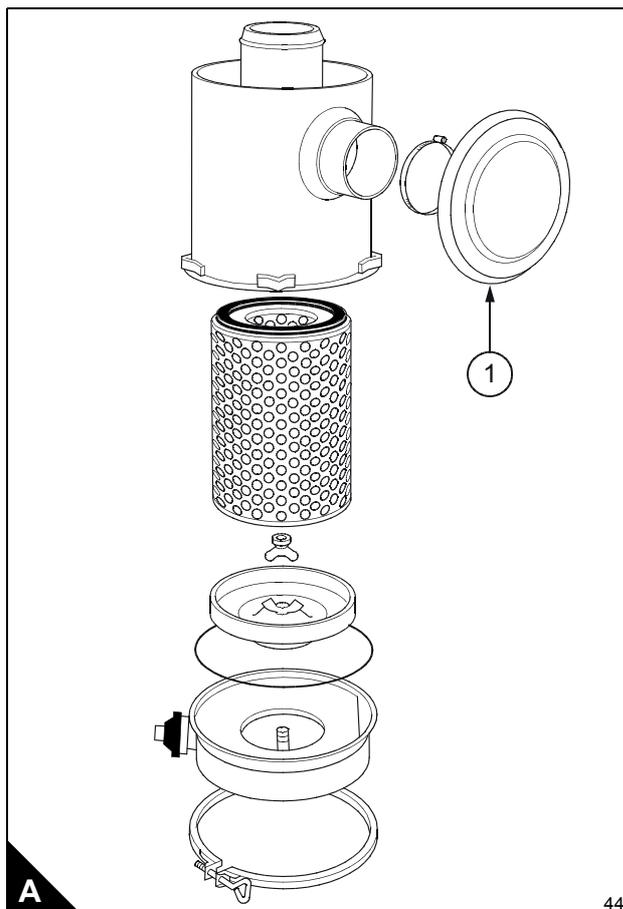
After a clean element has been fitted, press the reset button (B1) on the restriction indicator.

How to maintain the air filter

- 1 Loosen the clamp ring and remove the assembly of the dust bowl and the baffle plate.
- 2 Remove the wing nut and separate the dust bowl and the baffle plate.
- 3 Remove the debris from the dust bowl; clean and assemble the two components.
- 4 Remove the wing nut which retains the filter element and withdraw carefully the filter element.
- 5 Use compressed air at a maximum pressure of 700 kN/m² (100 lbf/in²) to clean the inner side of the element. Do **not** hold the outlet for the compressed air near to the element.

Another method to clean the element is to soak it in a solution of 'D1400' detergent. The detergent, with instructions for its use, may be obtained from Donaldson Filter Components Limited, or their distributors.

- 6 Put a light inside the element and inspect the material of the element for damage. Thin areas or holes indicate that the element must be renewed immediately.
- 7 Clean the body of the air filter, fit the element and the assembly of the dust bowl and the baffle plate, and tighten the clamp ring.
- 8 Press the reset button (B1) on the restriction indicator.



How to check the drive belts

Check all drive belts and renew a belt if it is worn or damaged. Where more than one belt is used between two pulleys, all of the belts must be renewed together.

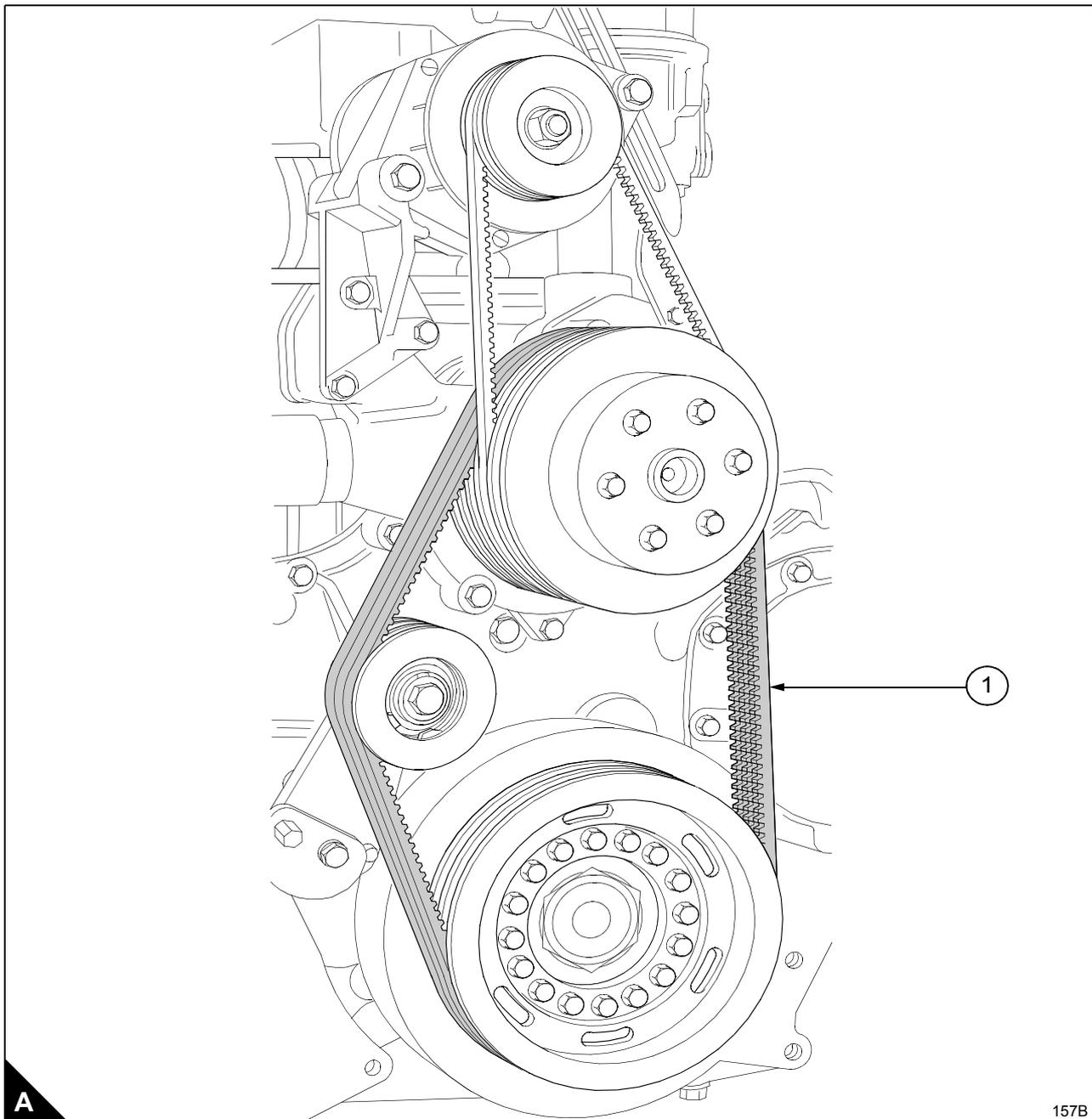
Check the belt tension at the centre of the longest free length, for example (A1).

Use a 'Gates "Krikit" V-belt tension gauge' or similar tool to check the tension of the belts.

The correct tension for all belts is **400 to 489 N** (90 to 100 lbf).

Refer to "How to adjust the tension of the fan belts" on page 27 and "How to adjust the tension of the alternator belt" on page 28 for the correct procedure.

Note: When new belts are fitted they must be checked again after the engine has been run for 15 minutes and, if necessary, adjusted to the correct tension.

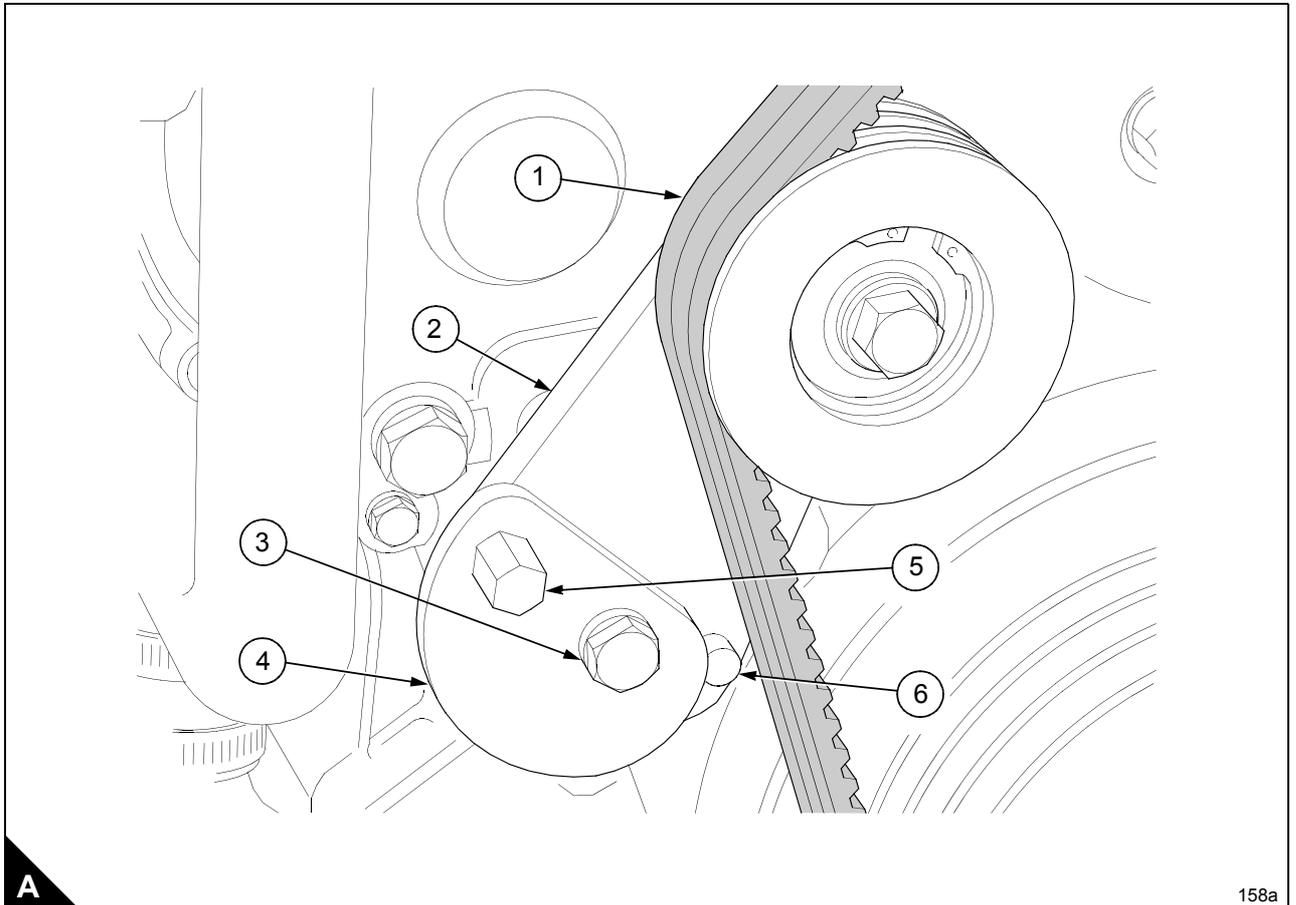


How to adjust the tension of the fan belts

Loosen the bolt which is covered by the triple fan belts (A1). The plate (A2), which holds the tensioner pulley, pivots about this bolt.

Loosen the bolt (A3) which locks the cam plate (A4) and also clamps the plate (A2).

Use a spanner on the hexagon (A5) and rotate the cam plate until the correct tension is obtained (see "How to check the drive belts" on page 26). Then tighten the bolts (A3 and A1).

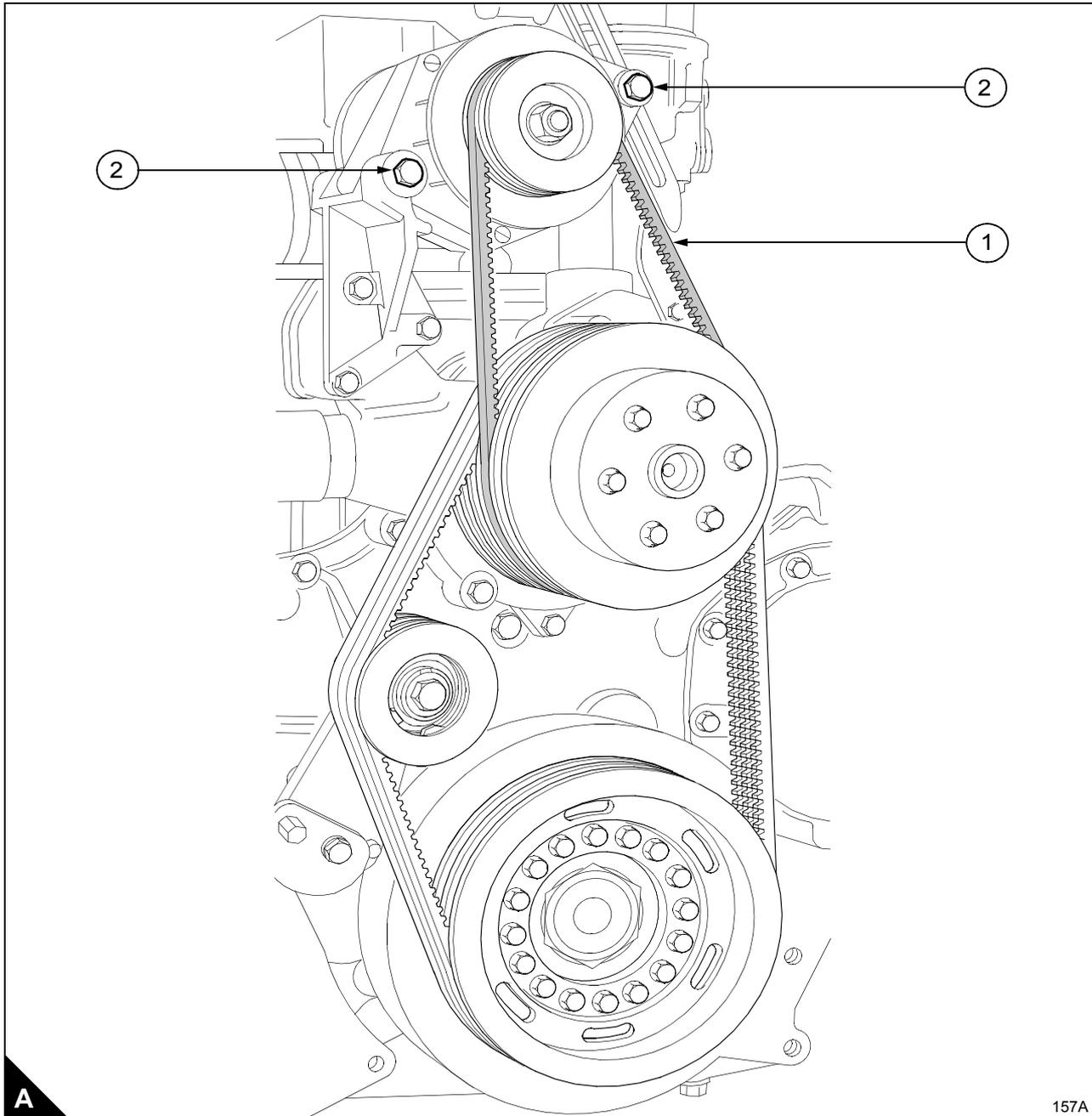


How to adjust the tension of the alternator belt

Loosen the two bolts (A2) and rotate the alternator on the pivot bolt to tighten the belt (A1) to the correct tension (see "How to check the drive belts" on page 26). Tighten the two bolts.

Check again the belts to ensure that the tensions are still correct. Maximum belt life will be obtained only if the belts are kept at the correct tensions.

Where more than one belt is used between two pulleys, check/adjust the tension on the tightest belt.



How to renew the engine lubricating oil

Ensure that the engine is on level ground.

1 Operate the engine until it is warm.

2 Stop the engine, remove the sump drain plug (A1, B1, C1, C2 or D1) and drain the lubricating oil into a suitable container.

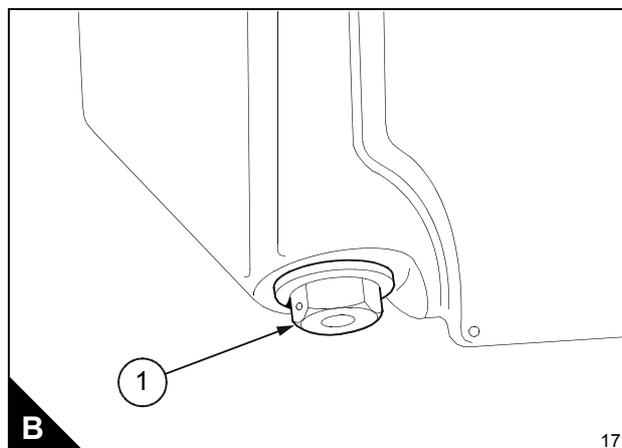
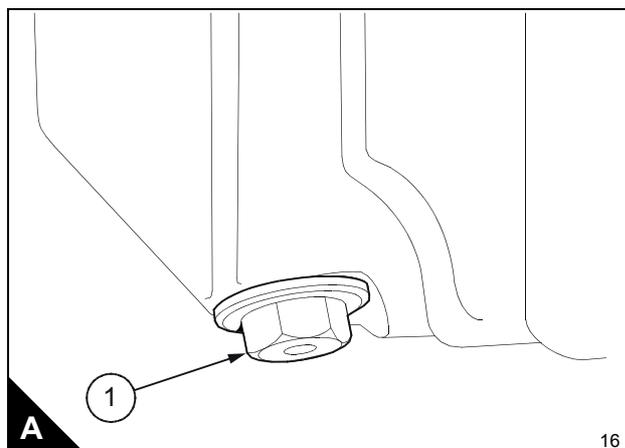
Caution: A thread insert is fitted to certain sumps. Inspect the thread to find which type is fitted to your engine.

3 Fit the drain plug and a new sealing washer and, according to the type of thread, proceed as follows:

Sump with a thread insert (A): This plug has a $\frac{7}{8}$ UNS thread. Use a spanner - size $1\frac{1}{8}$ AF - to tighten the drain plug (A1) to a torque of 115 Nm (85 lbf ft). Retain the drain plug with locking wire if it is possible.

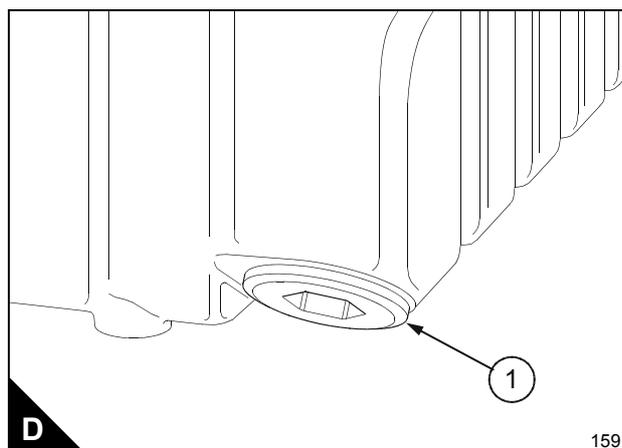
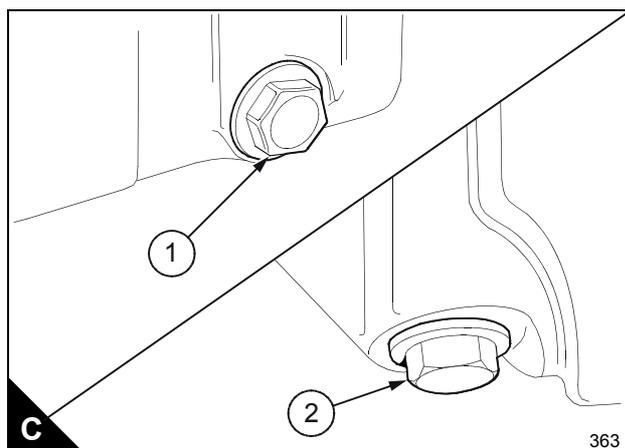
Sump without a thread insert (B): This plug has a $\frac{5}{8}$ BSP thread. Use a spanner - size $\frac{13}{16}$ AF - to tighten the drain plug (B1) to a torque of 47,5 Nm (35 lbf ft). Retain the drain plug with locking wire if it is possible.

Note: The drain plugs of engines manufactured from build line number 95200 have a $\frac{3}{4}$ BSP thread.



Sump without a thread insert (C): These plugs have a $\frac{3}{4}$ BSP thread. Use a spanner - size $\frac{15}{16}$ AF - to tighten the drain plug (C1 or C2) to a torque of 61 Nm (45 lbf ft).

Plastic composite sump (D): These engines are fitted with a plug which has a 19 mm socket. For some applications the plug may have a $\frac{1}{2}$ inch square recess. Tighten the sump plug by use of a 19 mm socket spanner or a $\frac{1}{2}$ inch extension bar from a set of socket spanners as necessary. Tighten the plug (D1) to a torque of 61 Nm (45 lbf ft).

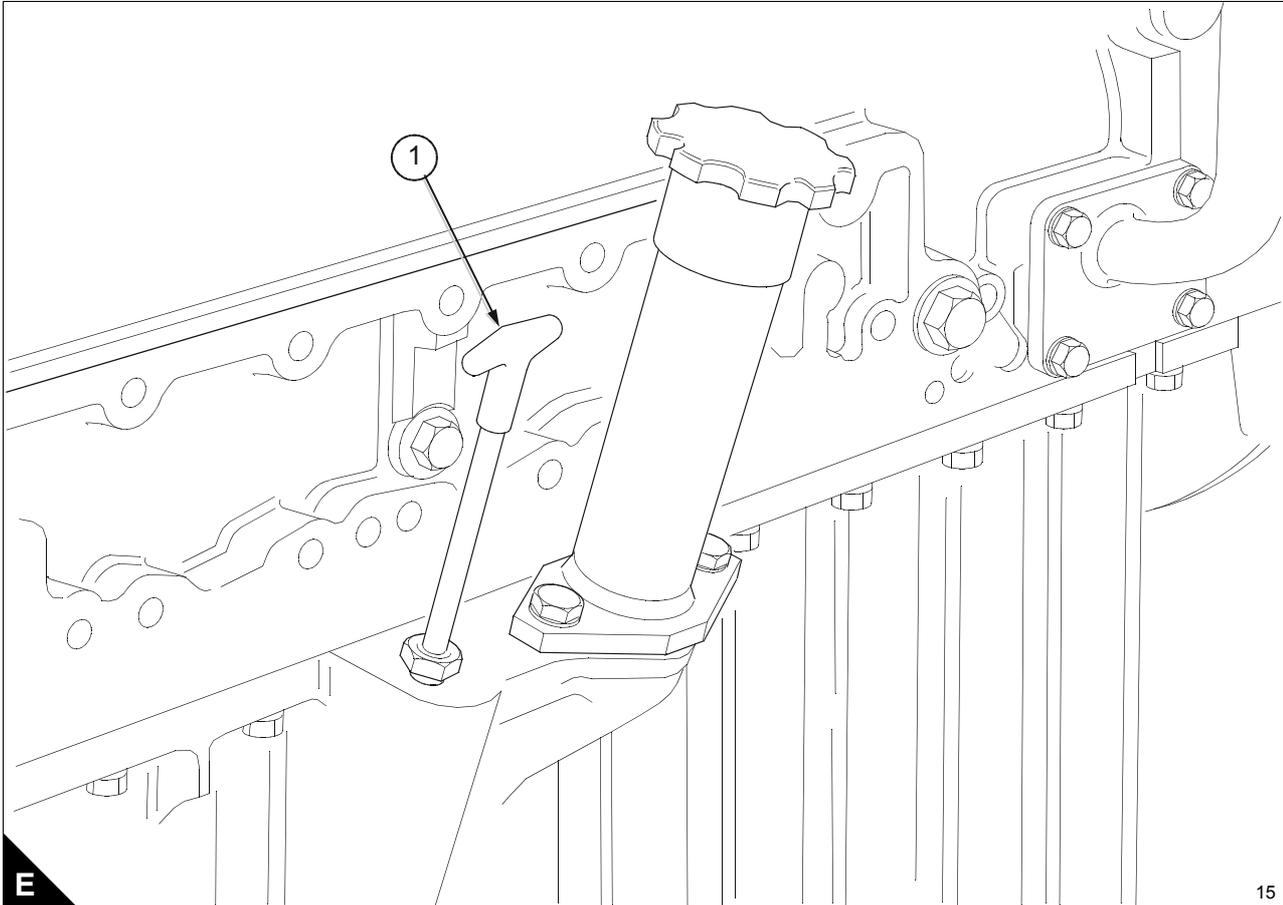


Continued

- 4 Renew both of the oil filter canisters, see "How to renew the canisters of the oil filter" on page 31.
- 5 Clean the area around the oil filler cap and remove the cap. Fill the sump to the H mark on the dipstick (E1) with clean new lubricating oil of an approved grade (see "Lubricating oil" on page 54).

Caution: Do not overfill.

- 6 Operate the engine and check for leakage from the filter canisters. When the engine has cooled, check the oil level on the dipstick and put more oil into the sump, if necessary.

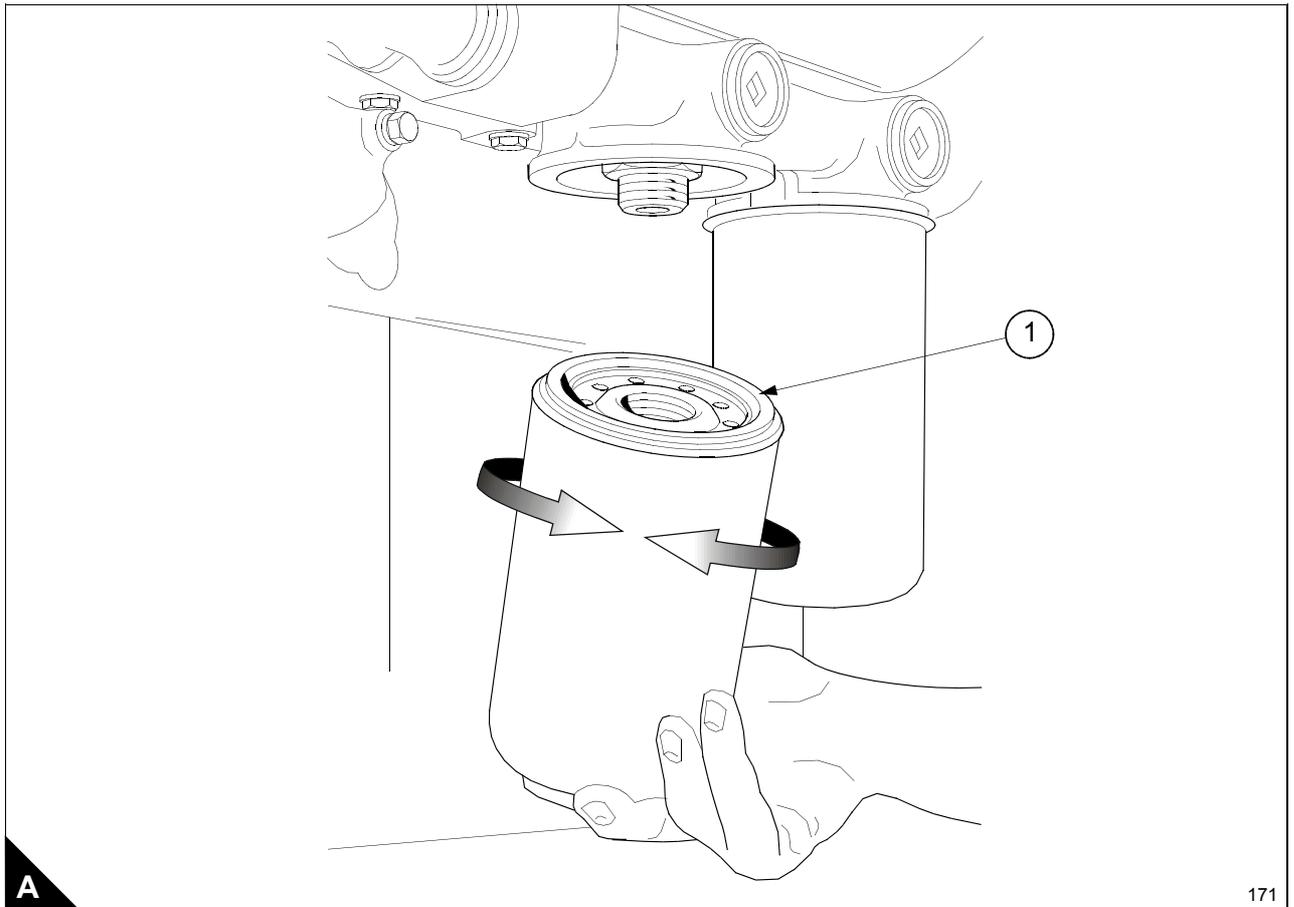


How to renew the canisters of the oil filter

Two screw-on type canisters are fitted to the filter head, which is integral with the casing of the heat exchanger and is fitted to the right side of the engine at the front.

- 1 Put a tray under the canisters and use a strap wrench, 21825 825, to remove each canister.
- 2 Check that the sealing rings (A1) are correctly fitted to the new canisters and clean the contact faces of the filter head.
- 3 Fill the two new canisters with new engine lubricating oil of the correct grade and lubricate the top of each canister seal with the same oil.
- 4 To install the new canisters use this procedure: Tighten the canisters, on their adaptors, until the sealing rings are in contact with the face of the filter head, then turn the canisters a further $1\frac{1}{4}$ turns, by hand.

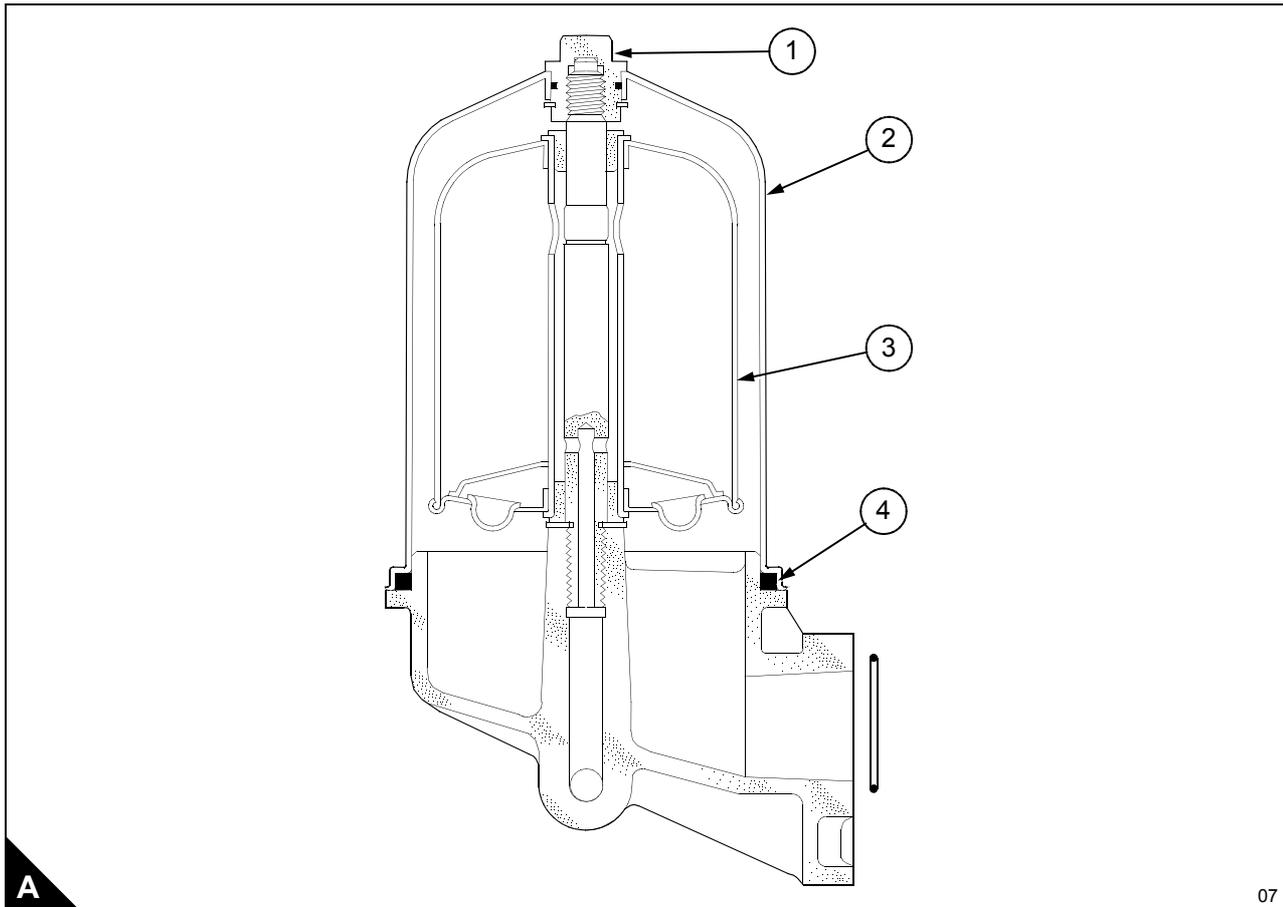
Caution: Do not overtighten.



How to renew the rotor of the by-pass filter for the lubricating oil

Some engines are also fitted with a by-pass filter for the lubricating oil. The rotor of the by-pass filter must be renewed at the periods given in the relevant schedule.

- 1 Clean the area around the by-pass filter. Remove the filter bowl (A2), remove and discard the rotor (A3).
- 2 Remove the seal (A4) from the filter bowl and clean all the components, especially the recess for the seal in the filter bowl and the contact face for the seal on the housing.
- 3 Fit a new seal to the recess in the filter bowl and lubricate the face of the seal with clean engine lubricating oil.
- 4 Fit a new rotor to the spindle and ensure that it can rotate freely. Fit the filter bowl and tighten the nut (A1) to a torque of 20 Nm (15 lbf ft).
- 5 When the engine is operated, check for leakage from the by-pass filter.



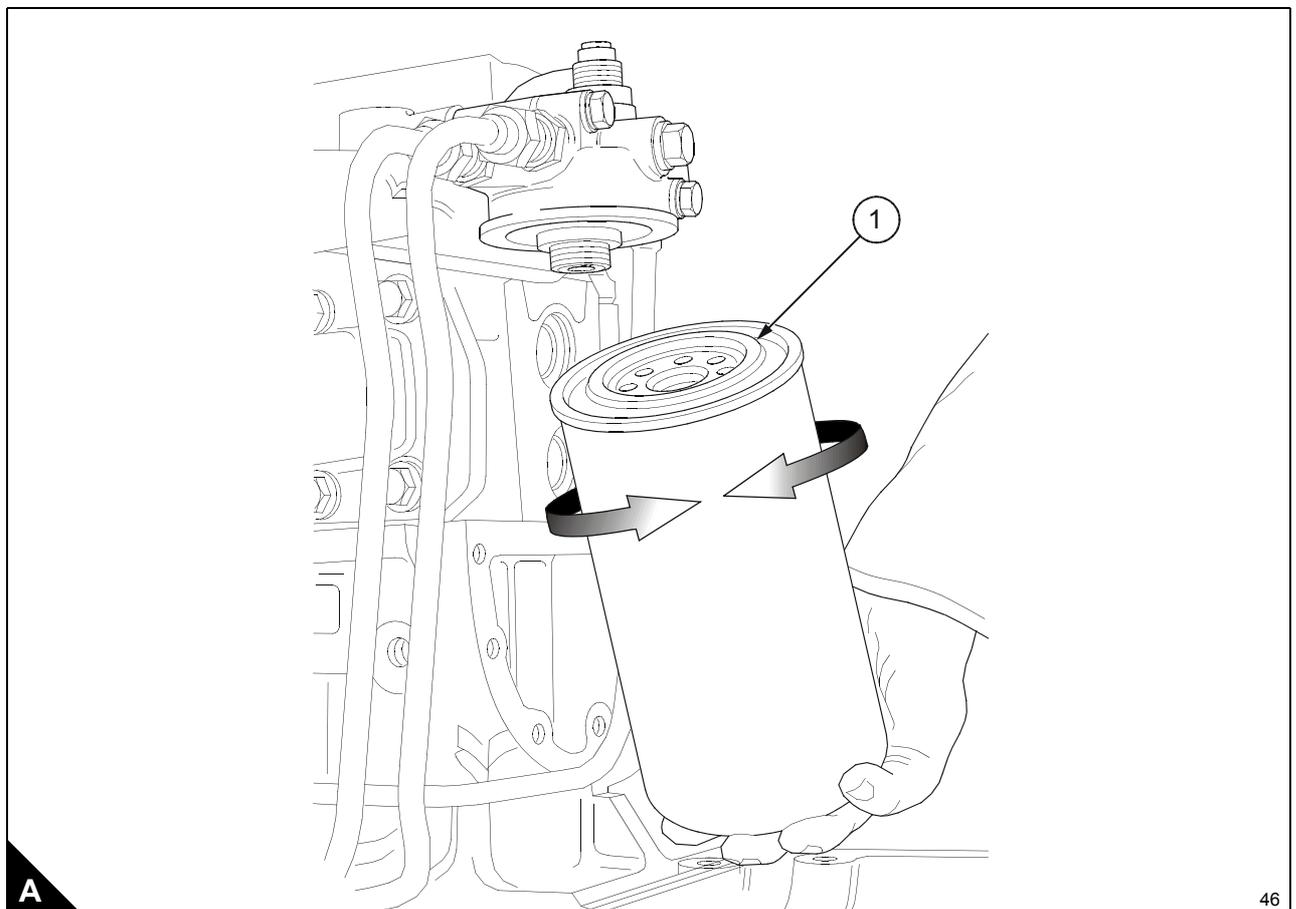
How to renew the canister of the main fuel filter

The main fuel filter is at the rear of the engine on the 'A' bank side and has a single canister.

- 1 Clean the area around the filter and remove the fuel filter canister. If necessary, use a strap wrench 21825 825. Discard the canister.
- 2 Check that the sealing ring (A1) is fitted correctly to the new canister and clean the contact face of the filter head.
- 3 Fill the new canister with clean fuel oil of the correct specification, lubricate the top of the canister seal with clean fuel oil and renew the sealing ring on the adaptor.
- 4 To install the new canister use this procedure: Tighten the canister on its adaptor, until the sealing ring is in contact with the face of the filter head, then turn the canister a further $1\frac{1}{4}$ turns, by hand, or to a torque of 20 Nm (15 lbf ft).

Caution: Do not overtighten.

After the fuel filter canister has been renewed, turn on the fuel supply. Eliminate air from the low pressure fuel system, see "How to eliminate air from the fuel system" on page 41.



How to drain and clean the primary fuel filter

To drain the primary fuel filter

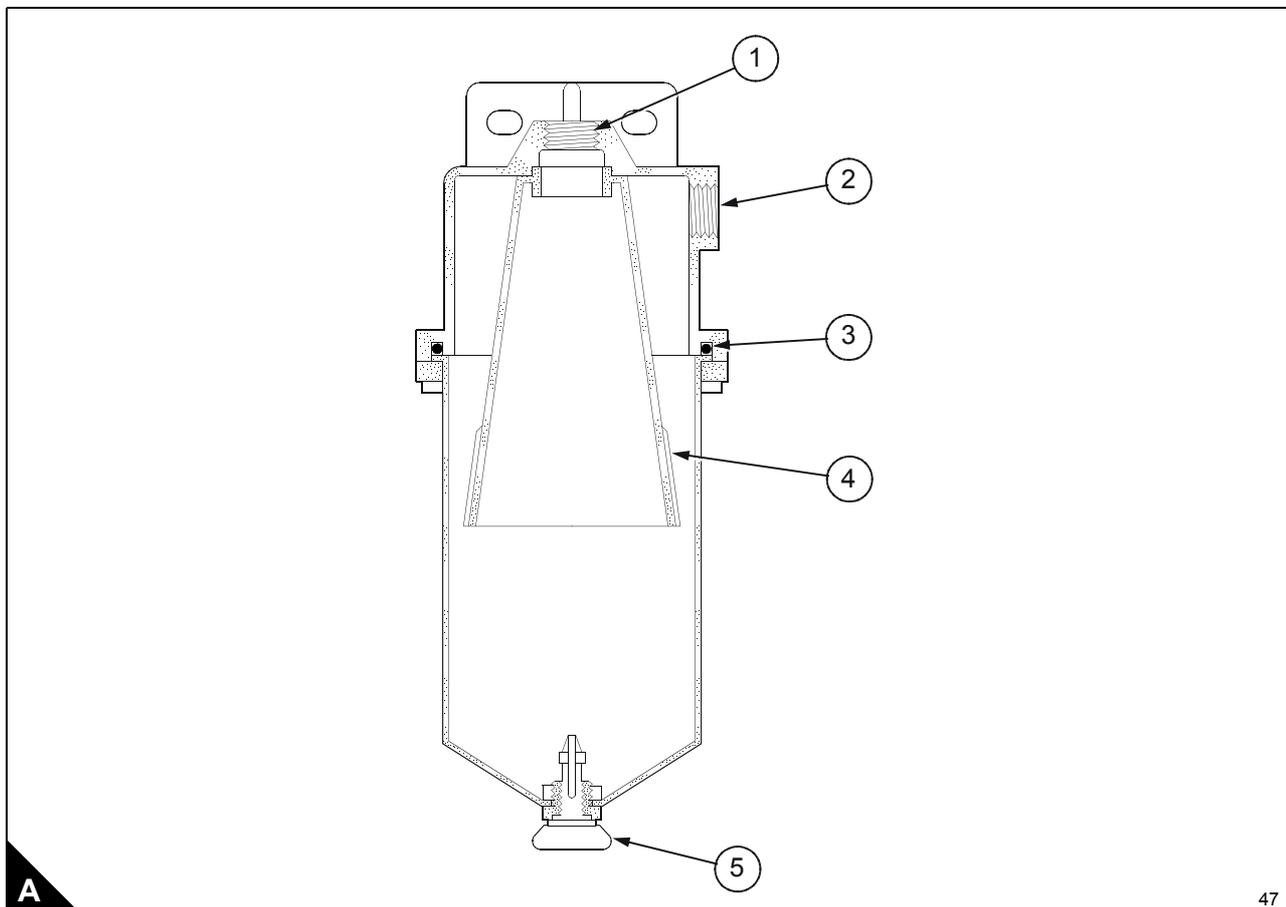
The primary fuel filter (A) is fitted between the fuel tank and the lift pump and works on the principle of centrifugal separation. The fuel is obtained from the tank by the suction of the lift pump and enters the filter through the port (A2).

The fuel rotates around the tapered tube (A4) to cause all sediment and water to move toward the outer wall of the filter, and then to fall to the bottom of the sediment bowl. The fuel flows out through the port (B1) to the fuel lift pump.

- 1 Remove the drain plug (A5) from the base of the filter bowl and allow all water and sediment to drain from the unit.
- 2 Fit the drain plug and tighten it securely.

To clean the primary fuel filter

- 1 Remove the three bolts and remove the sediment bowl.
- 2 Clean all of the components with paraffin and dry them with compressed air.
- 3 Fit the sediment bowl to the filter head, together with a new sealing ring (A3). Align the clamp ring and fasten it with the three bolts.



How to check the specific gravity of the coolant

Drain some coolant from the cooling system after the engine has been stopped and before the formation of sediment. Proceed as follows:

For mixtures which contain inhibited ethylene glycol

- 1 Put a hydrometer, and a reliable thermometer, into the antifreeze mixture and check the readings on both instruments.
- 2 Compare the readings obtained with the chart and adjust the strength of the mixture as necessary.

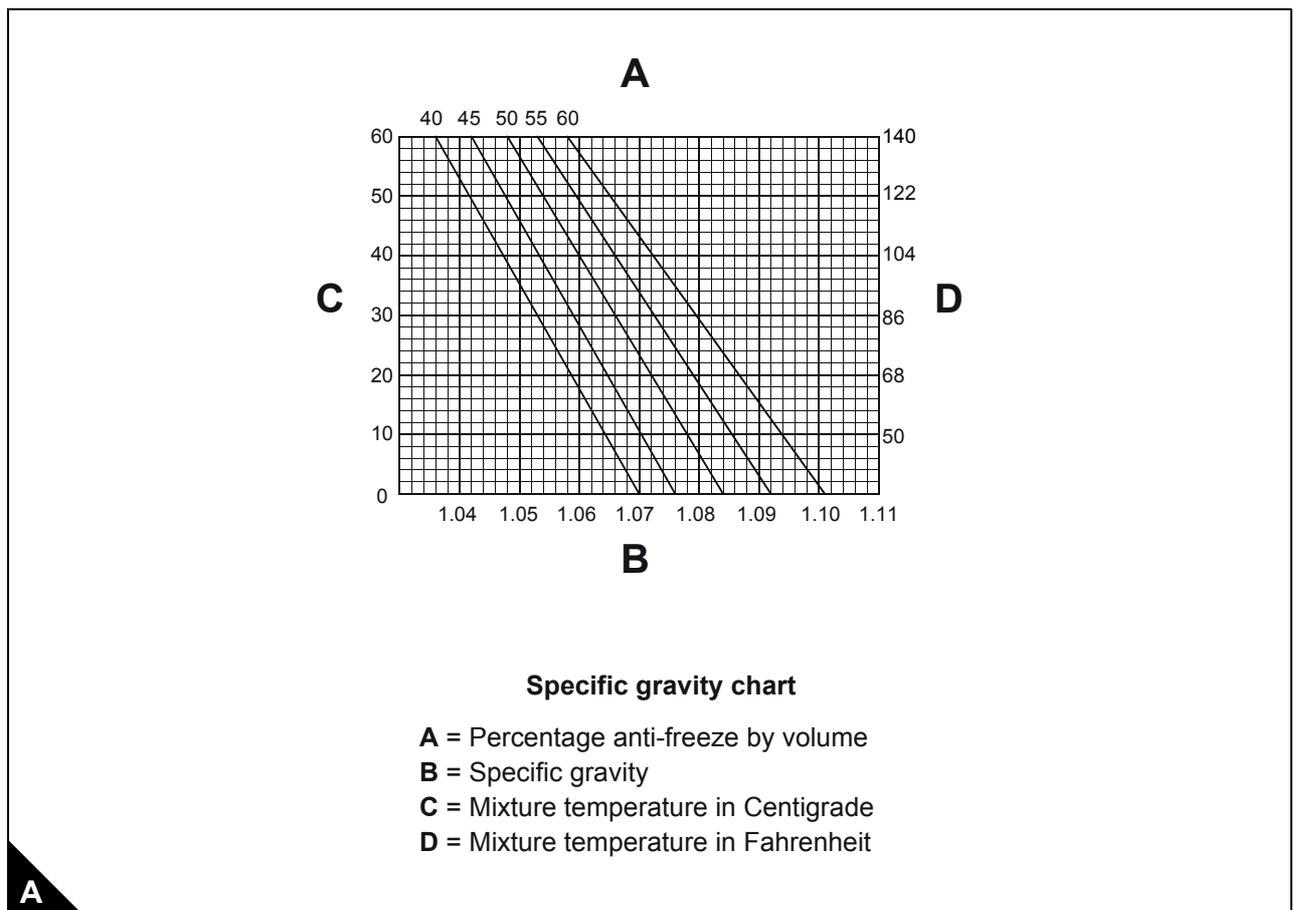
For mixtures which contain inhibited propylene glycol:

- 1 Open the cover of the refractometer, check that the clear panel is clean and use a small syringe to apply three or four drops of the coolant mixture to the clear panel.
- 2 Spread the coolant over the full area of the clear panel and close the cover. Hold the refractometer horizontally with the clear panel at the top and inspect the sample through the viewer.
- 3 Compare the reading with the chart in the instructions; adjust the strength of the mixture as necessary.

Caution: The clear panel must be cleaned thoroughly before use. Some of the fluid which was tested earlier can remain on the clear panel and this will affect the reading of the sample.

Protection against frost is as follows:

Antifreeze/water (% by volume)	Protection down to (°C)
50/50	-35
60/40	-40



How to check the pH value of the coolant

The pH value of the coolant must not be less than pH7 or more than pH9.5. The pH value can be found by the use of a pH meter or test papers, which are available from pharmaceutical manufacturers.

If these limits are exceeded the pH value may be adjusted by the addition of a corrosion inhibitor to the same specification as that already in use. If this is not possible, the system must be drained, flushed and filled with new coolant.

Fuel injector fault

A fuel injector fault can cause an engine misfire.

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

Warnings!

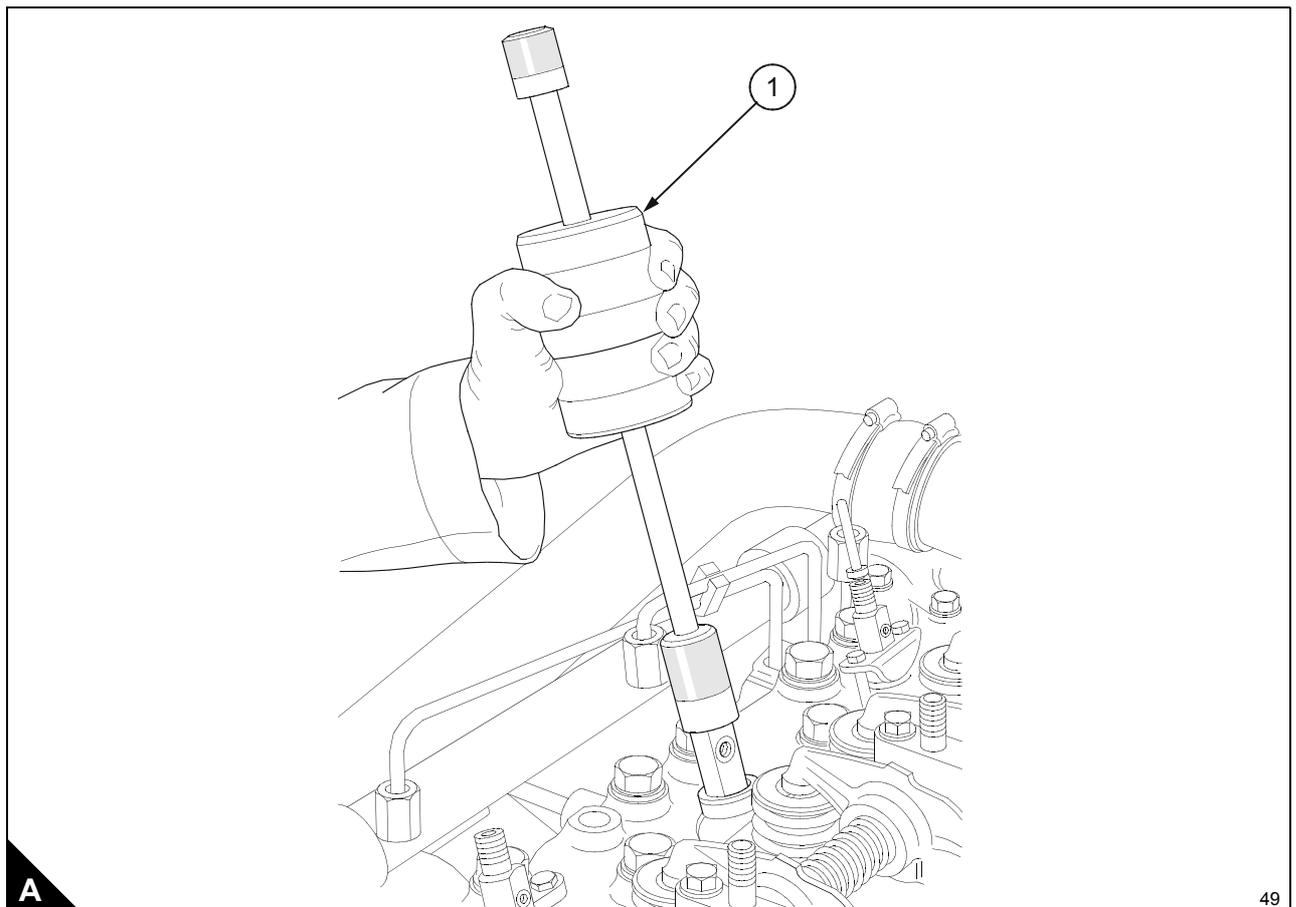
- Ensure that the fuel does not spray onto your skin.
- Ensure that the fan guards are fitted.

How to remove a fuel injector

- 1 Clean the area around the fuel injector.
- 2 Disconnect and remove the leak-off pipe from the fuel injector.
- 3 Disconnect and remove the high pressure pipe. If necessary, release the pipe clip. Do **not** bend the pipe.

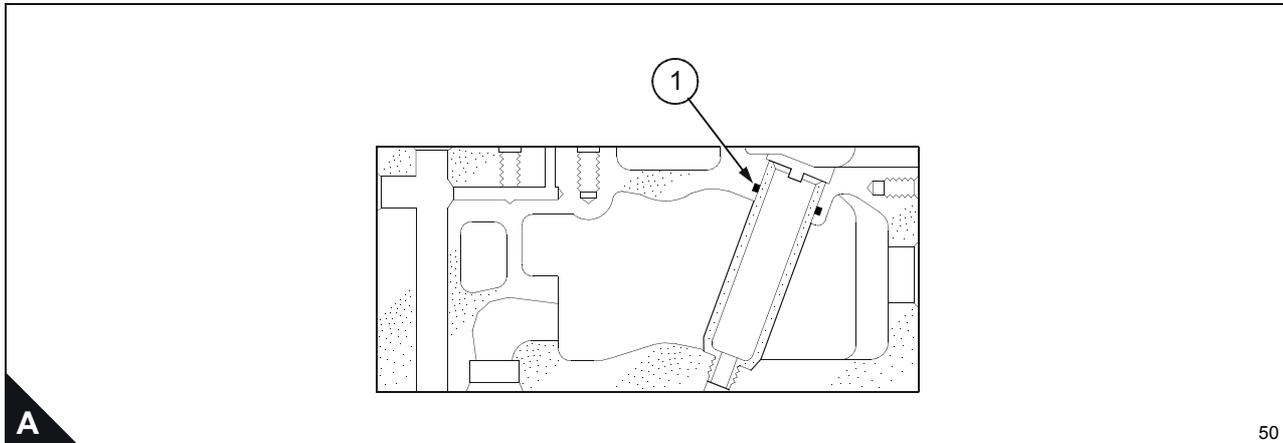
Caution: Ensure that dirt does not enter the fuel injector.

- 4 Remove the bolts and the clamp which retains the fuel injector and withdraw the fuel injector. Remove and discard the copper sealing washer and the rubber seal, and temporarily seal the top of the fuel injector sleeve to prevent the entry of contamination.
- 5 To remove a tight fuel injector, use the slide hammer, 21825 849 (A1) and the relevant adaptor 21825 860.



Fuel injector sleeves

Steel fuel injector sleeves are fitted through the coolant galleries of each cylinder head and are retained by a thread at the bottom of the cylinder head. The thread is sealed with 'Hylomar Universal' sealing compound. The top of the fuel injector sleeve is sealed by an 'O' ring (A1) which is fitted to a groove in the cylinder head.



How to correct a fuel injector sleeve

Before the fuel injectors are renewed, the faces of the seats in the fuel injector sleeves should be cleaned by the method given below.

- 1 To retain carbon and metal particles, grease must be applied to both of the cutters of the tool in the cleaning kit 21825 909 before it is used. Insert the tool into the fuel injector sleeve and remove the carbon deposits from the faces of the seats. **DO NOT REMOVE METAL FROM THE FACES OF THE SEATS.**
- 2 When a fuel injector is removed, if the copper sealing washer remains in the fuel injector sleeve, it can be removed with the tool which is used to clean the fuel injector sleeve.

How to fit a fuel injector

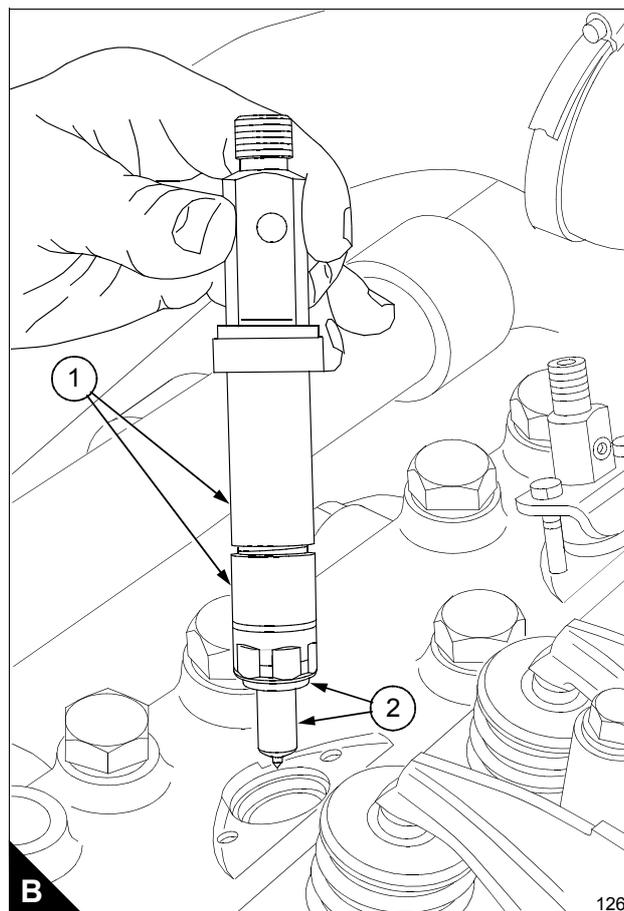
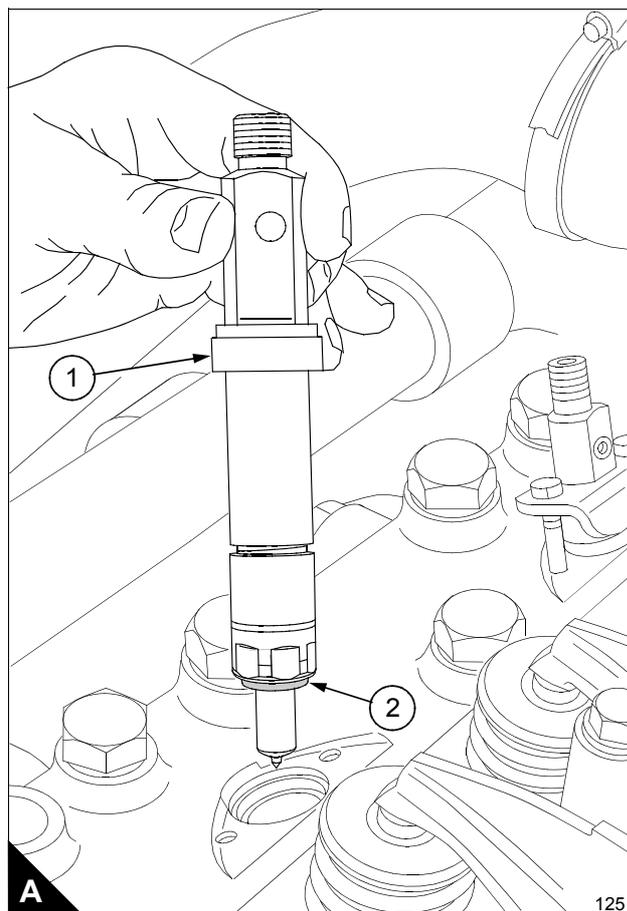
The seal between the nozzle of the fuel injector and the fuel injector sleeve is made by a copper sealing washer which must be renewed at the recommended intervals given in the schedules for the preventive maintenance of the fuel injectors.

To prevent the entry of dirt between the fuel injector and the fuel injector sleeve, a rubber seal is fitted onto the body of the fuel injector over a counterbore in the cylinder head. An aluminium distance piece is then fitted above the rubber seal. When the clamp for the fuel injector is tightened, the rubber seal is pressed into the counterbore. The rubber seal should be renewed at the recommended intervals given in the schedules for the preventive maintenance of the fuel injectors.

- 1 Ensure that the fuel injector sleeve is clean and is free from carbon deposits.
- 2 Fit a new rubber seal (A1) onto the body of the fuel injector and a new copper sealing washer (A2) to the nozzle. Fit the aluminium distance piece above the rubber seal.
- 3 Apply evenly anti-seize compound ('Morris K72' or equivalent) to the body of the fuel injector between the arrows (B1). Do NOT allow the anti-seize compound to contaminate the copper washer or the nozzle of the fuel injector (B2).

Caution: Ensure that dirt does not enter the fuel injector.

- 4 Fit the fuel injector into the fuel injector sleeve. Apply an even layer of anti-seize compound of 1 mm thickness to the threads of the retaining bolts. Retain the fuel injector with the clamp and the bolts. Tighten evenly the bolts to a torque of 11 Nm (8 lbf ft).



Continued

- 5 Fit the high-pressure fuel pipe. Ensure that there is no tension on the connections and that the connections do not turn when the nut is tightened.
- 6 Fit and tighten all clamps which may have been removed.
- 7 Fit the leak-off pipe, complete with new washers, and eliminate air from the fuel system, see "How to eliminate air from the fuel system" on page 41.
- 8 Run the engine and check for leakage.

How to eliminate air from the fuel system

If air enters the fuel system, the injection pump pressure may become insufficient to operate the valves of the fuel injectors and the engine may stop, misfire, run badly or not start.

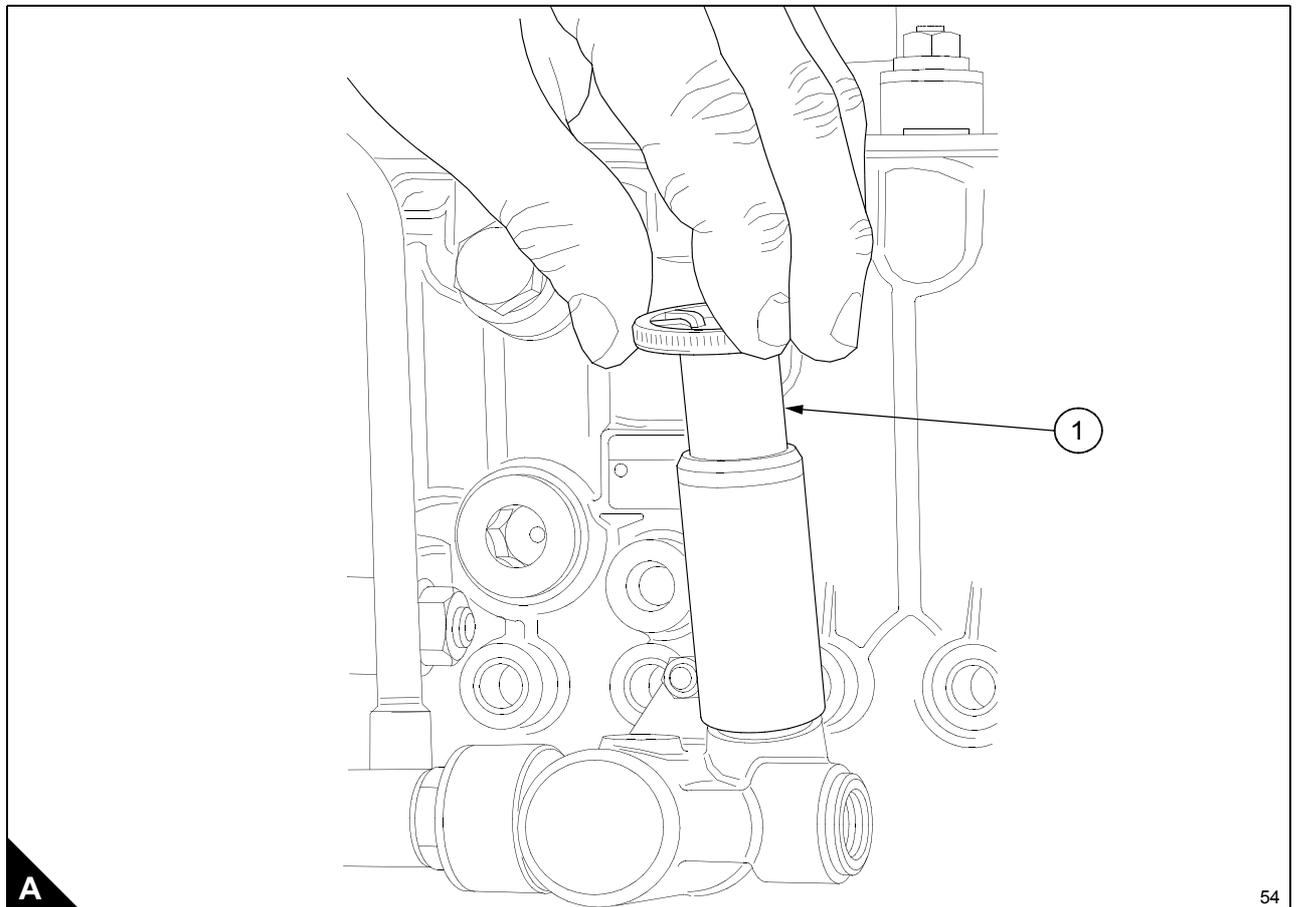
If air has entered the fuel system, the source of the problem must be found and corrected.

Air can enter the system if:

- The fuel tank is drained during normal operation.
- The low-pressure fuel pipes are disconnected.
- There is a leakage in the fuel system during the operation of the engine.
- The fuel filter canister has been removed.
- There is a leakage at the bowl of the primary fuel filter.

To eliminate air from the system, use the procedure which follows:

- 1 Ensure that there is fuel in the fuel tank and that the source of any leakage has been eliminated.
- 2 Loosen the union at the outlet pipe of the lift pump. Operate the hand priming pump (A1) to allow fuel to flow from the union, then tighten the union.
- 3 Continue to operate the hand priming pump and loosen the union on the outlet side of the fuel filter. When fuel which is free from air flows from the union, tighten the union.



Continued

4 Continue to operate the hand priming pump and loosen, one at a time, each union where the high pressure fuel pipe is connected to its fuel injector. Tighten each union once any air has been eliminated.

Caution: *Do not loosen more than one connection at the same time.*

5 When all the unions are tightened fully, continue to operate the hand priming pump until the relief valve on the fuel injection pump is heard to open.

Warnings!

- *Ensure that the pipes have not become bent and that they are free from distortion.*
- *Ensure that unions and clamps have been tightened correctly.*
- *Ensure fuel does not spray onto your skin.*
- *Ensure that spilt fuel has been cleaned away.*

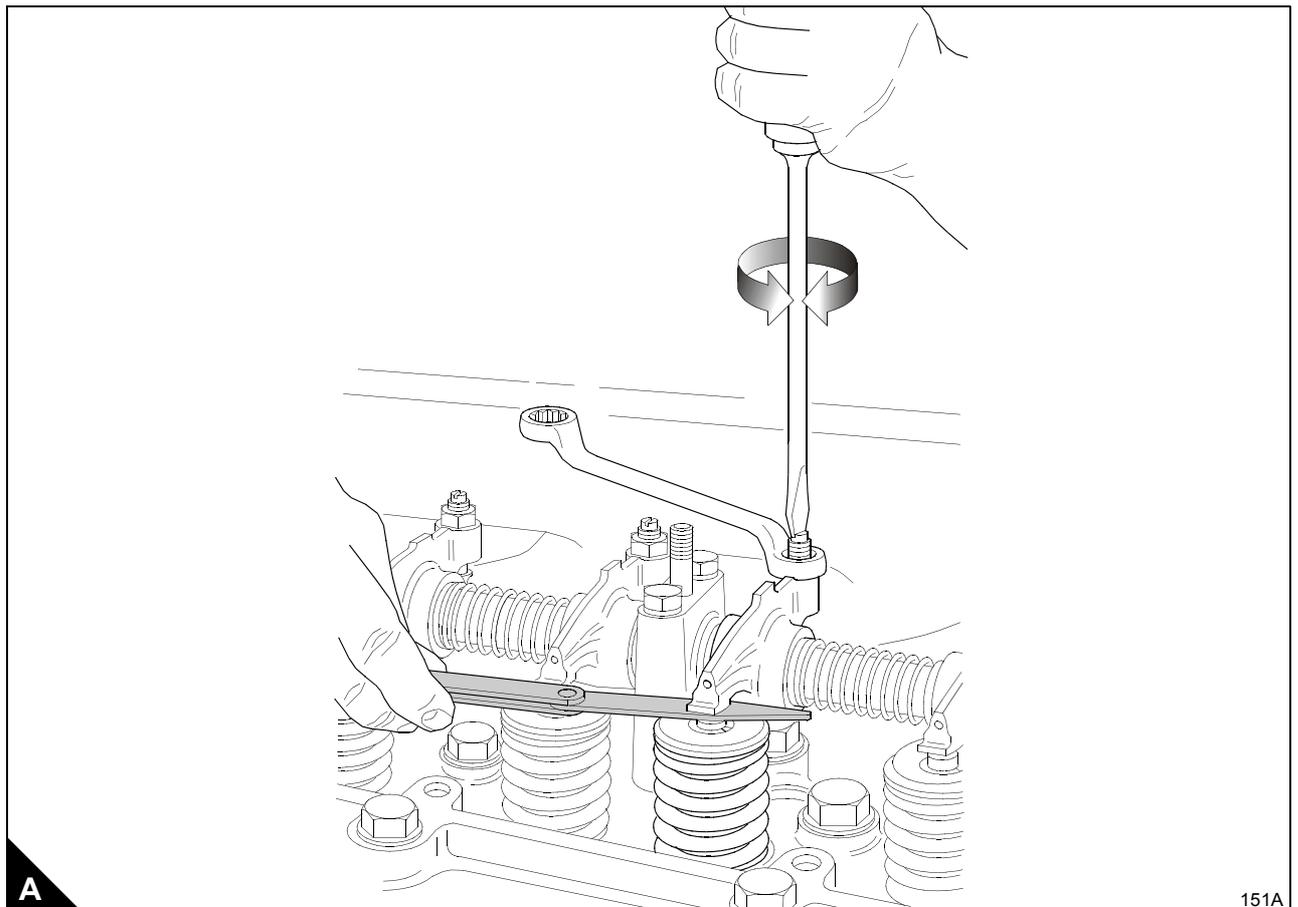
How to check the tappet clearances

Check and adjust the tappet clearances in the sequence which follows, while the injectors are removed for service.

The tappet clearances are measured between the rocker levers and the tips of the valves (A). Refer to "Engine data" on page 9 for the sizes of the clearances.

Valves set on cylinder No	Check tappets on cylinder No
6	1
3	4
5	2
1	6
4	3
2	5

- 1 Remove the rocker covers.
- 2 Turn the crankshaft in the normal direction of rotation until the inlet valve of number 6 cylinder has just opened and the exhaust valve of the same cylinder has not closed completely. The valves of number 6 cylinder are then 'set'.
- 3 Check the clearances of the valves of number 1 cylinder and adjust them if it is necessary (A). When the clearance has been set, tighten the lock nut.
- 4 Continue to turn the engine and adjust the remainder of the tappets in the sequence given above.
- 5 Fit the rocker covers.



Alternator

The alternator which is fitted on the 2000 Series engine is belt driven and has an integral regulator.

The three phase alternator is of the rotating field and stationary armature type. The rectifier consists of six silicon diodes. These are retained by the two heat sinks in the assembly of the rectifier, which is in the housing at the slip ring end.

Excitation of the field is done by three auxiliary diodes which are assembled in the centre of the rectifier.

The output is controlled by an integral regulator and the maximum rated output (hot) is 32 amps at 28 volts.

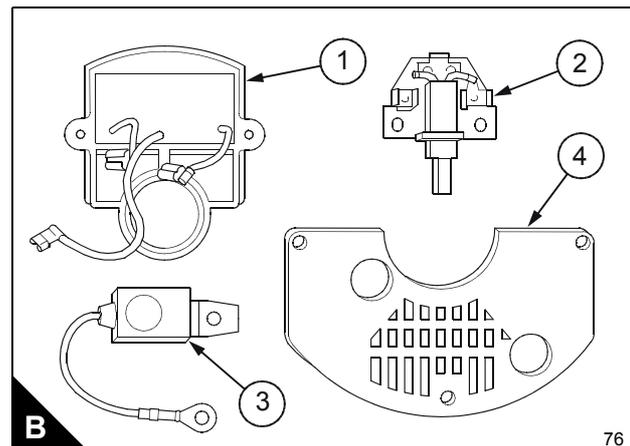
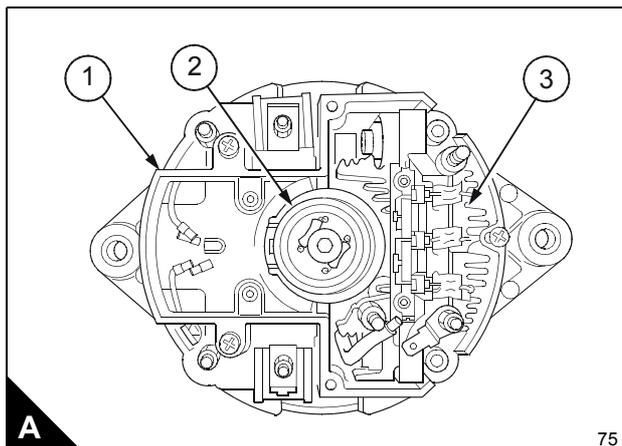
A centrifugal fan causes a flow of cool air through the alternator and the fins of the heat sinks.

How to maintain the alternator

Clean the outside of the alternator and ensure that the ventilation holes are clean, at the periods given in the service schedule. Contamination near to the diodes can cause sparks and must be removed with an approved cleaning fluid. A recommended fluid is Electronic Cleaning Fluid, Grade 8-23, available in aerosol containers or in larger quantities from Applied Chemicals Limited, Uxbridge, Middlesex.

The alternator must be checked and corrected, if necessary, by a person who has had the correct training, at the recommended intervals given in the schedules for the preventive maintenance of the alternator. Proceed as follows:

- 1 Check the condition and the tension of the drive belt, and adjust or renew as necessary.
- 2 Disconnect the two wires of the regulator (B1) from the terminals on the holder (B2) of the carbon brushes. Make a note of the correct position of each wire for their subsequent assembly. Remove the two screws which retain the regulator and lift away the regulator.
- 3 Remove the screws which retain the holder of the carbon brushes, disconnect the wires and lift out the assembly of the holder.
- 4 Check the carbon brushes for damage and ensure that they are suitable for use. The minimum possible protrusion of the carbon brushes from the holder must be 10,0 mm (0.394 in). Renew the carbon brushes if the protrusion is less than 10 mm.
- 5 Remove the four screws which retain the housing of the carbon brushes, withdraw the housing and inspect the assembly of the slip rings.
- 6 Clean the components and remove all of the dirt. Use a soft clean rag which is damp with gasoline or white spirit. Slip rings which are worn or rough must be renewed.



A1 Carbon brush housing
A2 Slip ring assembly
A3 Rectifier assembly

B1 Regulator
B2 Carbon brush holder
B3 Capacitor

B4 Plastic cover

Starter motor

The starter motor is an electrically operated 24 volt unit with a solenoid switch.

fitted on the outside of the yoke. The drive gear engages with a starter ring which is a component of the flywheel assembly.

How to maintain the starter motor

Caution: Before the starter motor is removed from the engine or other work is done to it, disconnect the cables from the battery terminals.

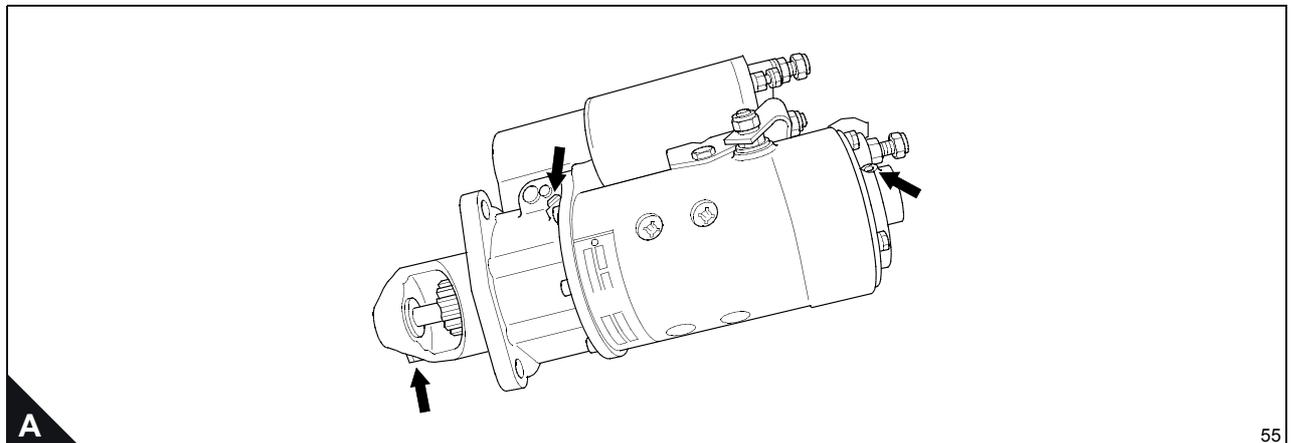
At intervals, inspect the starter cables for damage and ensure that the nuts of the terminals and the bolts which hold the starter motor are tight.

The starter motor must be checked and corrected, if necessary, by a person who has had the correct training, at the recommended intervals given in the schedules for the preventive maintenance of the starter motor.

Remove the starter motor and proceed as follows:

- 1 Clean the outside of the starter motor and remove the commutator cover. Use dry compressed air to remove dust from the area of the carbon brushes.
- 2 Inspect the commutator for wear and damage. A polished dark copper finish indicates that the condition is acceptable. Signs of wear or damage indicate that a new or reconditioned commutator is necessary.
- 3 Ensure that the carbon brushes slide freely in their holder and check that the load of the springs is 1,42 to 1,68 kgf (50 to 59 ozf). An excessively lower load indicates that the carbon brushes are worn. The minimum acceptable length is 15,9 mm (0.625 in).
- 4 If new carbon brushes are necessary, the shape of the contact faces must conform to the radius of the commutator. Keep away the wires of the carbon brushes from other components.
- 5 Spread a thin application of glycerine on the gasket of the cover for the carbon brushes, and fit the ends of the cover across one of the ribbed sections of the yoke. Tighten the two screws which retain the cover to 1,13 to 1,70 Nm (10 to 15 lbf in).
- 6 Remove the screws from the three points shown by arrows (A) and put three or four drops of SAE 5W/20 engine lubricating oil on the lubricator wicks. Fit the screws to the three points.

A new unit, or an exchange unit, should also be lubricated by the same procedure before it is fitted.



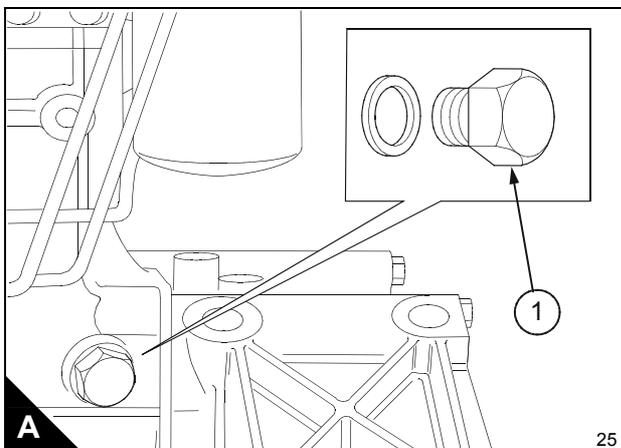
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- 7** Clean the splines of the pinion assembly and lubricate them with a thin application of graphite grease. Check that the pinion moves freely.
 - 8** Ensure that the starter motor is assembled correctly to the engine and retain it securely with the three bolts. Check that the terminals are clean.
 - 9** Fit the lugs of the relevant cables to the two terminals. Ensure that the polarity of the cables is correct and fit the locking washers and the lock nuts, or the stiffnuts if relevant.
 - 10** Hold a 19 mm (0.75 in) A/F spanner on the inner lock nuts to ensure that they do not move while the outer nuts are tightened to 34 Nm to 41 Nm (25 to 30 lbf ft) with a suitable torque wrench.

How to drain the coolant system

Drain and flush the coolant system every 12 months or less. It is recommended that the coolant system is drained as soon as possible after the engine has been stopped and before the formation of sediment. Proceed as follows:

- 1 Ensure that the engine is level.
- 2 Remove carefully the filler cap of the radiator, especially if the engine is hot.
Warning! Use care during the removal of the filler cap as the coolant system will be under pressure.
- 3 Remove the coolant drain plug (A1) from the rear of the left side of the engine. Ensure that the drain holes are not restricted.
- 4 To drain the radiator, refer to the Manufacturer's Instruction Publication.
- 5 Flush the system with clean water.
- 6 Fit the engine drain plug and all items which were removed in accordance with the Manufacturer's Instruction Publication.
- 7 Fit a 'coolant drained' label if the coolant system is not to be filled immediately.



How to clean the coolant system

The coolant system must be drained and flushed through with clean water until it flows clear from all of the drain outlets.

If the system has become contaminated, it must be cleaned. Use clean water with 1% of Symperonic 'N'. This is equivalent to 10 ml/litre or 45 ml/UK gallon.

- 1 Fill the system with clean water, at the same time add the necessary amount of Symperonic 'N' at the filler cap.
- 2 Operate the engine until the coolant reaches the normal temperature of operation, then operate the engine at maximum rated speed for 10 minutes. See the '**Note**' at the end of this section.
- 3 Stop the engine and drain immediately the coolant from all of the drain outlets.
- 4 Allow the engine to cool, then fill the system with clean water. Allow a minimum of 5 litres (1 UK gallon) to drain from the system before the drain outlets are closed.
- 5 Operate the engine as in step 2, but maintain maximum speed for 5 minutes only.
- 6 Repeat steps 3, 4 and 5.
- 7 Drain the system completely and close the drain outlets. Fill the system with the correct coolant mixture.

Note: In very cold ambient conditions, the thermostat may not open to allow full circulation of the cleaning fluid. If this occurs the engine must be operated on load. The thermostat is open when the pipe between the thermostat housing and the radiator is hot. If the pipe is cool, the thermostat valve is closed.

How to fill the coolant system

Fill the system slowly, with the approved coolant mixture, until the coolant is just in contact with the bottom of the filler tube inside the radiator. For radiators which have a short filler tube: check that the level of the coolant mixture is 76 mm (3 in) below the top of the filler tube of the radiator. Operate the engine until the coolant reaches the normal temperature of operation. Stop the engine, check the coolant level and, if necessary, add extra coolant. Fit the filler cap.

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

How to check the turbocharger

Disconnect and remove the pipes from between the air filters and the turbocharger, at the periods given in the service schedule. Turn, rapidly, the rotor assembly, check for freedom of movement and for sounds of interference. If necessary, recondition or renew the turbocharger.

Deposits must not be removed from the turbine wheel nor the compressor wheel, or the balance of the assembly will be affected.

Waste-gates are fitted to the turbochargers of certain engines. These check the boost delivery pressure in the turbocharger compressor and, when it reaches a set amount, a valve opens and releases the excess pressure. The operation of the waste-gate should be checked as follows:

- 1** Apply air pressure up to a maximum of 207 kN/m^2 (30 lbf/in^2) and feel for movement of the end of the control rod. This should be about 1,15 mm (0.045 in).
- 2** If the rod fails to move, disconnect the rod from its lever and try to move the lever by hand. If the lever is tight, that part of the turbocharger must be dismantled and cleaned.
- 3** With the rod still disconnected, test the assembly again with air pressure upto 207 kN/m^2 (30 lbf/in^2). If the rod fails to move, the diaphragm and rod assembly must be renewed.

How to tighten the bolts of the cylinder head

Note: For engines from build line number 91880, this procedure is not necessary because of new procedures used when the engine is assembled.

Caution: Certain engines have a bolt marked "OIL" fitted at position 22 on the illustration (A). For these engines, the special bolt **MUST** be used at the correct position.

- 1 Remove the rocker covers and the rocker assembly.
- 2 Clean the nuts and the heads of the bolts which retain the cylinder heads.
- 3 Make a temporary mark on each nut and the head of each bolt, and also on the cylinder heads. Ensure that the marks are aligned.

Caution: Do **NOT** loosen more than one nut or bolt at a time.

- 4 Work on one nut or one bolt at a time, use the sequence shown in (A) and proceed as follows:

a Remove the bolt, or nut, lubricate lightly the threads and the face under the head of the bolt.

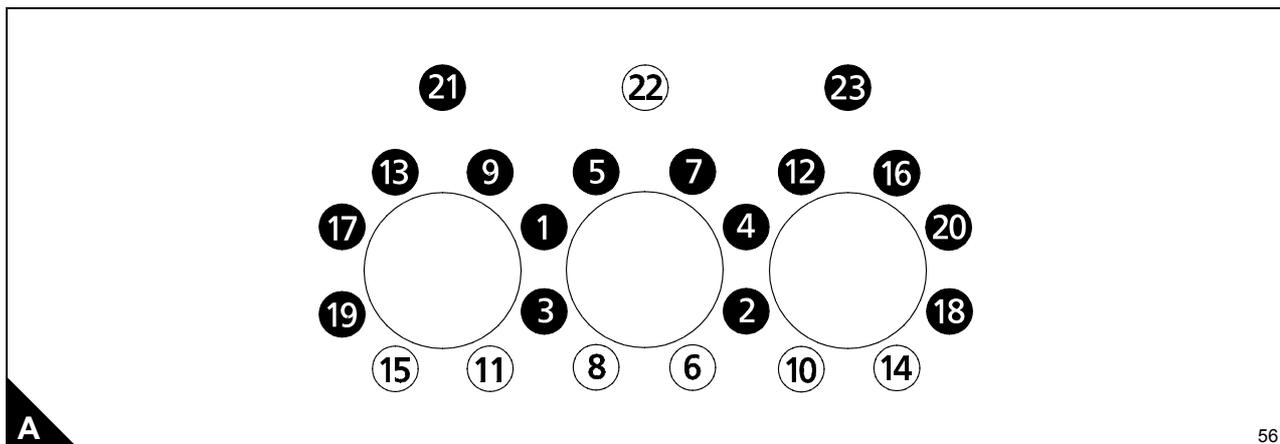
b Fit the bolt or nut and tighten it to 204 Nm (150 lbf ft) or until the marks align (the tighter of the two). If the bolt is one of those shown in a black circle, tighten it by a further 40° or until the marks align (the tighter of the two). A suitable torque angle gauge (part number 21825 924) is available.

c Continue in the correct sequence (A).

- 5 Fit the rocker gear, tighten the bolts evenly and gradually to a torque of 40 Nm (30 lbf ft).

6 Check the tappet clearances and, if necessary, adjust them to the correct dimensions as given in "Engine data" on page 9.

7 Pour approximately 0,6 litre (1 pint) of clean engine lubricating oil over the rocker assembly and fit the rocker covers.



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Coolant pump

Inspect the exterior of the coolant pump. Check for signs of leakage. Overhaul or renew as necessary.

Tensioner pulley for fan belts

At the periods given in the service schedule the tensioner pulley must be inspected. Proceed as follows:

- 1 Remove the fan belts, see "How to adjust the tension of the fan belts" on page 27.
- 2 Check that the pulley assembly is retained securely.
- 3 Check the condition of the bearings and renew if necessary.
- 4 Fit the fan belts and alternator belt, "How to adjust the tension of the alternator belt" on page 28.

Engine damper

At the periods given in the service schedule, examine the engine damper. Check for damage and signs of leakage. Renew if necessary.

Air compressor

At the periods given in the service schedule, check the performance of the air compressor. Examine the exterior for damage or signs of oil or air leaks. Overhaul or renew as necessary.

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Engine fluids

Diesel fuel

Diesel fuel must conform to the specifications given below:

On highway

BS EN 590 1997 - maximum sulphur content 0.05%; minimum cetane number 49 and minimum cetane index 46.

Low sulphur fuels must conform to a lubricity performance such that when tested using HFRR (CEC F-06-A96) the wear scar meets a maximum of 460 microns.

Off highway

BS 2869: Part 2 1998 Class A2 - maximum sulphur content 0.20%; minimum cetane number 45 and minimum cetane index 45.

The use of fuels which do not conform to the above standards can cause damage and/or reduced engine life and could affect the warranty. Further details can be obtained from the Service Department at Perkins Engines Company Limited, Shrewsbury.

Coolant

Coolant mixture

The coolant approved for use in all diesel engines manufactured by PE(S)L is a mixture of 50% inhibited ethylene glycol, or inhibited propylene glycol, and 50% clean soft water.

Mixtures which contain methanol are **NOT** approved.

The corrosion inhibitor in the anti-freeze or coolant concentrate, must be based on sodium nitrite, sodium benzoate, sodium borate, sodium metasilicate and benzotriazole.

Amines or phosphates must not be used. If operators are in doubt, they should consult their source of supply.

In addition, all products which are used should conform to BS 6580-1992.

For marine engines and engines which have aluminium water-cooled exhaust manifolds, only 'BASF 007/400F' or Perkins anti-freeze are approved. The Perkins anti-freeze, part numbers 21825 166 (1 litre) and 21825 167 (5 litre), can be obtained from the Perkins worldwide distributor network.

Caution: Do not use salt water or any other coolant which can cause corrosion in the closed coolant circuit.

Continued

Corrosion inhibitor

If anti-freeze is not available and is not required then clean soft water, with 1% of PE(S)L corrosion inhibitor, may be used. This ratio is equivalent to 0,5 litres of corrosion inhibitor to 50 litres (11 UK gallons) of water. The corrosion inhibitor is available from the Perkins worldwide distributor network, part number 21825 735 (1 litre). The use of this product should be controlled in accordance with the manufacturer's instructions. For CHP (combined heat and power) sets an alternative inhibitor, part number OE45765, is recommended at a strength of 3%.

Water quality

Soft water means de-ionised water, distilled water, rain water, or water from a mains supply which has a maximum combined chloride and sulphate level of 150 mg/litre and a maximum total hardness of 250 mg/litre.

- 1 If soft water is not used, the cooling system may be affected by the formation of hard deposits which can cause the engine to overheat. This is especially important for engines which have coolant added frequently.
- 2 The use of products which are not approved for the cooling system may cause serious problems. Coolant mixtures with insufficient corrosion inhibitor can cause erosion and/or corrosion of the cooling system components.

Lubricating oil

1 Viscosity - Perkins Engines Company Limited recommend the use of SAE15W/40 for all engines that work in ambient temperatures above -15 °C (5 °F). Below -15 °C (5 °F) and down to -20 °C (-4 °F) the use of a 10W/30 oil is recommended. Down to -30 °C (-22 °F) a 5W/40 fully synthetic oil is recommended. For engines which operate in arctic conditions, below -30 °C (-22 °F), contact the Service Department at Perkins Engines Company Limited, Shrewsbury.

2 Performance Specification - For heavy duty operation, base load, or extended drain (Eagle Tx only), super high performance oils (SHPD) must be used. These oils exceed the requirements of ACEA E3 and are listed in the 'preferred' columns of the tables on the following pages.

For light duty operation, oils which exceed the requirements ACEA E2 may be used. These oils are listed in the 'acceptable' columns of the tables on the following pages.

It is recommended that the operator uses oils shown in the 'preferred' columns as these give the greatest protection.

Recommended oils for Europe

Below is a list of oils recommended by Perkins Engines Company Limited, Shrewsbury. The operator must ensure that the oil used conforms to the above requirements.

Manufacturer of lubricating oil	Preferred multi-grade oils which conform to ACEA E3	Acceptable multi-grade oils which conform to ACEA E2
AGIP	Sigma Turbo 15W/40 Blitum T 15W/40	Universal Multifleet 15W/40 Master Super Turbo SHPD 15W/40
BP	Vanellus C3 Extra 15W/40 Vanellus FE Extra 10W/40 Vanellus HT 10W/40 Vanellus HT Extra 10W/40	Vanellus C3 Multi-grade 15W/40
CALTEX	ONLY AVAILABLE IN FAR EAST, MIDDLE EAST, SOUTHERN AND EASTERN AFRICA AND AUSTRALASIA	
CASTROL	Syntruck 5W/40 Dynamax 10W/40 Turbomax 15W/40	RX Super Plus 15W/40
CHEVRON	Delo XLD 15W/40 Delo SHP 15W/40	Delo 500 15W/40
ELF	Performance EXPERTY 10W/40 Performance TROPHY DX 15W/40	Performance Super D 15W/40 Performance 3D 15W/40
ESSO	Essolube XTS 501 Essolube XT 401	Essolube XTS 301 Essolube XT 301
FINA	Kappa First 5W/30 Kappa Extra 15W/40 Kappa Ultra 10W/40	Kappa Supra 15W/40
FUCHS	Turbolene HPE 15W/40 Titan Unic Plus 10W/40 Titan Cargo MC 10W/40	Titan Formel Plus 15W/40 Turbolene D 15W/40 Turbolene D Plus 15W/40
KUWAIT	Q8T 700 15W/40 Q8T 710 15W/40 Q8T 800 10W/40	Q8T 500 15W/40
MILLERS	Multifleet XPD 15W/40 Truckmaster Global XD 15W/40 Truckmaster XHFE 10W/40	Maxifleet MP 15W/40 Suprex 15W/40
MOBIL	Delvac 1 SHC 5W/40 Delvac XHP 15W/40 Delvac HP 15W/40	Delvac MX 15W/40
MORRIS	XHD Plus 15W/40 XHD FE 10W/40 Ring Free Ultra 10W/40	Duplex CDX 15W/40 XHD 15W/40
SHELL	Rimula Ultra 5W/30 Rimula Super 15W/40	Rimula X 15W/40 Rimula TX 15W/40
SUN	Super HPD 15W/40	Forza 15W/40
TEXACO	URSA Super TDX 10W/40 URSA Super TD 15W/40	URSA Super LA 15W/40
TOTAL	Rubia TIR 8600 10W/40 Rubia TIR 6400 15W/40	Rubia 4400 15W/40 Rubia XT 15W/40

Recommended oils for remainder of the world

Below is a list of oils recommended by Perkins Engines Company Limited, Shrewsbury. The operator must ensure that the oil used conforms to the above requirements.

Manufacturer of lubricating oil	Mono-grade oils which conform to ACEA E2	Preferred multi-grade oils which conform to ACEA E3	Acceptable multi-grade oils which conform to ACEA E2
AGIP		Sigma Turbo 15W/40 Blitum T 15W/40	Universal Multifleet 15W/40 Master Super Turbo SHPD 15W/40
BP	Vanellus C3 30 Vanellus C3 40	Vanellus C3 Extra 15W/40 Vanellus FE Extra 10W/30	Vanellus C3 multi-grade 15W/40
CALTEX	Delo SHP SAE 30 and SAE 40 Delo 600 SAE 30 and SAE 40 Delo 350 SAE 30 and SAE 40	Delo XLD multi-grade SAE 10W/40	Delo SHP multi-grade SAE 15W/40 Delo 600 multi-grade SAE 15W/40 Delo 350 multi-grade SAE 15W/40
CASTROL		Syntruck 5W/40 Dynamax 10W/40 Turbomax 15W/40	RX Super Plus 15W/40
CHEVRON	Delo 1000 Marine SAE 30 or 40	Delo 400 multi-grade SAE 15W/40	RPM Heavy Duty Motor oil 15W/40
ELF	Performance Super D SAE 30 and 40 Performance 3D SAE 30 and 40	Performance TROPHY DX 15W/40	Performance Super D 15W/40 Performance 3D 15W/40
ESSO	Essolube X 301 SAE 30 Essolube X 301 SAE 40 Essolube XD 3+ SAE 30 Essolube XD 3+ SAE 40	Essolube XT 431 Essolube XD 3 Extra+	Essolube XT 331 Essolube XD 3+
FINA	Kappa Super 3 Kappa Super 40	Kappa First 5W/30 Kappa Extra 15W/40 Kappa Ultra 10W/40	Kappa Supra 15W/40
KUWAIT	Q8T 500 SAE 30 Q8T 500 SAE 40	Q8T 700 15W/40 Q8T 710 15W/40 Q8T 800 10W/40	Q8T 500 15W/40
MOBIL	Delvac 1430 Delvac 1330	Delvac 1 SHC 5W/40 Delvac XHP 15W/40 Delvac HP 15W/40	Delvac MX 15W/40
MORRIS	XHD SAE 30 or 40	XHD Plus 15W/40 XHD FE 10W/40	Duplex CDX 15W/40 XHD 15W/40
SHELL	Rimula X 30 Rimula X 40	Rimula Ultra 5W/30 Rimula Super 15W/40	Rimula X 15W/40 Rotella TX 15W/40
SUN	Super HPD 40	Super HPD 15W/40	Forza 15W/40
TEXACO	URSA Super LA 30 URSA Super LA 40	URSA Super TD 10W/40 URSA Super TD 15W/40	URSA Super LA 15W/40
TOTAL	Rubia FP 40	Rubia TIR 8600 15W/40 Rubia TIR 6400 15W/40	Rubia 4400 15W/40 Rubia XT 15W/40

Warranty

The engine must be operated with the approved fuel, lubricant and coolant, and maintained in accordance with the service schedule or the warranty can become invalid.

6

Fault diagnosis

Problems and possible causes

Problem	Possible causes	
	Checks by the user	Checks by service personnel
The starter motor turns the engine too slowly	1, 2, 3, 4	
The engine will not start	5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 17	34, 35, 36, 37, 38, 42, 43, 44
The engine is difficult to start	5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 19	34, 36, 37, 38, 40, 42, 43, 44, 64
Not enough power	8, 9, 10, 11, 12, 13, 16, 17, 18, 19, 20, 21	34, 36, 37, 38, 39, 42, 43, 44, 61, 63, 64
Misfire	8, 9, 10, 12, 13, 15, 20, 22	34, 36, 37, 38, 39, 40, 41, 43
High fuel consumption	11, 13, 15, 17, 18, 19, 21, 22	34, 36, 37, 38, 39, 40, 42, 43, 44, 63, 64
Black exhaust smoke	11, 13, 15, 17, 19, 21, 22	34, 36, 37, 38, 39, 40, 42, 43, 44, 61, 63, 64
Blue or white exhaust smoke	4, 15, 21, 23	36, 37, 38, 39, 42, 44, 45, 52, 58, 62
The pressure of the lubricating oil is too low	4, 24, 25, 26	46, 47, 48, 50, 51, 59
The engine knocks	9, 13, 15, 17, 20, 22, 23	36, 37, 40, 42, 44, 46, 52, 53, 60
The engine runs erratically	7, 8, 9, 10, 11, 12, 13, 15, 16, 18, 20, 22, 23	34, 38, 40, 41, 44, 52, 60
Vibration	13, 18, 20, 27, 28	34, 38, 39, 40, 41, 44, 52, 54
The pressure of the lubricating oil is too high	4, 25	49
The engine temperature is too high	11, 13, 15, 19, 27, 29, 30, 32	34, 36, 37, 39, 52, 55, 56, 57
Crankcase pressure	31, 33	39, 42, 44, 45, 52
Bad compression	11, 22	37, 39, 40, 42, 43, 44, 45, 53, 60
The engine starts and stops	10, 11, 12	6, 7, 8, 9, 10, 12, 16, 34, 35

Code list of possible causes

- 1 The battery capacity is low.
- 2 A bad electrical connection.
- 3 A fault in the starter motor.
- 4 The wrong grade of lubricating oil.
- 5 The starter motor turns the engine too slowly.
- 6 The fuel tank is empty.
- 7 A fault in the stop control.
- 8 A restriction in a fuel pipe.
- 9 A fault in the fuel lift pump.
- 10 A dirty element of the fuel filter.
- 11 A restriction in the air filter or the induction system.
- 12 There is air in the fuel system.
- 13 A fault in the fuel injectors, or the fuel injectors are of the wrong type.
- 14 The cold start system is not used correctly.
- 15 A fault in the cold start system.
- 16 A restriction in the vent of the fuel tank.
- 17 The wrong type or grade of fuel has been used.
- 18 A restriction in the movement of the engine speed control.
- 19 A restriction in the exhaust pipe.
- 20 The engine temperature is too high.
- 21 The engine temperature is too low.
- 22 The tappet clearances are incorrect.
- 23 Too much oil, or oil of a wrong specification is used in a wet type air cleaner.
- 24 Not enough lubricating oil in the sump.
- 25 A defective gauge.
- 26 A dirty element of the lubricating oil filter.
- 27 The fan is damaged.
- 28 A fault in the mountings of the engine or the flywheel housing.
- 29 Too much lubricating oil in the sump.
- 30 A restriction in the air passages or in the water passages of the radiator.
- 31 A restriction in the breather.
- 32 There is insufficient coolant in the system.
- 33 A fault in the exhauster, or there is a leakage in the vacuum pipe.
- 34 A fault in the fuel injection pump.
- 35 A broken drive on the fuel injection pump.
- 36 The timing of the fuel injection pump is incorrect.
- 37 The valve timing is incorrect.
- 38 There is bad compression.
- 39 The cylinder head gasket leaks.
- 40 The valves are not free.
- 41 Wrong high-pressure pipes.
- 42 The cylinder bores are worn.
- 43 A leakage between the valves and the seats.
- 44 The piston rings are not free, or they are worn or damaged.
- 45 The valve stems and/or the guides are worn.
- 46 The crankshaft bearings are worn or damaged.

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- 47 The lubricating oil pump is worn.
 - 48 The relief valve does not close.
 - 49 The relief valve does not open.
 - 50 The spring of the relief valve is broken.
 - 51 A fault in the suction pipe of the lubricating oil pump.
 - 52 A piston is damaged.
 - 53 The piston height is incorrect.
 - 54 The flywheel housing, or the flywheel, is not aligned correctly.
 - 55 A fault in the thermostat or the thermostat is of a wrong type.
 - 56 A restriction in the coolant passages.
 - 57 A fault in the water pump.
 - 58 There is damage to the oil seals (if they are fitted) of the valve stems.
 - 59 A restriction in the sump strainer.
 - 60 A valve spring is broken.
 - 61 The impeller of the turbocharger is damaged or is dirty.
 - 62 Leakage of lubricating oil from the oil seal of the turbocharger.
 - 63 The induction system leaks (turbocharged engines).
 - 64 Damaged or defective waste-gate (if fitted).

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