
Perkins 2300 Series

Models 2306A-E14 and 2306C-E14

USER'S HANDBOOK

6 cylinder turbocharged 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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General information

Introduction

The 2306 diesel engine 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 relevant information for your specific engine type, refer to "Engine identification" on page 5.

The terms "left side" and "right side" apply when the engine is seen from the rear end, the flywheel end. Number one cylinder is at the front end of the engine

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. 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.
 - Do not wash an engine while it runs or while it is hot. If cold cleaning fluids are applied to a hot engine, certain components on the engine could be damaged.
 - Fit only genuine Perkins parts.

How to care for your engine

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

Caution: Do not clean an engine while it runs. If cold cleaning fluids are applied to a hot engine, certain components on the engine may be damaged.

To obtain the best performance and the longest life from your engine, you must ensure that the maintenance operations are done at the correct intervals, refer to "Preventive maintenance periods" on page 15.

Ensure that all adjustments and repairs are done by personnel who have had the correct training.

Engine lift equipment

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.

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.

Engine preservation

Details not available at time of print.

Parts and service

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

Service literature

Workshop manuals and other service publications are available from your authorised distributor.

Training

Courses on the service and overhaul of the 2306 engine are available at the Factory. For details apply to: The Product Training Centre, Perkins Engines Company Limited, Peterborough, PE1 5NA, England.

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: FGB060125U 2905J, which consists of these codes:

F	Code for engine capacity
G	Engine application
B	Engine type
06	Number of engine cylinders
0125	Engine specification number
U	The country of manufacture
2905	Build line number
J	Year of manufacture

Engine data

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	16:1
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)

2

Engine views

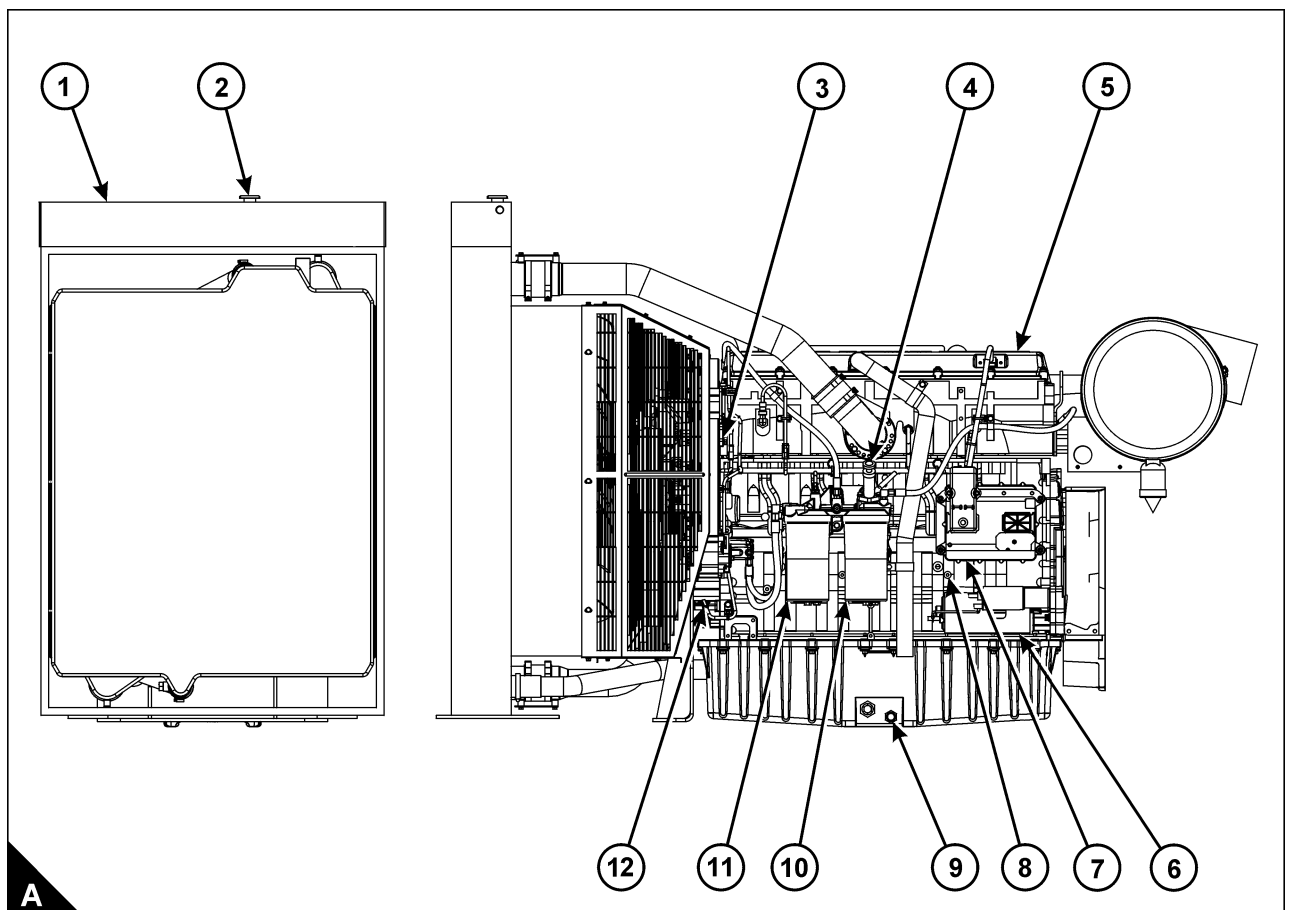
Introduction

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

Location of engine parts

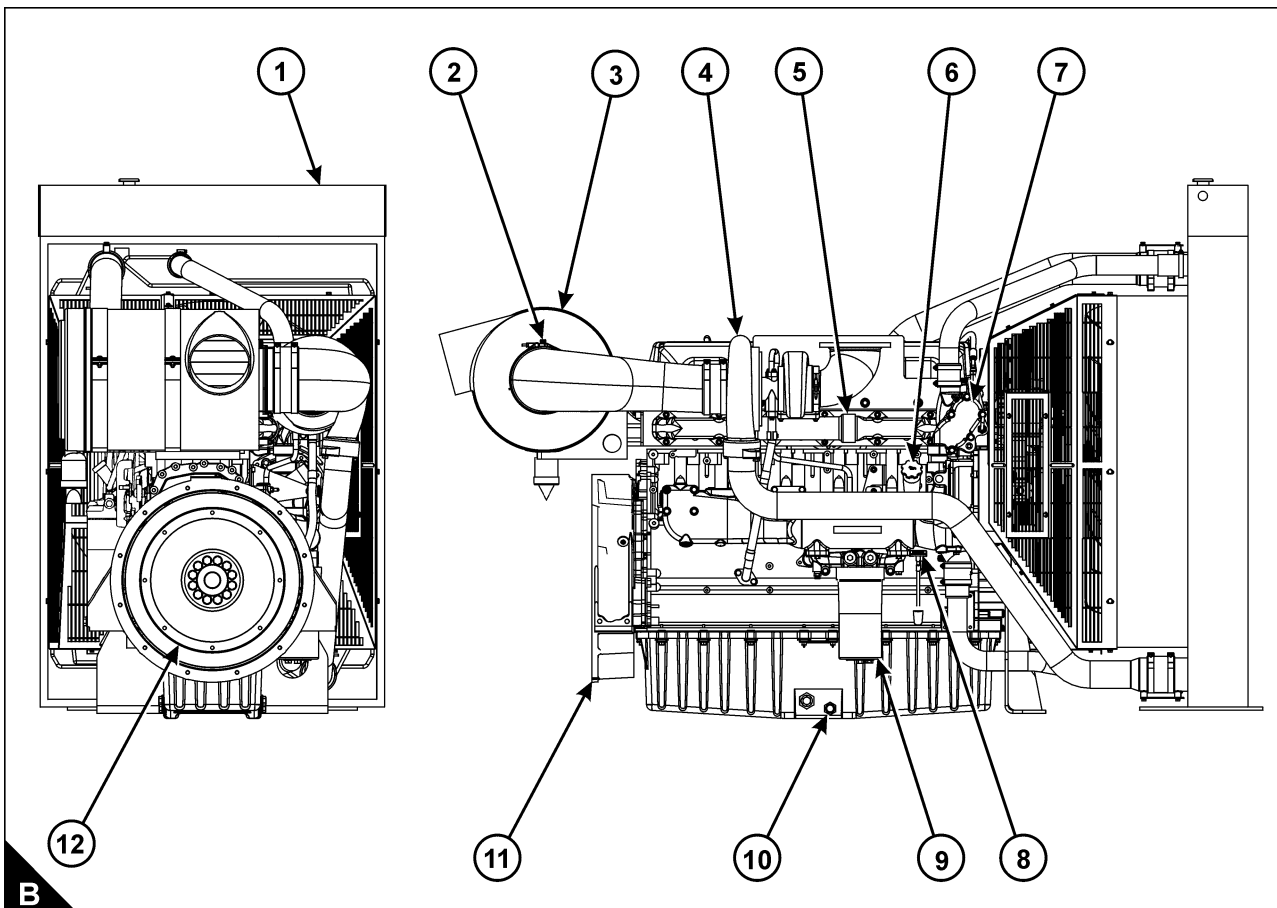
Front and left side view of engine (A)

- | | |
|-----------------------|-----------------------------------|
| 1 Radiator | 7 Electronic Control Module (ECM) |
| 2 Radiator filler cap | 8 Earth stud |
| 3 Speed/timing sensor | 9 Sump drain plug |
| 4 Hand priming pump | 10 Secondary fuel filter |
| 5 Rocker cover | 11 Primary fuel filter |
| 6 Starter motor | 12 Speed/timing sensor |



Rear and right side view of engine (B)

- | | |
|----------------------------------|--------------------------|
| 1 Radiator | 7 Thermostat housing |
| 2 Restriction indicator | 8 Dipstick |
| 3 Air cleaner | 9 Lubricating oil filter |
| 4 Turbocharger | 10 Sump drain plug |
| 5 Exhaust manifold | 11 Flywheel housing |
| 6 Filler cap for lubricating oil | 12 Flywheel |



3

Operation instructions

How to start the engine

Before the engine is started

Perform the required daily maintenance and other periodic maintenance before the engine is started. Refer to "Preventive maintenance periods" on page 15.

- Check the fuel supply. Drain water from the water separator. Open the fuel supply valve.

Caution: All valves in the fuel return line must be open before and during engine operation to help prevent high fuel pressure. High fuel pressure can cause failure of the filter housing or other damage.

Note: If the engine has not been started for several weeks, fuel may have drained from the fuel system. Air may have entered the filter housing. Also, when fuel filters have been changed, some air pockets will be trapped in the engine. If necessary refer to "How to eliminate air from the fuel system" on page 48.

- Do not start the engine or move any of the controls if there is a "DO NOT OPERATE" label or similar warning label attached to the start switch or to the controls.
- Ensure that the areas around rotating parts are clear.
- Reset all of the shutdown devices or alarm components.
- Check the level of the engine lubricating oil. Maintain the oil level between the "L" and the "H" marks on the dipstick.
- Check the level of the coolant. Maintain the level of coolant within 13 mm (0.5 inch) of the bottom of the filler pipe. If the engine is fitted with a sight glass, maintain the coolant level in the sight glass.
- Check the service indicator for the air cleaner. When the red warning indicator is seen through the clear panel after the engine has stopped, the air filter element must be renewed.
- Ensure that any driven equipment has been disengaged. Remove any electrical loads.

How to start a new, an overhauled engine or an engine which has been in storage

Prime the turbocharger. This can be achieved by cranking the engine briefly with no fuel.

When a new engine, or an engine which has been serviced, is first started, prepare to stop the engine if an overspeed condition occurs. Use the quickest method available, for example: Emergency Stop button.

Start procedure

This start procedure may be used for all engines which are not fitted with an air inlet heater.

Refer to the Owner's Manual of the OEM for your type of controls. Use this procedure to start the engine:

- 1 Move the ignition switch to the ON position. If a system fault is indicated by, for example a panel light, investigate the cause. If necessary use the Perkins Electronic Service Tool, EST.
- 2 Push the start button or turn the ignition switch to the START position to crank the engine.
- 3 If the engine fails to start within 30 seconds, release the start button or ignition switch. Wait for 30 seconds to allow the starter motor to cool before attempting to start the engine again.

Note: A system fault may be indicated after the engine is started. If this occurs the ECM has detected a problem with the system. Investigate the cause, if necessary use the Perkins service tool EST.

Caution: *Oil pressure should rise within 15 seconds after the engine starts. The electronic engine controls monitor the oil pressure and will stop the engine if the oil pressure is below normal.*

- 4 If possible, allow the engine to run at no load for approximately three minutes. Run the engine at no load until the water temperature gauge has started to rise. Check all gauges during the warm-up period.

How to start a cold engine in cold conditions

Refer to the Owner's Manual of the OEM for your type of controls. Use the procedure which follows to start the engine.

Warning! *DO NOT USE ETHER. The use of ether could result in engine damage and/or personal injury.*

The engine will start without aids down to a temperature of -10 °C (14 °F), but the ability to start at temperatures below 10 °C (50 °F) will improve by the use of a cylinder block coolant heater or a device which heats the crankcase oil. This will help to reduce white smoke and misfires when the engine is started in cold weather.

Note: If the engine has not been run for several weeks, fuel may have drained. Air may have moved into the filter housing. Also, when fuel filters have been changed, some air will be left in the filter housing. Refer to "How to eliminate air from the fuel system" on page 48.

- 1 Move the ignition switch to the ON position. If a system fault is indicated by, for example a panel light, investigate the cause. If necessary use the Perkins Electronic Service Tool, EST.
- 2 Push the start button or turn the ignition switch to the START position to crank the engine.
- 3 If the engine fails to start within 30 seconds, release the start button or ignition switch. Wait for 30 seconds to allow the starter motor to cool before attempting to start the engine again. Repeat for a maximum of three times; if the engine fails to start investigate the cause,
- 4 A system fault may be indicated after the engine is started. If this occurs the ECM has detected a problem with the system. Investigate the cause, if necessary use the Perkins service tool EST. Refer to the Diagnostic Manual for more information on engine diagnostics.

Note: Oil pressure should rise within 15 seconds after the engine starts. The electronic engine controls monitor the oil pressure and will stop the engine if the oil pressure is below normal.

- 5 If possible, allow the engine to run at no load for approximately three minutes. Run the engine at no load until the coolant temperature gauge starts to rise. Check all gauges during the warm-up period.

Caution: *The oil pressures and fuel pressures should be in the normal range on the instrument panel. Do not apply a load to the engine until the oil pressure gauge indicates at least normal pressure. Inspect the engine for leaks and/or unusual noises.*

Important notes

The cold start strategy will be activated when the coolant temperature is below 17 °C (63 °F). The cold start strategy will continue until the coolant temperature reaches 28 °C (82 °F), or until the engine has been running for 14 minutes. A timer will disable the cold start strategy after a maximum time of 14 minutes.

If the cold start strategy is active and if the ECM measures engine speed, the engine power that is available is reduced.

After the ECM has completed the cold mode (or the cold mode is disabled), it cannot be enabled again until the ECM is switched OFF.

If an engine has been stopped, for example after a fault has been indicated, do not attempt to restart the engine until it has fully stopped.

After the engine has started

- 1 Check all of the gauges during the warm-up period.
- 2 Perform another walk-around inspection. Check the engine for fluid leaks and air leaks.

Note: Gauge readings should be observed and the data should be recorded frequently while the engine runs. A comparison of the data over time will help to determine normal readings for each gauge, it will also help to detect abnormal conditions of operation. Significant changes in the readings should be investigated.

Engine emergency stop

Caution: *Emergency shut-off controls are for EMERGENCY use ONLY. For the normal stop procedure DO NOT use emergency shut-off devices or controls.*

Ensure that any components for the external system that support the engine operation are secured after the engine is stopped.

Manual stop procedure

Individual applications will have different control systems. Ensure that the engine shut-down procedures are understood. To stop the engine, use the general guidelines which follow:

- 1 Run the engine with no load for five minutes to allow it to cool.
- 2 After the cool-down period, turn the start switch to the OFF position.

Engine diagnostics

Self-diagnostics

Perkins electronic engines can perform a self-diagnostics test. Diagnostic codes are stored in the permanent memory of the Electronic Control Module (ECM) and can be retrieved by use of the Perkins electronic service tool, EST. A list of diagnostic codes is given in the table under "Diagnostic codes" on page 20.

Some installations have electronic displays that provide a direct reading of the engine diagnostic codes. Refer to the manual that is provided by the OEM for more information on retrieving engine diagnostic codes.

Active codes, indicated by a warning lamp or similar device (depending on application), represent problems that currently exist. These problems should be investigated first.

Logged codes represent:

- Intermittent problems
- Recorded events
- Performance history

The problems may have been repaired since the code was logged. These codes do not indicate that a repair is needed; the codes are guides or signals when a situation exists. Codes may be helpful to diagnose problems.

When the problems have been corrected, the corresponding logged fault codes should be cleared, where possible.

Use the Perkins service tool EST to determine the diagnostic code.

Fault logging

The system provides the capability of fault logging. When the Electronic Control Module (ECM) generates a diagnostic code, the code will be logged in the memory of the ECM. The codes that have been logged in the memory of the ECM can be retrieved with Perkins electronic service tools. The codes that have been logged can be cleared with Perkins electronic service tools. The codes that have been logged in the memory of the ECM will be automatically cleared from the memory after 100 hours. If the engine is operated in protection override mode, then low engine oil pressure and high engine coolant temperature events cannot be cleared without a factory password.

Engine operation with active diagnostic codes

If a fault is indicated during normal engine operation, the system has identified a situation that is not within the specification. Use Perkins electronic service tools to check the active diagnostic codes.

The active diagnostic code should be investigated. The cause of the problem should be corrected as soon as possible. If the cause of the active diagnostic code is repaired, and there was only one active diagnostic code, the warning lamp or similar device will turn off.

Engine operation with intermittent diagnostic codes

If during normal engine operation a fault is indicated by a fault lamp or similar device and the lamp or device then returns to normal, an intermittent fault may have occurred. If a fault has occurred, the fault will be logged in the memory of the Electronic Control Module (ECM).

In most cases, it is not necessary to stop the engine because of an intermittent code. However, the operator should retrieve the codes and refer to the relevant information to identify the nature of the event. The operator should note the circumstances that are involved during the time that the lamp was on:

- Engine load
- Limits of the engine speed
- Excessive smoke, etc.

This information can be useful to help diagnose the situation. The information can also be used for future reference. For more information on diagnostic codes, refer to the Diagnostic Manual for this engine.

Customer specified parameters

Customer specified parameters that will enhance the fuel efficiency and the operator's convenience can be programmed into the Electronic Control Module (ECM). Some parameters may affect engine operation. This may lead to complaints from the operator about power or performance. The engine related parameters which follow may be programmed by the customer, by use of the Perkins electronic service tool, to influence the operation of the engine:

- Engine ratings selection, the ability to choose between the relevant torque maps (prime/stand-by, 50/60 Hz)
- Governor gain tuning parameters
- Analogue throttle enable
- Equipment identification
- Droop set point
- Engine acceleration rate
- Enable speed selection by the use of an external switch
- Enable droop/isochronous selection by the use of an external switch

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. Use the periods which are shortest. 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.

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

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

- A** Daily
- B** Every 250 hours or 12 months
- C** Every 500 hours or 12 months
- D** Every 12 months
- E** Every 1000 hours or 24 months
- F** Every 3000 hours or 24 months
- G** Every 5000 hours

A	B	C	D	E	F	G	Operation
●							Check the amount of coolant
●							Check the air cleaner service indicator
●							Check the amount of lubricating oil in the sump
●							Drain water/sediment from the primary fuel filter
●							Visual inspection
	●						Check battery electrolyte level
	●						Drain water/sediment from fuel tank
		●					Perform diagnostics check
		●					Renew the element of the primary fuel filter
		●					Renew the element of the secondary fuel filter
		●					Check the specific gravity and the pH value of the coolant
		●					Renew the engine lubricating oil ⁽¹⁾⁽²⁾
		●					Renew the element of the lubricating oil filter
		●					Inspect/adjust/renew the alternator and fan belts
		●					Inspect the crankshaft vibration damper
		●					Inspect/clean/tighten the earth stud
		●					Inspect/renew the coolant hoses, air hoses and hose clips
		●					Inspect and, if necessary, clean the exterior of the radiator/charge cooler
		●					Inspect the engine mountings
			●				Drain and flush the coolant system and renew the coolant mixture
				●			Check/adjust the tappet clearances and the electronic unit injectors ⁽³⁾
					●		Check the engine protection devices ⁽³⁾
					●		Renew the thermostats of the coolant system
					●		Check/clean/calibrate the engine speed/timing sensors
					●		Inspect the turbocharger ⁽³⁾
						●	Inspect the battery charging alternator ⁽³⁾
						●	Inspect the starter motor ⁽³⁾
						●	Inspect the coolant pump

(1) The life of the engine lubricating oil may be extended by the use of an oil sample analysis programme.
(2) For TAG2 engines, with the 1/2 TA luff option, which operate at standby duty with an average load factor of 80%, the lubricating oil MUST be changed at 250 hour intervals.
(3) By a person who has had the correct training.

How to check the amount of the coolant

Check the coolant level when the engine is stopped and cool.

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

- 1 Remove the filler cap from the expansion tank slowly to relieve the pressure.
- 2 Maintain the coolant level at the bottom of the filler pipe.
- 3 Clean the filler cap and check the condition of the filler cap gaskets. Renew the filler cap if the gaskets are damaged. Fit the filler cap.
- 4 Inspect the coolant system for leaks.

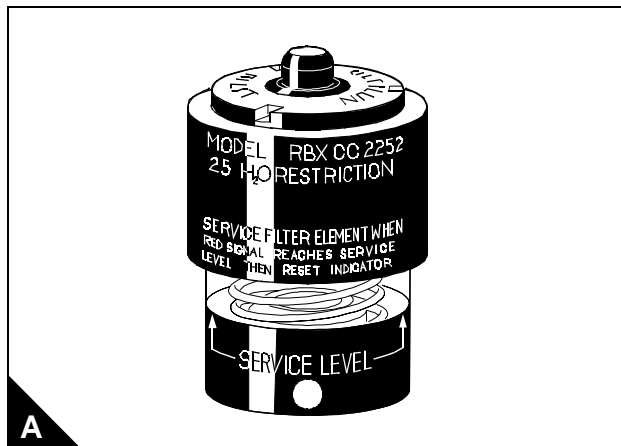
How to check the air cleaner service indicator

Caution: Do not operate the engine if there is a blockage in the air filter or the air ducts. This can cause lubricating oil to enter the cylinders through the engine breather valve.

The air filter is fitted with a restriction indicator (A) which gives a visual warning when the filter needs a service. When the red warning indicator is seen through the clear panel after the engine has stopped, the air filter element must be renewed.

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

Environmental conditions have an important effect on the frequency at which the air filter needs to be serviced.



How to check the amount of lubricating oil

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

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

- 1 Check the oil level with the engine stopped. The level must be maintained between the "L" mark and "H" mark on the dipstick.
- 2 If necessary, remove the oil filler cap and add more oil of the same grade and specification as that which is already in the system. Do not overfill.
- 3 Clean and fit the oil filler cap.

How to drain the primary fuel filter

At the periods given in the service schedule, the bowl of the primary fuel filter must be checked and, if necessary, drained.

- 1 Open the drain; the drain is self-ventilated. Use a suitable container to collect the water drained from the filter housing. Dispose of the water safely.
- 2 Close the drain. Tighten the drain valve securely to prevent air from entering the fuel system.

Visual inspection

A visual inspection should take only a few minutes and can prevent costly repairs and accidents.

- For maximum engine life, inspect the engine compartment before the engine is started. Look for items such as oil or coolant leaks, loose fastenings, worn belts or loose connections. Repair as necessary.
- The guards must be at the correct positions. Repair damaged guards or renew missing guards.
- Wipe all caps and plugs before the engine is serviced to reduce the chance of system contamination.
- For any type of leak (coolant, lubricating oil or fuel), clean away the fluid. If a leak is observed, find the source and correct the leak. If a leak is suspected, check the fluid levels frequently until the leak is found and repaired.
- Accumulated grease and/or oil on an engine is a fire hazard. Remove it by steam cleaning or by the use of a high pressure water jet.
- Ensure that the coolant pipes are fitted correctly and that they are secure. Check for leaks. Check the condition of all pipes.
- Inspect the coolant pump for leaks.

Note: The coolant pump seal is lubricated by the coolant in the coolant system. It is normal for a small amount of leakage to occur as the engine cools and the parts contract.

- Excessive coolant leakage may indicate the need to renew the coolant pump seal. For the removal of the coolant pump and the installation of the coolant pump and/or coolant pump seals, refer to the Workshop Manual.
- Inspect the lubrication system for leaks at the front crankshaft seal, the rear crankshaft seal, the sump, the oil filter and the rocker cover. If many oil leaks are present, particularly on an old engine, there could be a blockage of the engine breather.
- Inspect the fuel system for leaks. Check for loose fuel line clamps or for loose ties on the fuel lines.
- Inspect the ducts for the air inlet system and the elbows for cracks. Check also for loose clamps and check the condition of mounting rubbers. Ensure that hoses and tubes are not in contact with other hoses, tubes, wiring harnesses, etc.
- Inspect the fan belts and the alternator belt for cracks, breaks or other damage. Where more than one belt is used between two pulleys, all of the belts must be renewed together. Maximum belt life will only be obtained if the belts are maintained at the correct tension.
- Drain the water and sediment from fuel tanks on a daily basis to ensure that only clean fuel enters the fuel system.
- Inspect the wiring and the wiring harnesses for loose connections and for worn or frayed wires.
- Inspect the earth strap for a good connection and for good condition.
- Inspect the ECM-to-cylinder head earth strap for a good connection and for good condition.
- Disconnect any battery chargers which are not protected against the current drain of the starter motor. Check the condition and the electrolyte level of the batteries, unless the engine is fitted with a maintenance free battery.
- Check the condition of the gauges. Renew any gauges that are cracked. Renew any gauge that cannot be calibrated.

Diagnosics check

At the periods specified in the service schedule, use the Perkins Electronic Service Tool to retrieve the diagnostic codes. A key to the codes is given below. Refer to the relevant Diagnostic Manual for further details.

Diagnostic codes

CID-FMI	Diagnostic code description
1-11	Injector cylinder No. 1 fault
2-11	Injector cylinder No. 2 fault
3-11	Injector cylinder No. 3 fault
4-11	Injector cylinder No. 4 fault
5-11	Injector cylinder No. 5 fault
6-11	Injector cylinder No. 6 fault
41-03	8 volt Sensor power supply open/short to B+
41-04	8 volt Sensor power supply short to ground
91-08	PWM Speed control abnormal
100-03	Engine oil pressure sensor open/short to B+
100-04	Engine oil pressure sensor short to ground
110-03	Engine coolant temp sensor open/short to B+
110-04	Engine coolant temp sensor short to ground
168-02	Intermittent battery power to the ECM
172-03	Intake manifold temperature sensor open/short to B+
172-04	Intake manifold temperature sensor short to ground
174-03	Fuel temperature sensor open/short to B+
174-04	Fuel temperature sensor short to ground
190-02	Engine speed sensor data intermittent
190-09	Engine speed sensor abnormal update
190-11, 12	Engine speed sensor mechanical fault
248-09	Perkins data link communications abnormal
253-02	Check customer or system parameters
254-12	ECM Fault
261-13	Engine timing calibration required
262-03	5 volt Sensor power supply open/short to B+
262-04	5 volt Sensor power supply short to ground
268-02	Check programmable parameters
273-03	Turbo outlet pressure sensor open/short to B+
273-04	Turbo outlet pressure sensor short to ground
274-03	Atmospheric pressure sensor open/short to B+
274-04	Atmospheric pressure sensor short to ground
281-03	Action alert lamp open/short to B+
281-04	Action alert lamp short to ground
281-05	Action alert lamp open circuit
282-03	Engine overspeed lamp open/short to B+
282-04	Engine overspeed lamp short to ground
285-03	Engine coolant temperature lamp open/short to B+
285-04	Engine coolant temperature lamp short to ground
286-03	Engine lubricating oil pressure lamp open/short to B+
286-04	Engine lubricating oil pressure lamp short to ground
286-05	Engine lubricating oil pressure lamp open circuit
323-03	Engine shutdown lamp open/short to B+
323-04	Engine shutdown lamp short to ground
323-05	Engine shutdown lamp open circuit

CID-FMI	Diagnostic code description
324-03	Engine warning lamp open/short to B+
324-04	Engine warning lamp short to ground
324-05	Engine warning lamp open circuit
342-02	Engine speed sensor No. 2 data intermittent
342-11, 12	Engine speed sensor No. 2 mechanical fault
443-03	Crank terminate relay open/short to B+
799-12	Service tool fault
1266-03	Diagnostic lamp open/short to B+
1266-04	Diagnostic lamp short to ground
1690-8	Analogue throttle signal abnormal

How to renew the element of the primary fuel filter

Cautions:

- Do not allow dirt to enter the fuel system. Clean thoroughly the area around a fuel system component that will be disconnected. Fit a suitable cover to any disconnected component of the fuel system.
- Do not loosen fuel pipes or fittings except where indicated in this handbook.

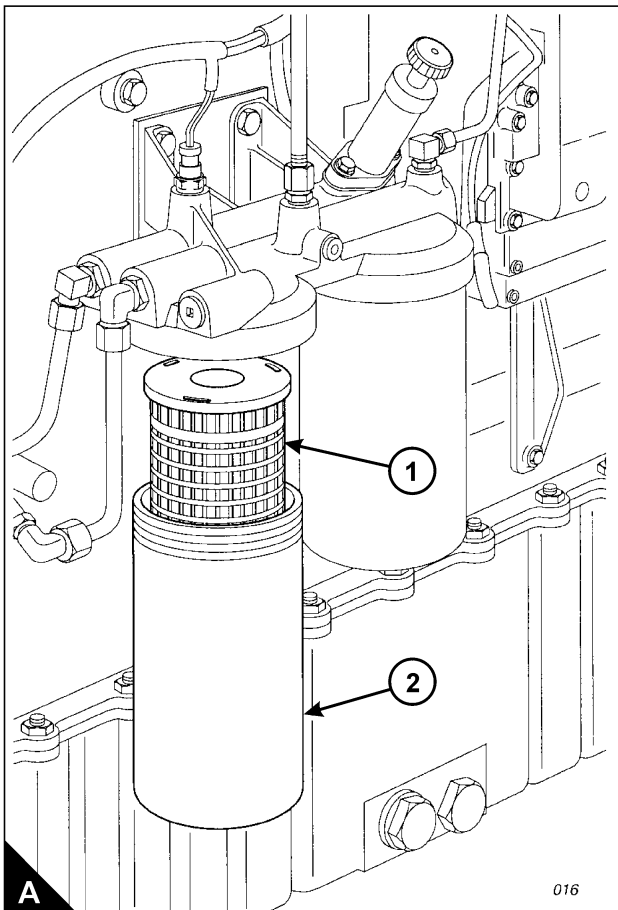
- 1 Stop the engine. Turn the start switch to the "OFF" position. Disconnect the battery.
- 2 Close the fuel tank supply valve. Remove the drain plug from the base of the filter housing (A2) and drain the water and fuel into a suitable container. Dispose of the mixture safely.
- 3 Remove the filter housing, remove the 'O' ring seal from the housing and withdraw the filter element (A1).

Warning! Discard the used filter element and 'O' ring seal in a safe place and in accordance with local regulations.

- 4 Clean the inside of the housing and the housing thread with clean fuel oil and clean the contact face of the filter head. Clean the drain plug and fit it to the housing.

Notes:

- 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.
- The correct filter element will be marked with the symbol shown (B).

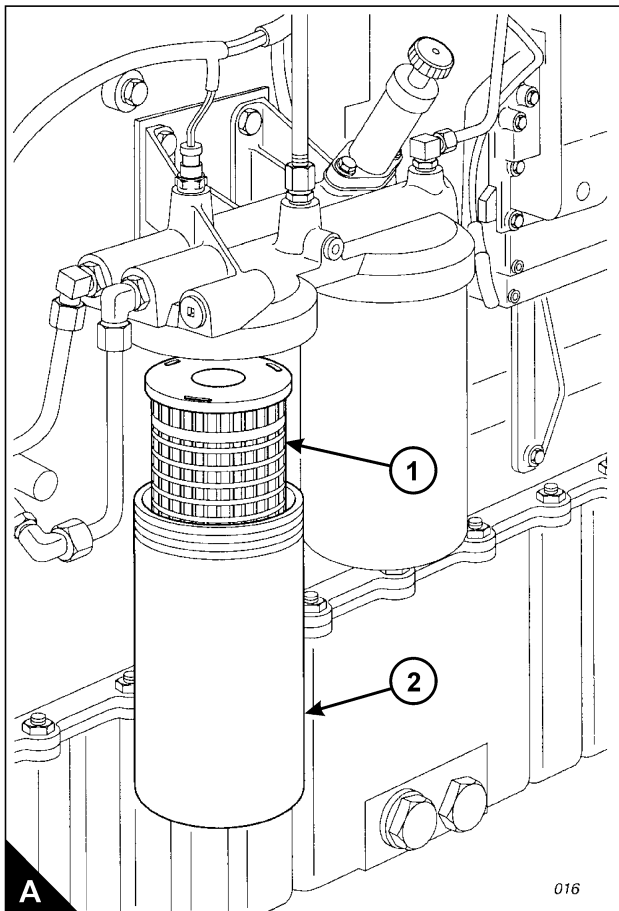


Continued

5 Fit a new element (A1) into the housing (A2), ensure that it engages fully with the guide in the base of the housing. Fit a new 'O' ring seal to the top of the housing.

Cautions:

- *It is important that only genuine Perkins parts are used. The use of wrong parts could damage the fuel injection equipment.*
 - *Do not fill the primary fuel filter with fuel before installation. The fuel would not be filtered and could be contaminated. Contaminated fuel will cause accelerated wear to components of the fuel system.*
- 6 Fit the housing onto the filter head. Tighten the housing to a torque of 80 Nm (59 lbf ft). Do NOT overtighten. Ensure that the drain plug is tightened securely.
- 7 Clean away any fuel which has been spilled.
- 8 Open the fuel tank supply valve and eliminate air from the fuel system as given in "How to eliminate air from the fuel system" on page 48.
- 9 Check for leaks.



How to renew the element of the secondary fuel filter

Cautions:

- Do not allow dirt to enter the fuel system. Clean thoroughly the area around a fuel system component that will be disconnected. Fit a suitable cover to any disconnected component of the fuel system.
- Do not loosen fuel pipes or fittings except where indicated in this handbook.

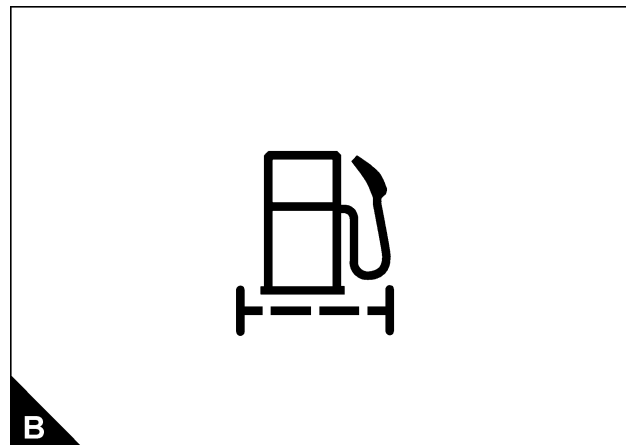
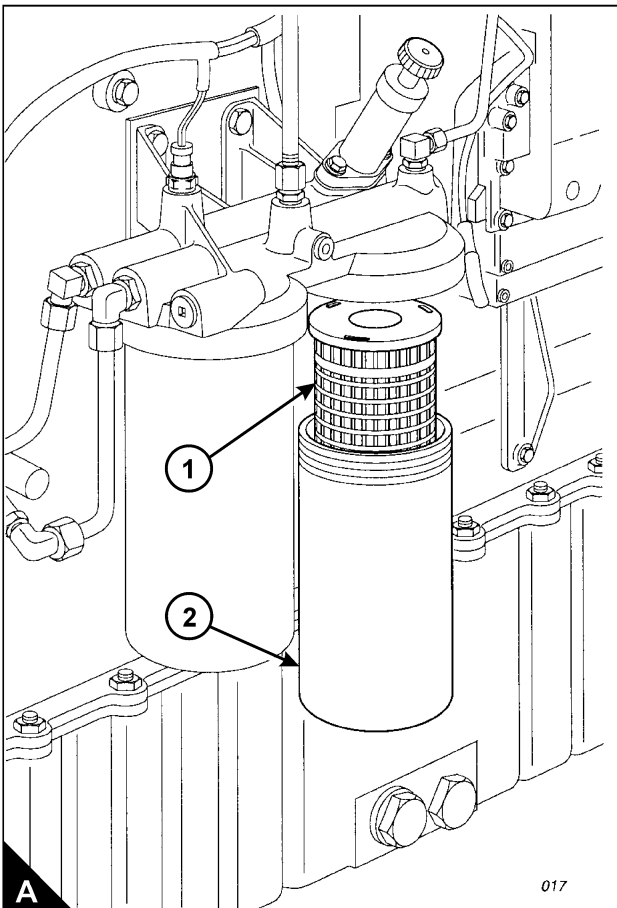
- 1 Stop the engine.
- 2 Turn the start switch to the "OFF" position. Disconnect the battery.
- 3 Close the fuel tank supply valve. Remove the drain plug from the base of the filter housing (A2) and drain the fuel into a suitable container.
- 4 Remove the filter housing, remove the 'O' ring seal from the housing and withdraw the filter element (A1).

Warning! Discard the used filter element and 'O' ring seal in a safe place and in accordance with local regulations.

- 5 Clean the inside of the housing and the housing thread with clean fuel oil and clean the contact face of the filter head. Clean the drain plug and fit it to the housing.

Notes:

- 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.
- The correct filter element will be marked with the symbol shown (B).



Continued

6 Fit a new element (A1) into the housing (A2), ensure that it engages fully with the guide in the base of the housing. Fit a new 'O' ring seal to the top of the housing.

Cautions:

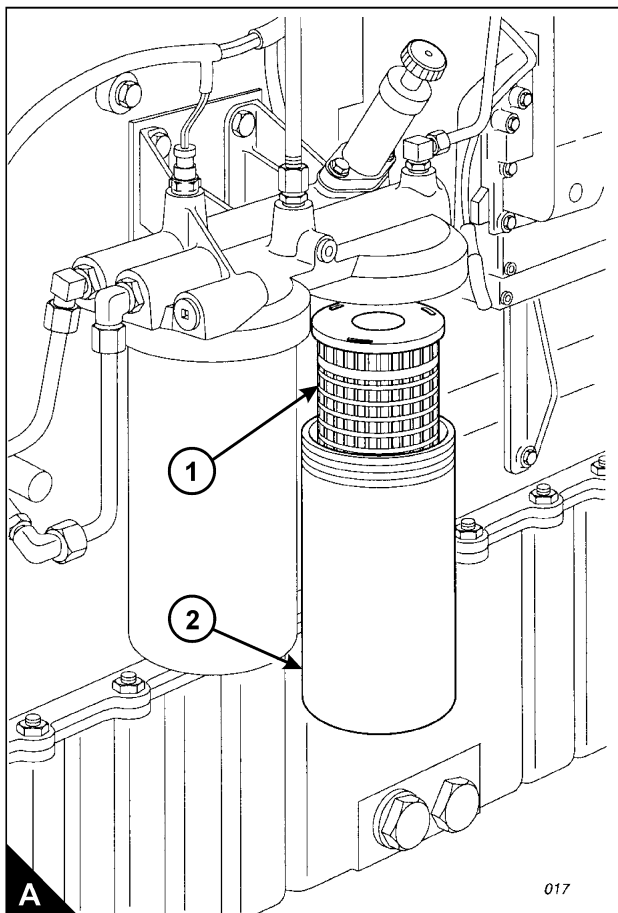
- *It is important that only genuine parts are used. The use of wrong parts could damage the fuel injection equipment.*
- *Do not fill the secondary fuel filter with fuel before installation. The fuel would not be filtered and could be contaminated. Contaminated fuel will cause accelerated wear to components of the fuel system.*

7 Fit the housing onto the filter head. Tighten the housing to a torque of 80 Nm (59 lbf ft). Do NOT overtighten. Ensure that the drain plug is tightened securely.

8 Clean away any fuel which has been spilled.

9 Open the fuel tank supply valve and eliminate air from the fuel system as given in "How to eliminate air from the fuel system" on page 48.

10 Check for leaks.



How to check the specific gravity of the coolant

Warning! Do not remove the radiator cap while the engine is still hot and the system is under pressure because dangerous hot coolant can be discharged.

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

1 For mixtures which contain inhibited ethylene glycol:

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

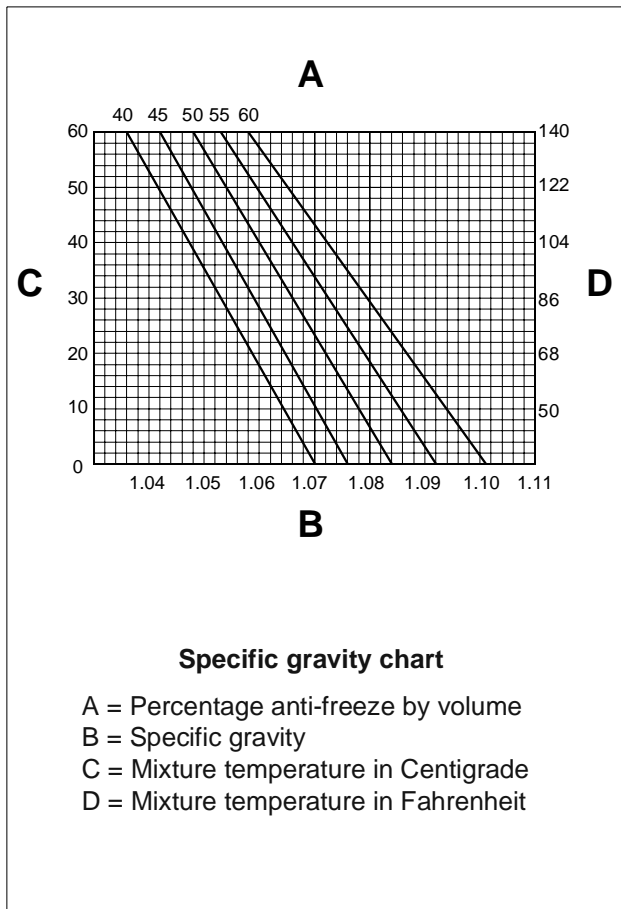
2 For mixtures which contain inhibited propylene glycol:

- 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.
- 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.
- 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 obtain an oil sample

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

This operation must only be performed by personnel with the correct training. To avoid contamination of the oil sample, ensure that the tools and equipment used are clean.

An oil sample kit (part number KRP1572), which includes the relevant sample bottles, is available from Perkins dealers. Certain engines are fitted with an oil sample valve, use the relevant procedure given below.

Engines fitted with an oil sample valve

1 Fit the vented cap to the sample bottle and insert the open end of the tube into the one of the holes in the cap.

Warning! Hot oil under pressure is present at the oil sample valve. Protective clothing must be worn during this operation. Do not allow hot oil or hot components to contact the skin.

2 With the engine running at the normal temperature of operation, remove the dust cap from the sample valve on the engine and insert the nozzle of the tube into the sample valve. Press the nozzle against the valve, the valve will open and allow the oil to flow. Ensure that the sample bottle remains upright and withdraw the nozzle when the correct amount of oil is obtained; a mark on the bottle indicates the correct level for the oil sample.

3 Fit the dust cap to the sample valve.

4 Remove the vented cap from the sample bottle and fit the sealed cap. Dispose of the tube, nozzle and vented cap in accordance with local regulations.

5 Complete the adhesive label and attach it to the sample bottle. Send the oil sample to a reputable oil analysis laboratory to provide a recommendations report.

Engines without an oil sample valve

1 Run the engine until the normal temperature of operation is achieved, stop the engine and proceed with the operation immediately.

2 Use a vacuum pump and a long flexible tube: remove the engine oil dipstick, insert the flexible tube into the dipstick tube and withdraw the oil sample. Fit the dipstick to the dipstick tube.

3 Complete an adhesive label and attach it to the sample bottle. Send the oil sample to a reputable oil analysis laboratory to provide a recommendations report.

4 Ensure that all equipment used is cleaned or, if relevant, disposed of in accordance with local regulations.

How to renew the engine lubricating oil

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

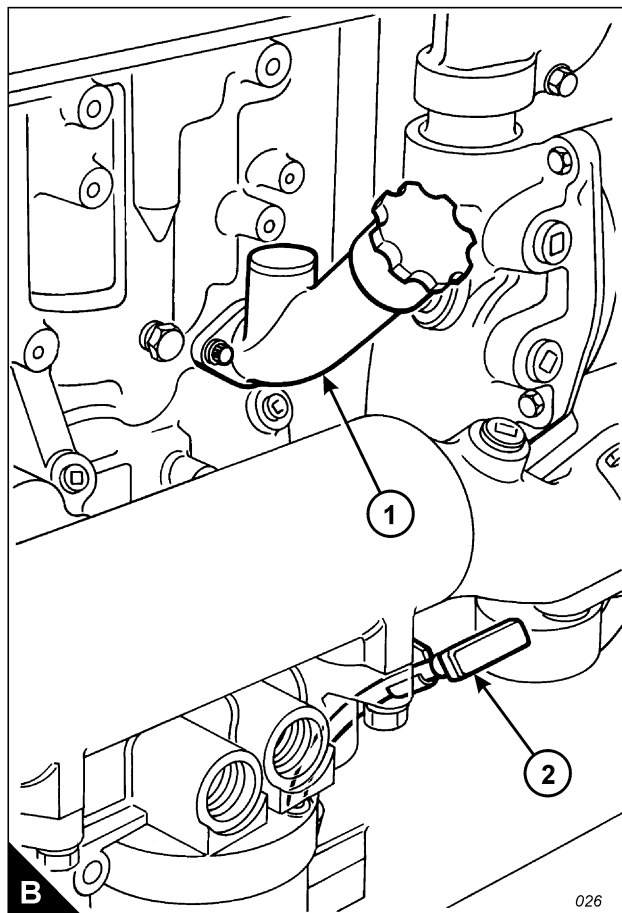
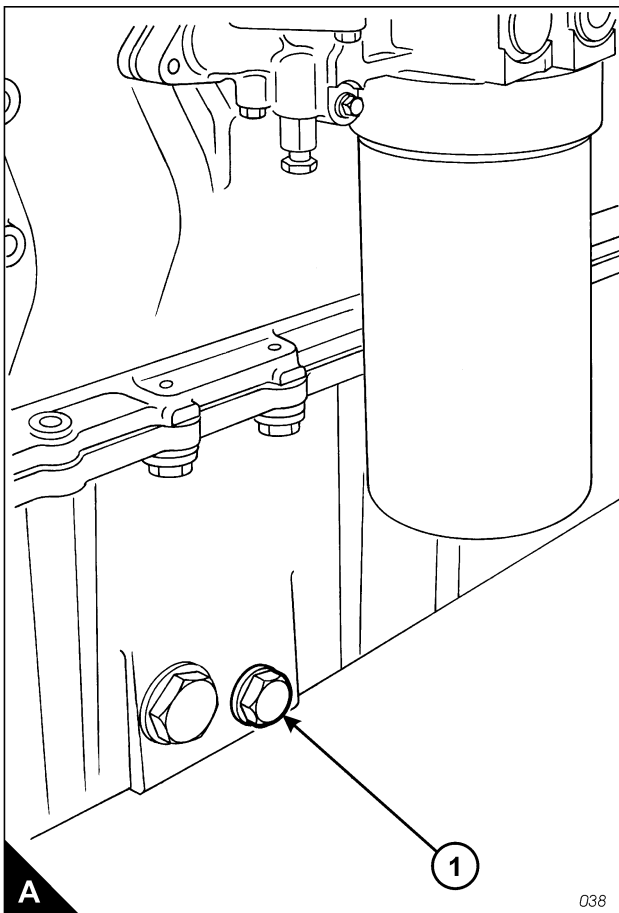
- 1 Operate the engine until it is warm, then stop the engine.
- 2 A drain plug is fitted to both sides of the sump, remove one of the sump drain plugs (A1) and drain the lubricating oil into a suitable container. Clean the drain plug and fit a new sealing washer. Fit the drain plug and tighten it to a torque of 45 Nm (33 lbf ft).

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

- 3 Renew the element of the lubricating oil filter as given in "How to renew the element of the lubricating oil filter" on page 29.
- 4 Clean the area around the oil filler cap (B1) and remove the cap. Fill the sump to the "H" mark on the dipstick (B2) with clean new lubricating oil of the correct grade as given in "Lubricating oil specification" on page 50. Do NOT overfill.

To prevent damage to the crankshaft bearings, crank the engine with the fuel OFF. This will fill the oil filters before the engine is started. Do NOT crank the engine continuously for more than 30 seconds. Ensure that oil pressure is indicated on the oil pressure gauge, or the service tool, before the engine is started.

- 5 Operate the engine at low idle speed for two minutes and check for leakage from the oil filter assembly.
- 6 Stop the engine and allow the oil to drain back to the sump for a minimum of ten minutes. Check the oil level on the dipstick and, if necessary, add more oil. The oil level must be between the "L" and "H" marks on the dipstick.



How to renew the element of the lubricating oil filter

- 1 Stop the engine.
- 2 Turn the start switch to the "OFF" position. Disconnect the battery.
- 3 Remove the drain plug (A2) from the base of the oil filter housing (A1) and drain the oil into a suitable container.
- 4 Remove the filter housing, remove the 'O' ring seal from the housing and withdraw the filter element.

Warning! Discard the used filter element, 'O' ring seal and used engine oil in a safe place and in accordance with local regulations.

- 5 Clean the housing 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.

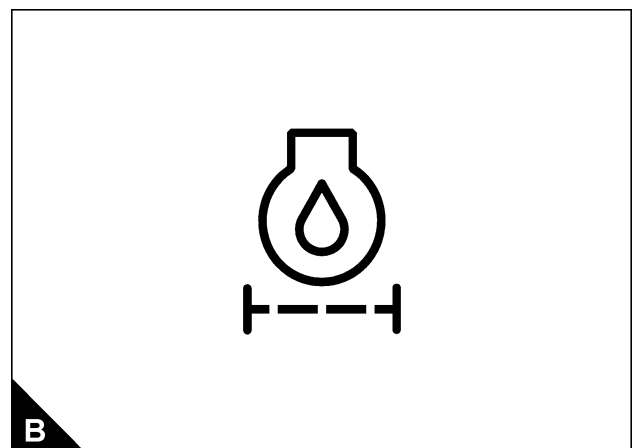
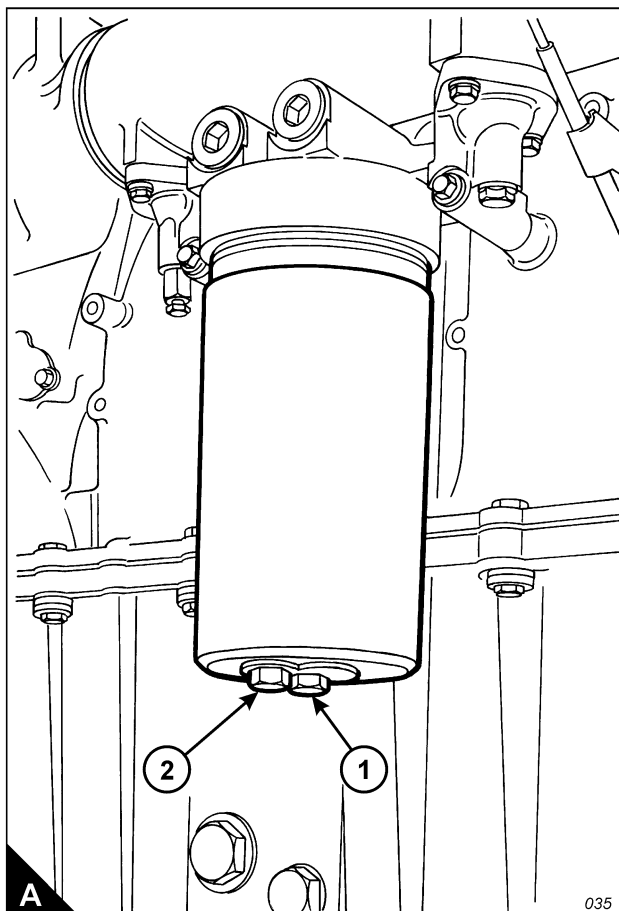
- 6 Fit a new element into the housing, ensure that it engages fully with the guide in the base of the housing. Fit a new 'O' ring seal around the top of the housing.

Caution: It is important that only genuine Perkins parts are used. The use of incorrect parts could damage the engine. The correct filter element will be marked with the symbol shown (B).

- 7 Fit the housing 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 80 Nm (59 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 "Lubricating oil specification" on page 50.

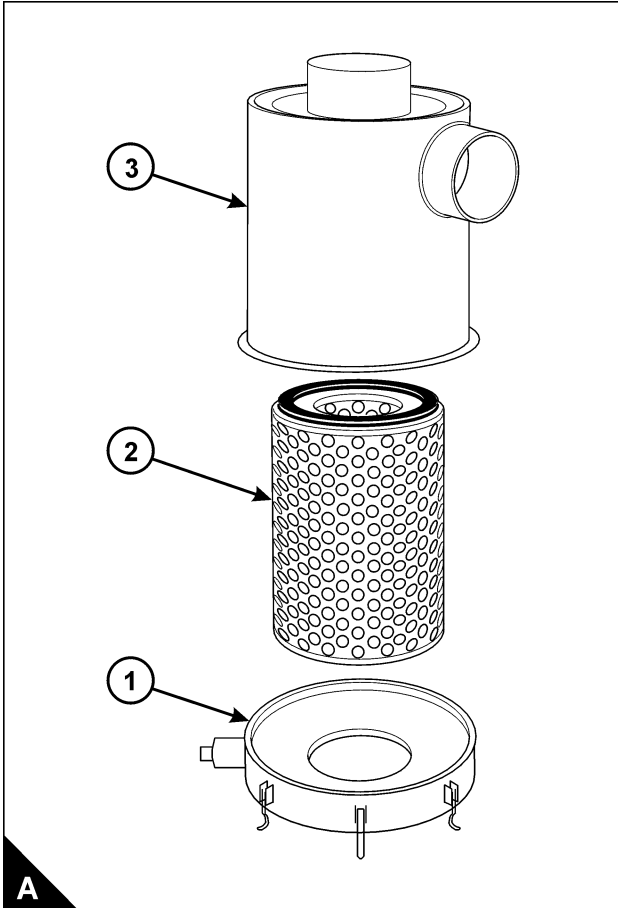
- 9 Run the engine and check for leaks.



How to renew the air cleaner element

The air filter contains a paper element. This must not be washed. Renew the paper element as follows:

- 1 Loosen the clamp and remove the end cover (A1). Withdraw and discard the filter element (A2).
- 2 Clean, thoroughly, the inside of the casing (A3). Fit a new filter element and fit the end cover.
- 3 Reset 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. Maximum belt life will be obtained only if the belts are kept at the correct tensions. Where more than one belt is used, check/adjust the tension on the tightest belt.

How to adjust the tension of the fan belts

Remove the fan guards and proceed as follows.

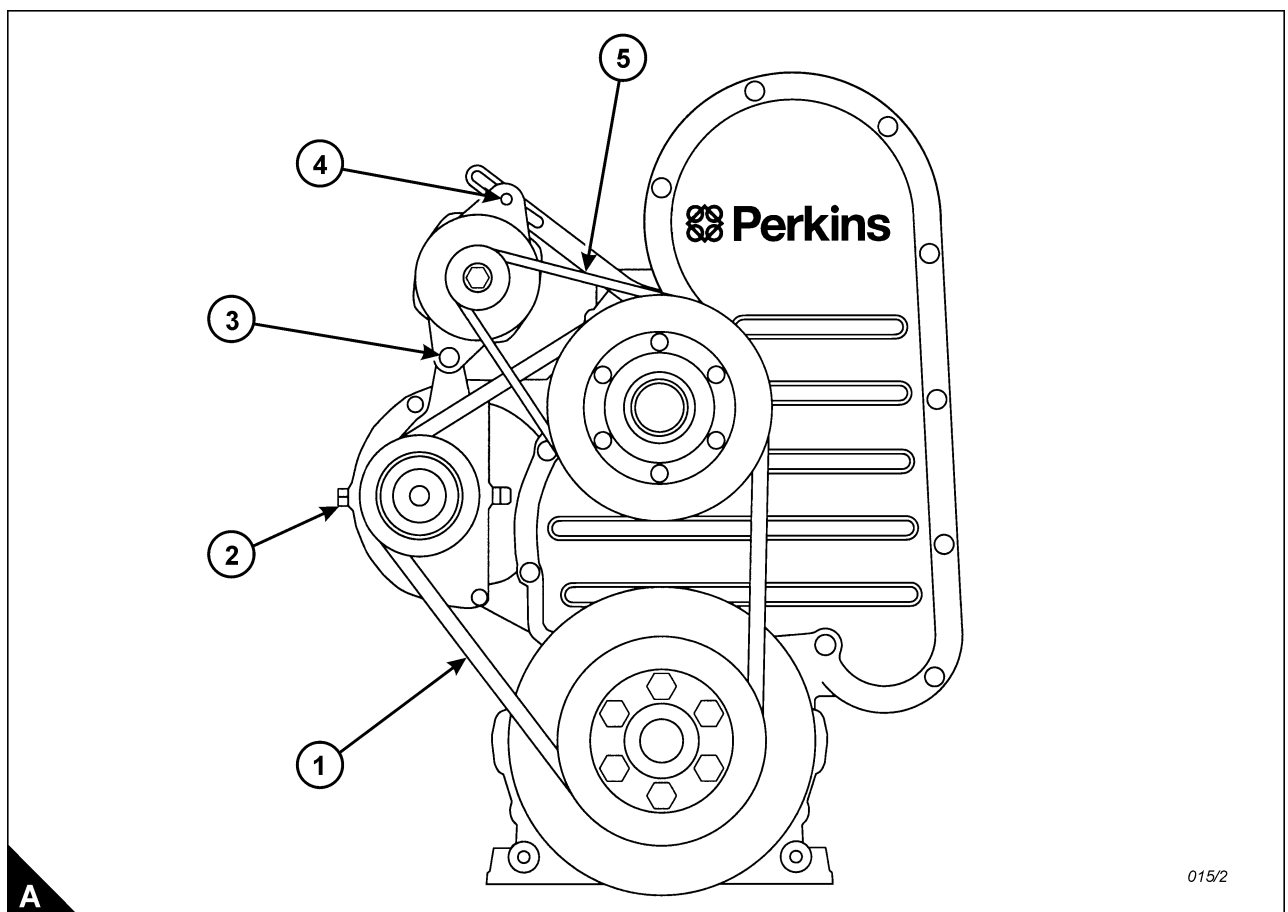
Use a Borroughs belt tension gauge. Check the tension at the position shown (A1). It should be 800 N, which is equivalent to 4,0 mm of movement when a force of 33 N is applied. To adjust the tension, proceed as follows:

1 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. Fully tighten the large lock nut and check the tension of the belts again. If the tension is correct, loosen the adjustment bolt (A2) just enough to release its tension, then tighten its lock nuts.

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

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.

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



How to adjust the tension of the alternator belt

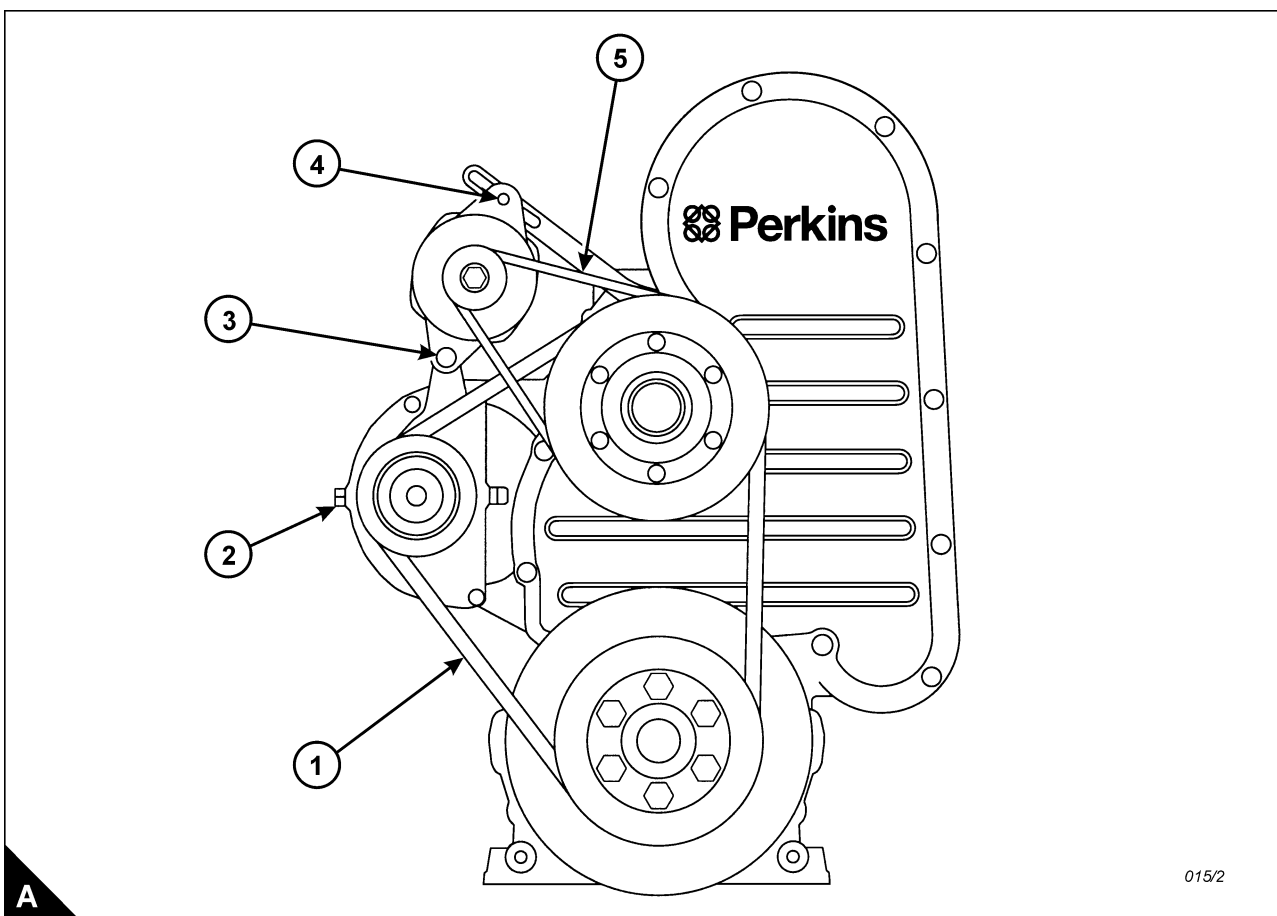
Remove the access panel in the fan guard and proceed as follows.

Use a Borroughs belt tension gauge. 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:

- 1 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.
- 2 Fit the access panel to the fan guard and run the engine for 15 minutes. Remove the access panel and check again the tension.

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.

- 3 When the correct tension is obtained, fit the access panel to the fan guard.



How to renew the fan belts

- 1 Remove the fan guards.
- 2 Remove the six bolts which secure the fan and hub assembly to the pulley and remove the assembly.
Caution: *Take care during the removal of the fan; ensure that the radiator does not become damaged.*
- 3 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.
- 4 Fit the fan and tighten the bolts securely. Adjust the fan belts to the correct tension, as given in "How to adjust the tension of the fan belts" on page 31, and fit the fan guards.

How to renew the alternator belt

- 1 Remove the fan guards.
- 2 Remove the six bolts which secure the fan and hub assembly to the pulley and remove the assembly.
Caution: *Take care during the removal of the fan; ensure that the radiator does not become damaged.*
- 3 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.
- 4 Fit the fan and tighten the bolts securely. Adjust the alternator belt to the correct tension, as given in "How to adjust the tension of the alternator belt" on page 32, and fit the fan guards.

How to inspect the crankshaft vibration damper

The viscous damper has a weight that is located inside a case filled with fluid. The weight moves in the case to limit torsional vibration. Inspect the damper for evidence of dents, cracks or leaks of the fluid.

Renew the damper if it is dented, cracked or leaking.

The damper is mounted on the crankshaft and is located behind the belt guard at the front of the engine. Refer to the Workshop Manual for the correct procedure to remove and to fit the damper.

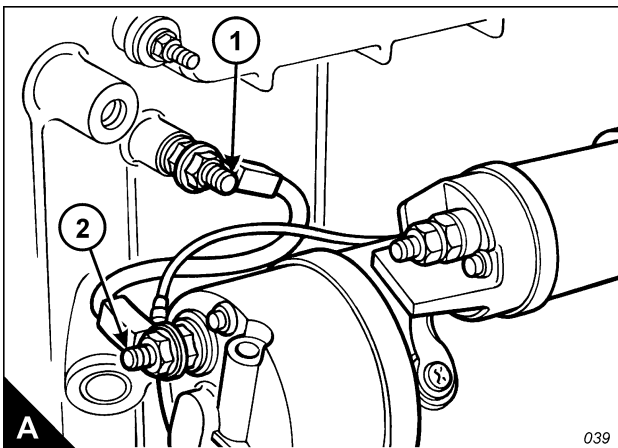
Earth stud

Inspect the wiring harness for good connections and inspect the condition of the harness. Check the tightness of the earth stud (A1) at the periods specified in the service schedule. The earth stud is fitted below the ECM at the left side of the crankcase. The earth strap is fitted between the earth stud and a terminal on the starter motor (A2). For engines which have the starter motor fitted to the right side, or engines not fitted with an electric starter motor, the earth strap is fitted between the earth stud and the negative terminal of the starter battery.

- 1 Disconnect the batteries before any service work is attempted.
- 2 Remove the nut which retains the earth strap on the earth stud (A1) and remove the earth strap.
- 3 Remove the washer and use a torque wrench and suitable socket to check the tightness of the earth stud. The earth stud must be tightened to a torque of 47 Nm (35 lbf ft).

Notes:

- If the earth stud is removed, the short end must be fitted into the crankcase.
 - If the earth strap is disconnected from the starter motor, it must be connected again and the nut which retains it must be tightened to a torque of 30,5 +/- 3,5 Nm (22.5 +/- 2.5 lbf ft).
- 4 Clean the earth stud and the earth strap with a clean cloth. If the connections are corroded, clean them with a solution of sodium bicarbonate and water.
 - 5 Fit the washer and the earth strap. Fit the retaining nut and tighten to a torque of 47 Nm (35 lbf ft).
 - 6 Keep the earth stud and the strap clean and coated with petroleum jelly.
 - 7 Connect the batteries.



Hoses and hose clips

Inspect all hoses for leaks which may be caused by:

- Cracks
- Softness
- Loose clips

Renew hoses that are cracked or soft. Tighten any loose clips.

Check for these conditions:

- End fittings that are damaged or leaking
- Outer covering that is chafed or cut
- Exposed wire that is used for reinforcement
- Outer covering that is ballooning locally
- Flexible part of the hose that is kinked or crushed
- Armour that is embedded in the outer covering

To renew a hose

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

- 1 Stop the engine. Allow the engine to cool.
- 2 Loosen the filler cap of the coolant system slowly to relieve any pressure. Remove the filler cap.

Note: Drain the coolant into a suitable, clean container. The coolant can be used again.

- 3 Drain the coolant to a level below the hose which is to be renewed.
- 4 Remove the hose clips and remove the old hose.
- 5 Fit the new hose.
- 6 Fill the coolant system to the correct level with the specified coolant mixture.
- 7 Clean the filler cap and inspect the gaskets. Renew the filler cap if the gaskets are damaged. Fit the filler cap.
- 8 Start the engine. Inspect the coolant system for leaks.

How to clean the radiator

Inspect the radiator for damaged fins, corrosion, dirt, grease, insects, leaves, oil, and other debris. Clean the exterior of the radiator, if necessary.

Warnings!

- *During the use of high pressure air, wear a protective face shield and protective clothing.*
- *Maximum air pressure at the nozzle must be less than 205 kPa (30 psi) for cleaning purposes.*

Use a high pressure air jet to remove loose debris. Direct the air in the opposite direction to the fan's air flow. Hold the nozzle approximately 6 mm (0.25 in) away from the fins. Move the air nozzle slowly in a direction that is parallel with the tubes to remove debris from between them.

A high pressure water jet may also be used to clean the radiator. The maximum water pressure for cleaning purposes must be less than 275 kPa (40 psi). Do not hold the nozzle too close to the radiator as the fins can be damaged. Use pressurized water to soften mud. Clean the core from both sides.

Use a degreaser and steam for the removal of oil and grease. Clean both sides of the core. Wash the core with detergent and hot water. Rinse thoroughly with clean water.

After the radiator has been cleaned, start the engine and run it at high idle speed. This will help to dry the core and remove debris. Stop the engine and use a light bulb, held behind the core, to inspect for cleanliness. Clean again, if necessary.

Inspect the fins for damage. Check the condition of the welds, the mounting brackets, the connections and seals. Arrange for repairs as necessary.

How to inspect the engine mountings

Inspect the engine mountings. Check for damage or deterioration and check that the bolts are tightened to the correct torque. Note that engine vibration can be caused by:

- Incorrect mounting of the engine.
- Deterioration of the engine mounts.

If an engine mount shows signs of deterioration, it must be renewed.

How to drain the coolant system

Warnings!

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

1 Stop the engine and allow the engine to cool. Loosen slowly the filler cap of the coolant system to relieve any pressure. Remove the filler cap.

2 Open the drain valve of the coolant system (if fitted). If the coolant system is not fitted with a drain valve, disconnect the lowest coolant hose.

Allow the coolant to drain.

How to clean the coolant system

1 Flush the coolant system with clean water.

2 Close the drain valve (if fitted), or connect the coolant hose used to drain the system.

Note: To avoid air locks, fill the coolant system no faster than 19 L (4.2 UK gal) per minute.

3 Fill the coolant system with a mixture of clean water and Holts Fast Acting Cooling System Cleaner or equivalent. Refer to the manufacturer's instructions. Fit the filler cap.

4 Start and run the engine at low idle speed for a minimum of 30 minutes. The coolant temperature should be at least 82 °C (180 °F).

5 Stop the engine and allow the engine to cool. Loosen the filler cap of the coolant system slowly to relieve any pressure. Remove the filler cap. Open the drain valve (if fitted) or disconnect the lowest coolant hose. Allow the cleaning mixture to drain. Flush the coolant system with clean water. Close the drain valve (if fitted), or connect the coolant hose used to drain the system.

How to fill the coolant system

1 Fill the coolant system with the correct coolant mixture, refer to "Coolant mixture" on page 49. Do not fit the filler cap.

2 Start and run the engine at idle for 1 minute to eliminate air from the cavities of the engine block. Stop the engine.

3 Check the coolant level. Maintain the coolant level at the bottom of the filler pipe in the expansion tank.

4 Clean the filler cap of the coolant system. Inspect the gasket on the filler cap. If the gasket is damaged, renew the filler cap. If the gasket is not damaged, use a proprietary pressure test kit to perform a test on the filler cap. The correct pressure for the filler cap is stamped on its face. If the filler cap does not retain the correct pressure, fit a new filler cap.

5 Start the engine. Inspect the coolant system for leaks and for correct temperature of operation.

How to check the tappet clearances

Tappet clearances	
Inlet	0,38 +/- 0,08 mm (0.015 +/- 0.003 in)
Exhaust	0,76 +/- 0,08 mm (0.030 +/- 0.003 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 "How to check/adjust the electronic unit injectors" on page 41.

- 1 Remove the rocker cover.
- 2 Remove the top bolt (A1) from the cover (A2) on the flywheel housing and slacken 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 turning tool can be inserted.

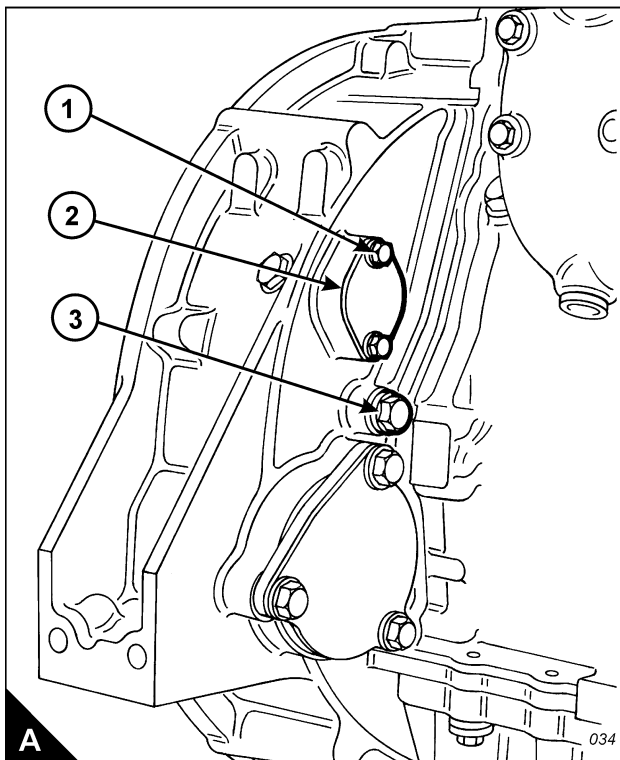
- 3 Remove the plug (A3) from the timing bolt location in the flywheel housing and fit the timing bolt.

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

- 4 Insert the engine turning tool, CH11148, into the flywheel housing through the aperture behind the cover (A2). Use a $\frac{1}{2}$ 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.

- 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.



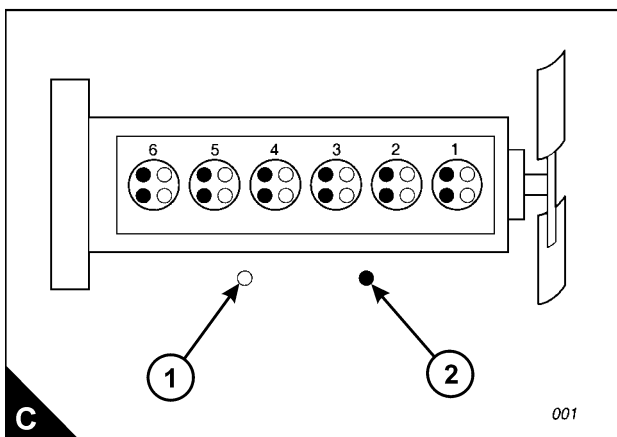
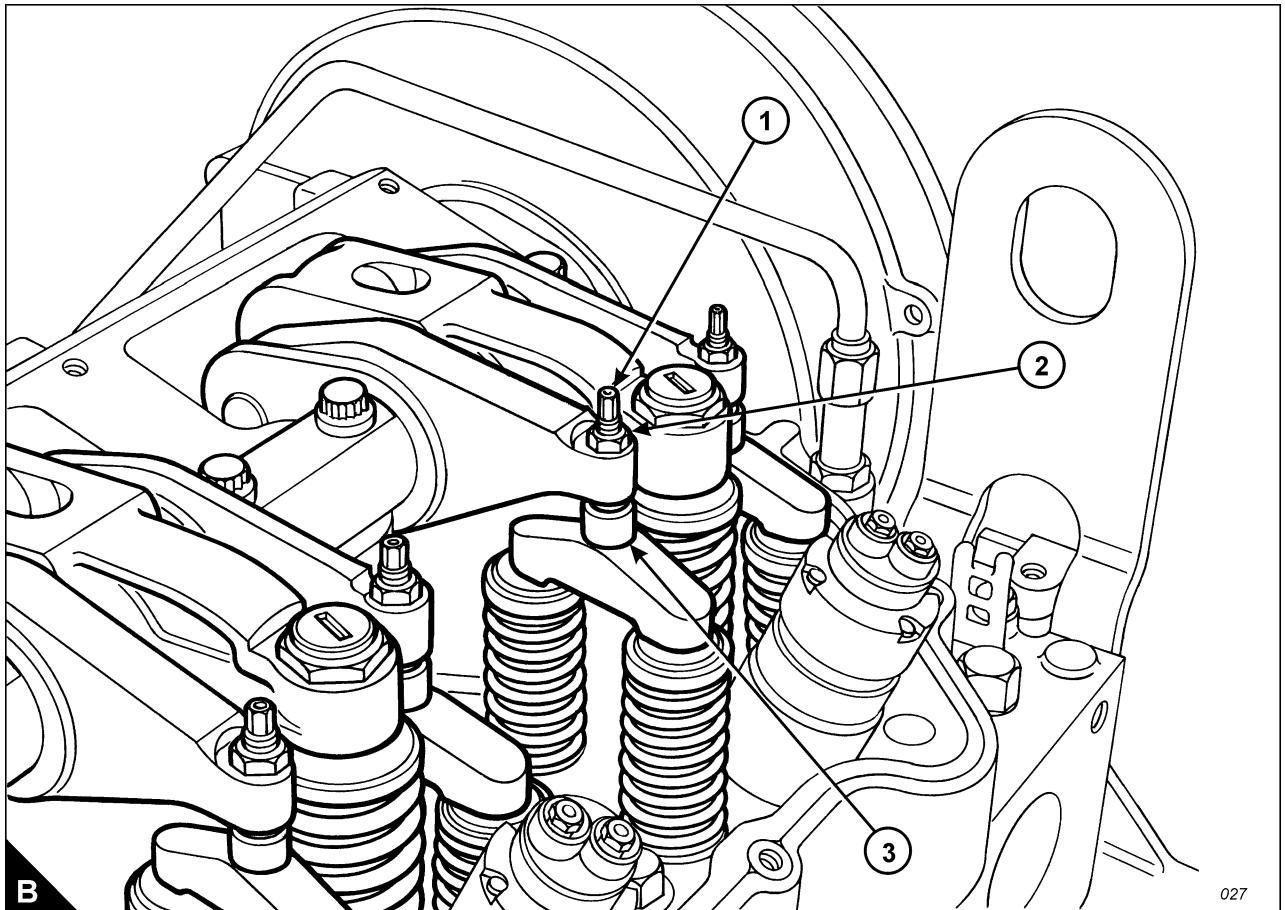
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6 Before each set of tappet clearances is adjusted, ensure that the roller of the rocker lever is fully against the camshaft lobe.

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.

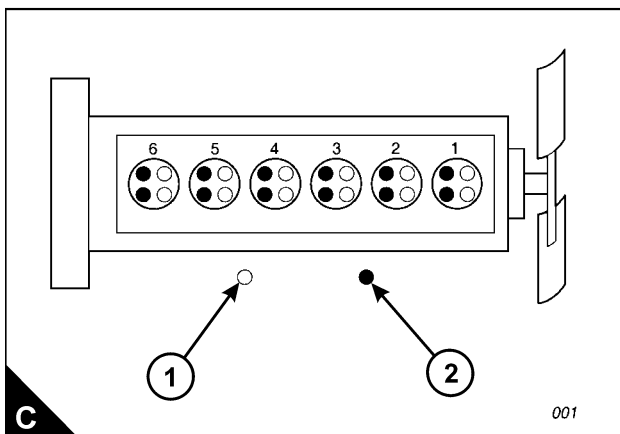
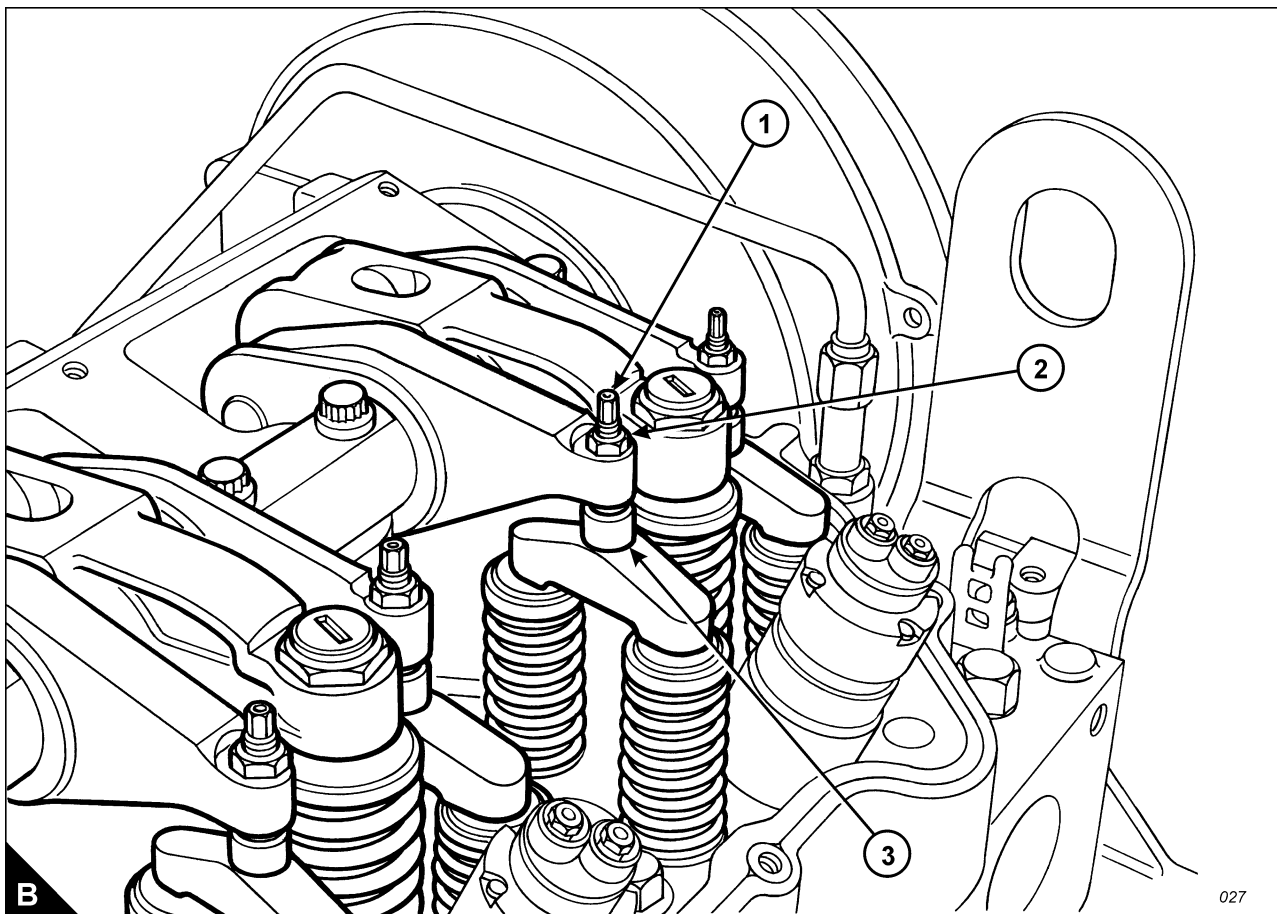
Notes:

- 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



Continued

- 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.
- 14 Fit the plug to the timing bolt location.

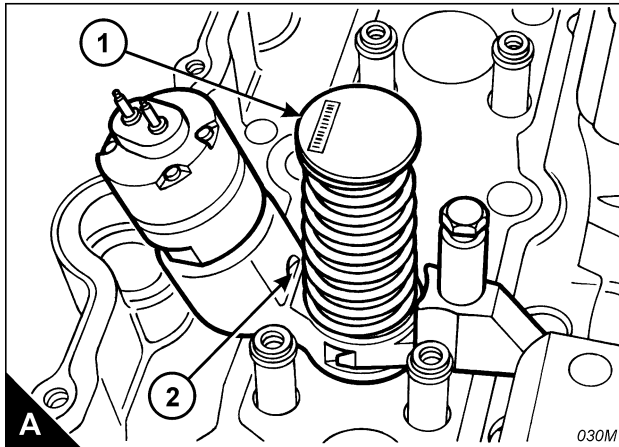


How to check/adjust the electronic unit injectors

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 $78,0 \pm 0,2$ 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.
- 5 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.



Engine protection devices

The engine is fitted with an electronic management unit which monitors all critical engine temperatures and pressures and will stop the engine if a critical fault occurs.

If any of the sensors fail, the diagnostics indicator will be activated and your Perkins dealer should be contacted so that the fault can be identified by use of the Perkins Electronic Service Tool (EST).

Visual inspection

Check visually the condition of all gauges, sensors and wiring. Look for wiring and components that are loose, broken, or damaged. Damaged wiring or components should be repaired or renewed immediately.

How to renew the thermostats of the coolant system

Renew the coolant thermostats at the periods given in the service schedule. This is recommended preventive maintenance practice.

Cautions:

- Failure to replace the thermostats at the periods given in the service schedule could cause severe engine damage.
- The engine **MUST** be operated with the thermostats installed. If a thermostat is fitted incorrectly the engine may overheat.

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

Caution: Certain sensors fitted to the engine have a short lead which is part of the sensor unit. For this type of sensor ensure that the wiring harness is disconnected from the end of the lead. Do NOT attempt to remove the lead from the sensor unit.

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

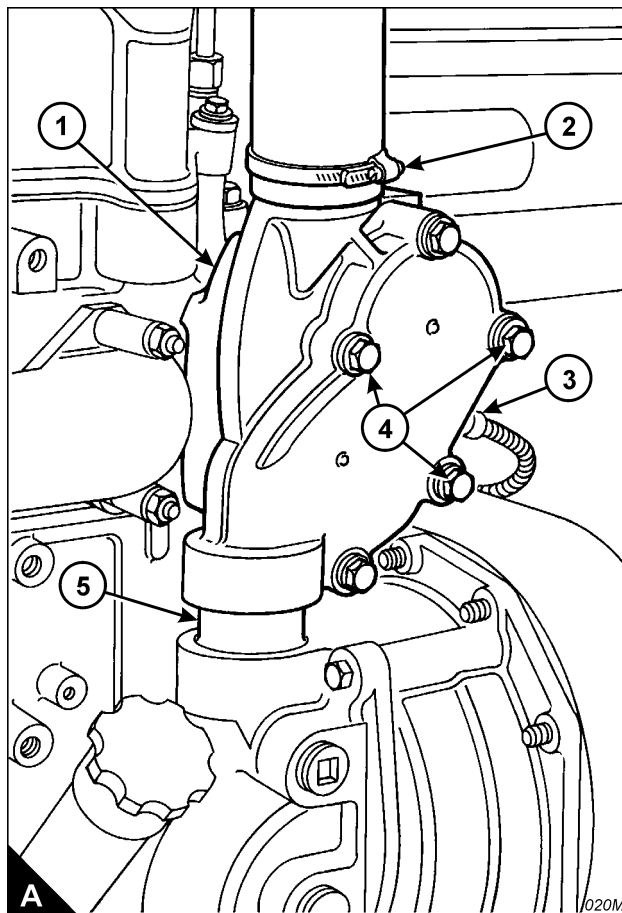
3 Release the hose clips (A2) and disconnect the pipe and hose clip from the top of the unit.

4 Slacken all five bolts of the thermostat housing; then remove fully the three bolts (A4) which retain the thermostat housing on the cylinder head.

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

6 Remove the two short bolts which remain, separate the two halves of the assembly and remove the thermostats.

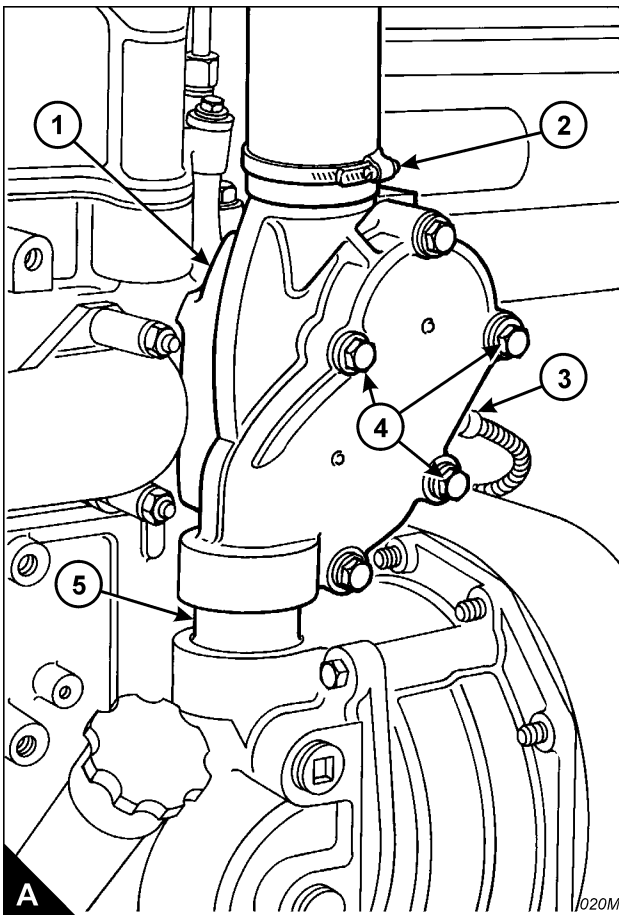
7 Clean thoroughly both parts of the assembly and check the condition of the lip-type seals. Renew the seals if they are worn or damaged.



Continued

- 8 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 two short bolts.
- 9 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 type 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 fully all five bolts.
- 10 Connect the hose to the top of the housing and tighten the hose clip (A2).
- 11 Connect the cable (A3) to the coolant temperature sensor.
- 12 Fill the coolant system to the correct level with the approved coolant mixture.
- 13 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.



How to clean and to calibrate the engine speed/timing sensors

1 Disconnect the wiring harness and remove the two speed-timing sensors from the left side of the engine at the back of the gear case.

Caution: *Certain sensors fitted to the engine have a short lead which is part of the sensor unit. For this type of sensor ensure that the wiring harness is disconnected from the end of the lead. Do NOT attempt to remove the lead from the sensor unit.*

2 Check the condition of the plastic end of the sensors for wear and/or contaminants.

3 Clean the metal shavings and other debris from the face of the sensors.

4 Fit the sensors to the correct locations and connect the wiring harness.

Note: If a new ECM unit has been fitted, or the engine gear train has been renewed or dismantled and assembled, the engine speed/timing sensors must be calibrated. Refer to engine timing calibration in the Diagnostic Manual.

How to inspect the turbocharger

At the periods given in the service schedule, with the engine switched off and cool, disconnect and remove the pipe from between the air filter and the turbocharger. Turn, rapidly, the rotor assembly of the turbocharger, check for freedom of movement and for sounds of interference. Contact your Perkins dealer if necessary.

Caution: *Failure of the turbocharger bearings can cause large amounts of oil to enter the air inlet and exhaust systems. Loss of engine lubricant can cause serious engine damage.*

Minor leakage of a turbocharger housing under extended low load operation should not cause problems unless turbocharger bearing failure has occurred.

Caution: *When a turbocharger bearing failure is accompanied by a significant loss in engine performance (exhaust smoke or engine speed up at no load), do not continue to operate the engine until the turbocharger has been repaired or renewed.*

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

Check the oil supply and drain pipes for oil leaks.

Check for air leakage when the engine is run.

To remove and to fit the turbocharger

Refer the Workshop Manual for details of how to remove and to fit the turbocharger.

How to inspect the battery charging alternator

Inspect the battery charging alternator, for loose connections. Inspect the ammeter (if fitted) during engine operation to ensure correct battery performance and/or correct performance of the electrical system. Clean the outside of the alternator and ensure that the ventilation holes are clear.

The alternator must be checked and corrected, if necessary, by a person who has had the correct training, at the periods given in the service schedule.

How to inspect the starter motor

Check the electrical connections of the starter motor assembly and clean them. Check the starter motor for correct operation.

The starter motor must be checked and corrected, if necessary, by a person who has had the correct training, at the periods given in the service schedule.

How to inspect the coolant pump

Inspect the coolant pump for leaks. If leakage is observed, renew the coolant pump seal or the coolant pump assembly. Refer to the Workshop Manual for the dismantle and assembly procedures.

Refer to the Workshop Manual or consult your Perkins dealer if any repair or replacement is needed.

Notes:

- 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.

How to eliminate air from the fuel system

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.

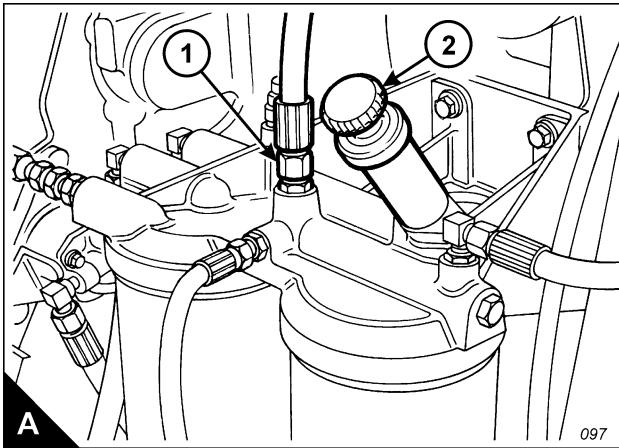
3 Start the engine.

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.



5

Engine fluids

Fuel specification

Diesel fuel must conform to one of these specifications:

ASTM D975 No 1-D or No 2-D

BS 2869: Part 2 1998 Class A2

BS EN 590 1997

General fuel requirements are: Maximum sulphur content 0.2%; minimum Cetane number 45.

Fuel cleanliness

The modern, high pressure fuel injection system used on the 2300 Series engine requires a high level of fuel cleanliness to ensure correct operation and reliability.

The fuel must conform to all aspects of the ASTM D975 specification, but in particular to the requirement for number 2-D to have less than 0.05% water and sediment. The fuel should also be free from biological growth. If biological growth is suspected, contact Perkins to discuss a suitable measurement and course of action. For long term storage of fuel, the recommendations given in ASTM D975 must be followed where appropriate.

The use of fuels which do not conform to the above standards can cause: difficulty with starting, poor combustion, deposits in the fuel injectors or combustion chamber, reduced service life of the fuel system and filters, 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 2300 Series engines is a mixture of 50% heavy duty, commercially available, ethylene glycol antifreeze and 50% clean soft water. The antifreeze must meet ASTM D5345 or ASTM D4985 specifications.

A 50/50 ethylene glycol antifreeze mixture gives protection against freezing down to -35 °C. A 60% glycol mix gives protection down to -40 °C and should be used for Arctic conditions.

Propylene glycol antifreeze is an acceptable alternative to ethylene glycol but only in 50/50 mixture strength, at which it will protect against freezing down to -29 °C.

Caution: *Mixtures containing methanol are not approved.*

If anti-freeze is not available, and the ambient temperature is not expected to fall below 10 °C, then clean soft water, with 1% of Perkins corrosion inhibitor (part number 21825 735 - 1 litre), may be used. This ratio is equivalent to 0,5 litres of corrosion inhibitor to 50 litres (11 UK gallons) of water. The use of this product should be controlled in accordance with the manufacturer's instructions.

Water quality

Soft water means de-ionised water, distilled water, rain water or water from a mains supply which has the following requirements:

Chlorides - 40 mg/l max, sulphates - 100 mg/l max, total hardness 170 mg/l max, total solids 340 mg/l max and pH of 5.5 to 9.0.

If in doubt consult the local water treatment and supply company.

If soft water is not used, the coolant 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.

The use of products which are not approved for the coolant system may cause serious problems. Coolant mixtures with insufficient corrosion inhibitor can cause erosion and/or corrosion of coolant system components.

Lubricating oil specification

The lubricating oil used in the 2306 engine must be a 15W40 oil which conforms to the API CG-4 specification as a minimum. Oil produced to the higher specification, API CH-4, has greater soot handling capability and wear resistance leading to longer service intervals and/or engine life.

The recommendation is therefore API CG-4 acceptable oil and API CH-4 preferred oil.

Oil change period is 500 hours where fuel sulphur is less than 0.2%. Use of fuels having a higher sulphur level than this will reduce the oil life, which will have to be determined by oil analysis conducted by the customer and a reputable analysis service.

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 the workshop personnel
The starter motor turns the engine too slowly	1, 2, 3, 4	
The engine does not start	5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 17	34, 35, 36, 37, 38, 42, 43, 67
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, 67
Not enough power	8, 9, 10, 11, 12, 13, 16, 8, 9, 20, 21	34, 36, 37, 38, 39, 42, 43, 44, 63, 64, 66, 67
Misfire	8, 9, 10, 12, 13, 15, 20, 22	34, 36, 37, 38, 39, 40, 41, 43, 67
High fuel consumption	11, 13, 15, 17, 18, 19, 23, 22	34, 36, 37, 38, 39, 40, 42, 43, 44, 63
Black exhaust smoke	11, 13, 15, 17, 19, 21, 22	34, 36, 37, 38, 39, 40, 42, 43, 44, 63, 64, 67
Blue or white exhaust smoke	4, 15, 21, 23	36, 37, 38, 39, 42, 44, 45, 52, 58, 61, 62
The pressure of the lubricating oil system 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	8, 9, 10, 11, 12, 13, 15, 16, 18, 20, 22, 23	34, 38, 40, 41, 44, 52, 60, 67
Vibration	13, 18, 20, 27, 28	34, 38, 39, 40, 41, 44, 52, 54, 67
The pressure of the lubricating oil system is too high	4, 25	49
The engine oil temperature is too high	11, 13, 15, 19, 27, 29, 30, 32, 65	34, 36, 37, 39, 52, 55, 56, 57, 66
Crankcase pressure	31, 33	39, 42, 44, 45, 52, 61
Bad compression	11, 22	37, 39, 40, 42, 43, 44, 45, 53, 60
The engine starts and stops	10, 11, 12	67

List of possible causes

- 1 Battery capacity low.
- 2 Bad electrical connections.
- 3 Fault in starter motor.
- 4 Wrong grade of lubricating oil.
- 5 Starter motor turns engine too slowly.
- 6 Fuel tank empty.
- 7 Fault in stop control.
- 8 Restriction in a fuel pipe.
- 9 Fault in fuel lift pump.
- 10 Dirty fuel filter element.
- 11 Restriction in air induction system.
- 12 Air in fuel system.
- 13 Fault in fuel injectors or fuel injectors of an incorrect type.
- 14 Cold start system used incorrectly.
- 15 Fault in cold start system.
- 16 Restriction in fuel tank vent.
- 17 Wrong type or grade of fuel used.
- 18 Restricted movement of engine speed control (not applicable to 2300 series engines).
- 19 Restriction in exhaust pipe.
- 20 Engine temperature is too high.
- 21 Engine temperature is too low.
- 22 Incorrect valve tip clearances.
- 23 Too much oil or oil of the wrong type is used in wet type air cleaner, if one is fitted.
- 24 Not enough lubricating oil in sump.
- 25 Defective gauge.
- 26 Dirty lubricating oil filter element.
- 27 Fan damaged.
- 28 Fault in engine mounting or flywheel housing.
- 29 Too much lubricating oil in sump.
- 30 Restriction in air or water passages of radiator.
- 31 Restriction in breather pipe.
- 32 Insufficient coolant in system.
- 33 Vacuum pipe leak or fault in exhauster (not applicable to 2300 series engines).
- 34 Fault in fuel injection pump.
- 35 Broken drive on fuel injection pump.
- 36 Timing of fuel injection pump incorrect.
- 37 Valve timing is incorrect.
- 38 Bad compression.
- 39 Cylinder head gasket leaks.
- 40 Valves are not free.
- 41 Wrong high-pressure pipes (not applicable to 2300 series engines).
- 42 Worn cylinder bores.
- 43 Leakage between valves and seats.

Continued

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- 44 Piston rings are not free or they are worn or broken.
 - 45 Valve stems and/or guides are worn.
 - 46 Crankshaft bearings are worn or damaged.
 - 47 Lubricating oil pump is worn.
 - 48 Relief valve does not close.
 - 49 Relief valve does not open.
 - 50 Relief valve spring is broken.
 - 51 Fault in suction pipe of lubricating oil pump.
 - 52 Piston is damaged.
 - 53 Piston height is incorrect.
 - 54 Flywheel housing or flywheel is not aligned correctly.
 - 55 Fault in thermostat or thermostat is of an incorrect type.
 - 56 Restriction in coolant passages.
 - 57 Fault in water pump.
 - 58 Valve stem seal is damaged.
 - 59 Restriction in sump strainer.
 - 60 Valve spring is broken.
 - 61 Turbocharger impeller is damaged or dirty.
 - 62 Lubricating oil seal of turbocharger leaks.
 - 63 Induction system leaks.
 - 64 Turbocharger impeller is damaged or dirty.
 - 65 Drive belt for water pump is loose.
 - 66 Induction system leaks (turbocharged engines).
 - 67 Faulty engine management system

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