
Perkins Phaser

Model AL (Euro 2)

USER'S HANDBOOK

4 cylinder diesel engines for automotive applications

Publication TPD 1355E Issue 2

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The information is correct at the time of print.

Published in April 1998 by Technical Publications,

Perkins Engines Company Limited, Peterborough PE1 5NA, England



This publication is divided into six chapters:

- 1 General information**
- 2 Engine views**
- 3 Operation instructions**
- 4 Preventive maintenance**
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1

General information

Introduction

The Perkins Phaser engine for automotive applications is the latest development from the Perkins Engines Company Limited, a world leader in the design and manufacture of high performance diesel engines.

The engine conforms with European emissions legislation (Euro 2) for automotive applications.

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

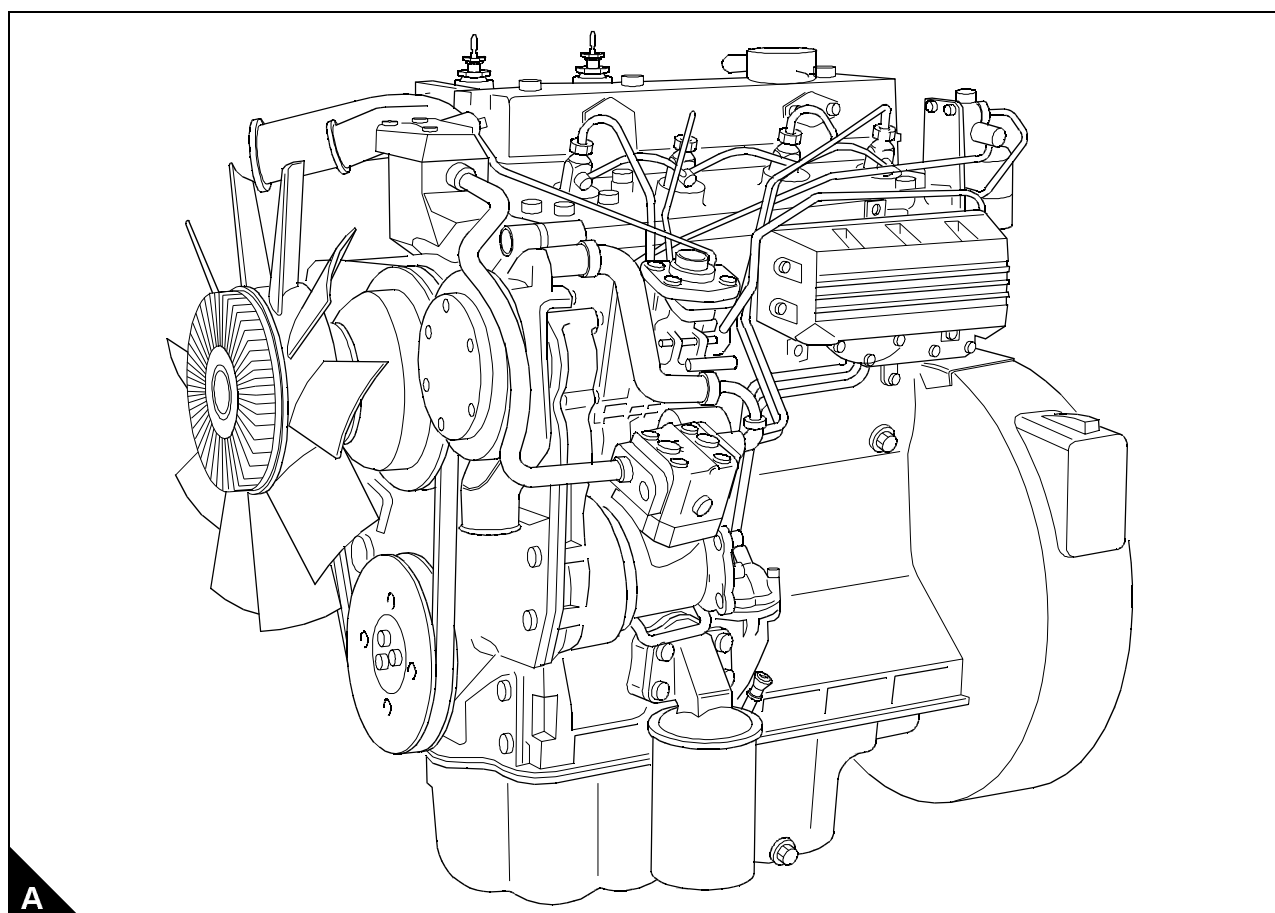
To ensure that you use the relevant information for your specific engine type, refer to "Engine identification" on page 9.

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 refer to specific applications.

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

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

- Do not operate the engine if a safety guard has been removed.
- Do not remove the filler cap or any component of the cooling system while the engine is hot and while the coolant is under pressure, because dangerous hot coolant can be discharged.
- Do not allow sparks or fire near the batteries (especially when the batteries are on charge) because the gases from the electrolyte are highly flammable. The battery fluid is dangerous to the skin and especially to the eyes.
- Disconnect the battery terminals before a repair is made to the electrical system.
- Only one person must control the engine.
- Ensure that the engine is operated only from the control panel or from the operators position. If your skin comes into contact with high-pressure fuel, obtain medical assistance immediately.
- Diesel fuel and lubricating oil (especially used lubricating oil) can damage the skin of certain persons. Protect your hands with gloves or a special solution to protect the skin.
- Do not wear clothing which is contaminated by lubricating oil. Do not put material which is contaminated with oil into the pockets of clothing.
- Discard used lubricating oil in accordance with local regulations to prevent contamination.
- Ensure that the control lever of the transmission drive is in the "out-of-drive" position before the engine is started.
- Use extreme care if emergency repairs must be made in adverse conditions.
- The combustible material of some components of the engine (for example certain seals) can become extremely dangerous if it is burned. Never allow this burnt material to come into contact with the skin or with the eyes.
- 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.
- Do not clean an engine while it runs. If cold cleaning fluids are applied to a hot engine, certain components on the engine may be damaged.
- Fit only genuine Perkins parts.

How to care for your engine

Warning! Read the "Safety precautions" on page 2 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.

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 indicated in Chapter 4, Preventive maintenance. If the engine works in a very dusty environment or other adverse conditions, certain maintenance intervals will have to be reduced. Renew the filter canisters and lubricating oil regularly in order 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.

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

Engine preservation

Introduction

The recommendations indicated below are designed to prevent damage to the engine when it is withdrawn from service for a prolonged period. Use these procedures after the engine is withdrawn from service. The instructions for the use of POWERPART products are given on the outside of each container.

Procedure

- 1 Completely clean the outside of the engine.
 - 2 When a preservative fuel is to be used, drain the fuel system and fill it with the preservative fuel. POWERPART Lay-Up 1 can be added to the normal fuel to change it to a preservative fuel. If preservative fuel is not used, the system can be kept full with normal fuel but the fuel must be drained and discarded at the end of the storage period together with the fuel filter canister.
 - 3 Operate the engine until it is warm. Then correct leakages of fuel, lubricating oil or air. Stop the engine and drain the lubricating oil from the sump.
 - 4 Renew the canister of the lubricating oil filter.
 - 5 Fill the sump to the full mark on the dipstick with new and clean lubricating oil and add POWERPART Lay-Up 2 to the oil to protect the engine against corrosion. If POWERPART Lay-Up 2 is not available, use a correct preservative fluid instead of the lubricating oil. If a preservative fluid is used, this must be drained and the lubricating oil sump must be filled to the correct level with normal lubricating oil at the end of the storage period.
 - 6 Drain the cooling system, see "How to drain the cooling system" on page 23. In order to protect the cooling system against corrosion, fill it with an approved antifreeze mixture because this gives a protection against corrosion, see "Coolant specification" on page 43.
- Caution:** *Certain corrosion inhibitor mixtures could cause damage to some engine components. It is recommended that you consult the Perkins Service Department, Peterborough.*
- 7 Operate the engine for a short period in order to circulate the lubricating oil and the coolant in the engine.
 - 8 Disconnect the battery. Then put the battery into safe storage in a fully charged condition. Before the battery is put into storage, protect its terminals against corrosion. POWERPART Lay-Up 3 can be used on the terminals.
 - 9 Clean the engine breather pipe (if one is fitted) and seal the end of the pipe.
 - 10 Remove the atomisers and spray POWERPART Lay-up 2 for one to two seconds into each cylinder bore with the piston at BDC.
 - 11 Slowly turn the crankshaft one revolution and then fit the atomisers with new seat washers and new dust seals.
 - 12 Remove the air filter. Then, if necessary, remove the pipe(s) installed between the air filter and turbocharger. Spray POWERPART Lay-Up 2 into the turbocharger. It is recommended that the spray time is 50% longer than the spray time indicated on the container label. Seal the turbocharger with waterproof tape.
 - 13 Remove the exhaust pipe. Spray POWERPART Lay-Up 2 into the turbine of the turbocharger. It is recommended that the spray time is 50% longer than the spray time indicated on the container label. Seal the turbocharger with waterproof tape.
 - 14 If the lubricating oil filler is fitted onto the rocker cover, remove the filler cap. If the lubricating oil filler is not fitted onto the rocker cover, remove the rocker cover. Spray POWERPART Lay-Up 2 around the rocker shaft assembly. Fit the filler cap or rocker cover.
 - 15 Seal the vent pipe of the fuel tank or the fuel filler cap with waterproof tape.

Continued

16 Remove the drive belts and put them into storage.

17 In order to prevent corrosion, spray the engine with POWERPART Lay-Up 3. Do not spray the area inside the alternator cooling fan.

Caution: *After a period in storage, but before the engine is started, operate the starter motor with the stop switch held in the "STOP" position, see "How to stop the engine" on page 19, until oil pressure is indicated. Oil pressure is indicated when the low pressure warning light is extinguished. If a solenoid stop control is used on the fuel injection pump, it must be disconnected for this operation.*

If the engine protection is done correctly according to the above recommendations, no corrosion damage will normally occur. Perkins are not responsible for damage which may occur when an engine is in storage after a period in service.

Parts and service

If problems occur with your engine or with the components fitted onto it, your Perkins distributor can make the necessary repairs and 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 POWER COMPONENTS system. These will enable you to reduce the cost of certain repairs.

POWERPART recommended consumable products

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

POWERPART Antifreeze

Protects the cooling system against frost and corrosion. Part number 1 litre 21825166 or 5 litres 21825167, see "Coolant specification" on page 43.

POWERPART Easy Flush

Cleans the cooling system. Part number 21825001

POWERPART Jointing compound

Universal jointing compound which seals joints. Currently Hylomar. Part number 1861155 or 1861117.

POWERPART Silicone rubber sealant

Silicone rubber sealant which prevents leakage through gaps. Currently Hylosil Part number 1861108.

POWERPART Lay-Up 1

A diesel fuel additive for protection against corrosion. Part number 1772204, see "Engine preservation" on page 4.

POWERPART Lay-Up 2

Protects the inside of the engine and of other closed systems. Part number 1762811, see "Engine preservation" on page 4.

POWERPART Lay-Up 3

Protects outside metal parts. Part number 1734115, see "Engine preservation" on page 4.

POWERPART Chisel

Allows easy removal of old gaskets and joints. Currently Loctite chisel. Part number 21825163.

POWERPART Repel

Dries damp equipment and gives protection against corrosion. Passes through dirt and corrosion to lubricate and to assist removal of components. Currently Loctite repel. Part number 21825164.

POWERPART Threadlock

To retain small fasteners where easy removal is necessary. Currently Loctite 222e. Part number 21820222.

POWERPART Nutlock

To retain and seal threaded fasteners and cup plugs where easy removal is necessary. Currently Loctite 242e. Part number 21820242

POWERPART Studlock

To permanently retain large fasteners and studs. Currently Loctite 270. Part number 21820270.

Continued

POWERPART Liquid gasket

To seal flat faces of components where no joint is used. Especially suitable for aluminium components. Currently Loctite 518. Part number 21820518

POWERPART Threadlock (hydraulic or pneumatic)

To retain and seal pipe connections with fine threads. Especially suitable for hydraulic and pneumatic systems. Currently Loctite 542. Part number 21820542

POWERPART Threadlock (pipe)

To retain and seal pipe connections with coarse threads. Pressure systems can be used immediately. Currently Loctite 575. Part number 21820575.

POWERPART Retainer (oil tolerant)

To retain components which have a transition fit. Currently Loctite 603. Part number 21820603.

POWERPART Retainer (high strength)

To retain components which have an interference fit. Currently Loctite 638. Part number 21820638.

POWERPART Atomiser thread sealant

To seal the threads of the atomiser into the cylinder head. Currently Hylomar Advance Formulation. Part number 21825474.

POWERPART Compound

To seal the outer diameter of seals. Currently Loctite Forma Gasket No 2. Part number 1861147.

POWERPART Platelock

For tight fitted metal surfaces. Suitable for metal plated surfaces and stainless steel, Currently Loctite 243. Part number 21826039.

POWERPART Gasket eliminator

Improves flange sealing when a gasket is not used. It provides a seal with temperature resistance that is flexible in positions where vibration and pressure occur. Currently Loctite 515. Part number 21826040.

POWERPART Silicone adhesive

An RTV silicone adhesive for application where low- pressure tests occur before the adhesive sets. Used to prevent leakage where movement of the joint occurs. Currently Loctite 5900. Part number 21826038.

Service literature

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

Training

Local training for the correct operation, service and overhaul of engines is available at certain Perkins distributors. If special training is necessary, your Perkins distributor can advise you how to obtain it at the Perkins Customer Training Department, Peterborough, or other main centres.

Engine identification

The Phaser 135Ti engine is rated at 135 bhp. The letters Ti indicate that the engine is turbocharged and intercooled.

The latest Phaser 135Ti can be identified by the letters AL at the beginning of the engine number. The correct identification of the engine is by the full engine number.

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

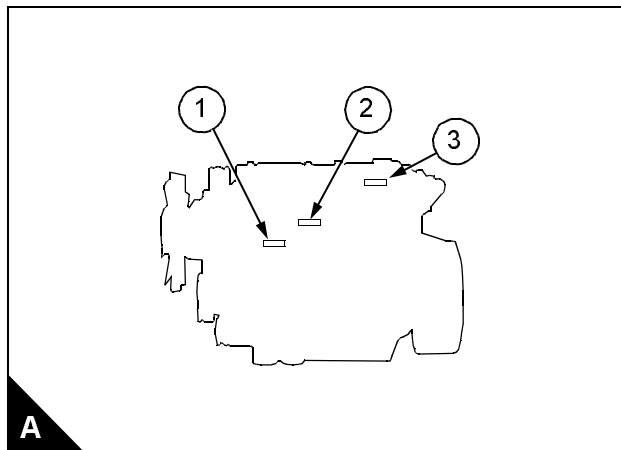
AL30126*U510256B*

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

Other identification labels fitted to the engine include:

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

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



General data

Number of cylinders	4
Cylinder arrangement	In line
Cycle	Four stroke
Induction system	Turbocharged/Intercooled
Combustion system	Direct injection
Nominal bore	100 mm (3.937 in)
Stroke	127 mm (5.00 in)
Compression ratio	17.25:1
Cubic capacity	4 litres (243 in ³)
Firing order	1, 3, 4, 2
Valve tip clearances (hot or cold)	
Inlet	0,20 mm (0.008 in)
Exhaust	0,45 mm (0.018 in)
Lubricating oil pressure ⁽¹⁾	280 kpa (40 lbf/in ²) 2,5 kgf/cm ²
Direction of rotation	Clockwise from the front

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

2

Engine views

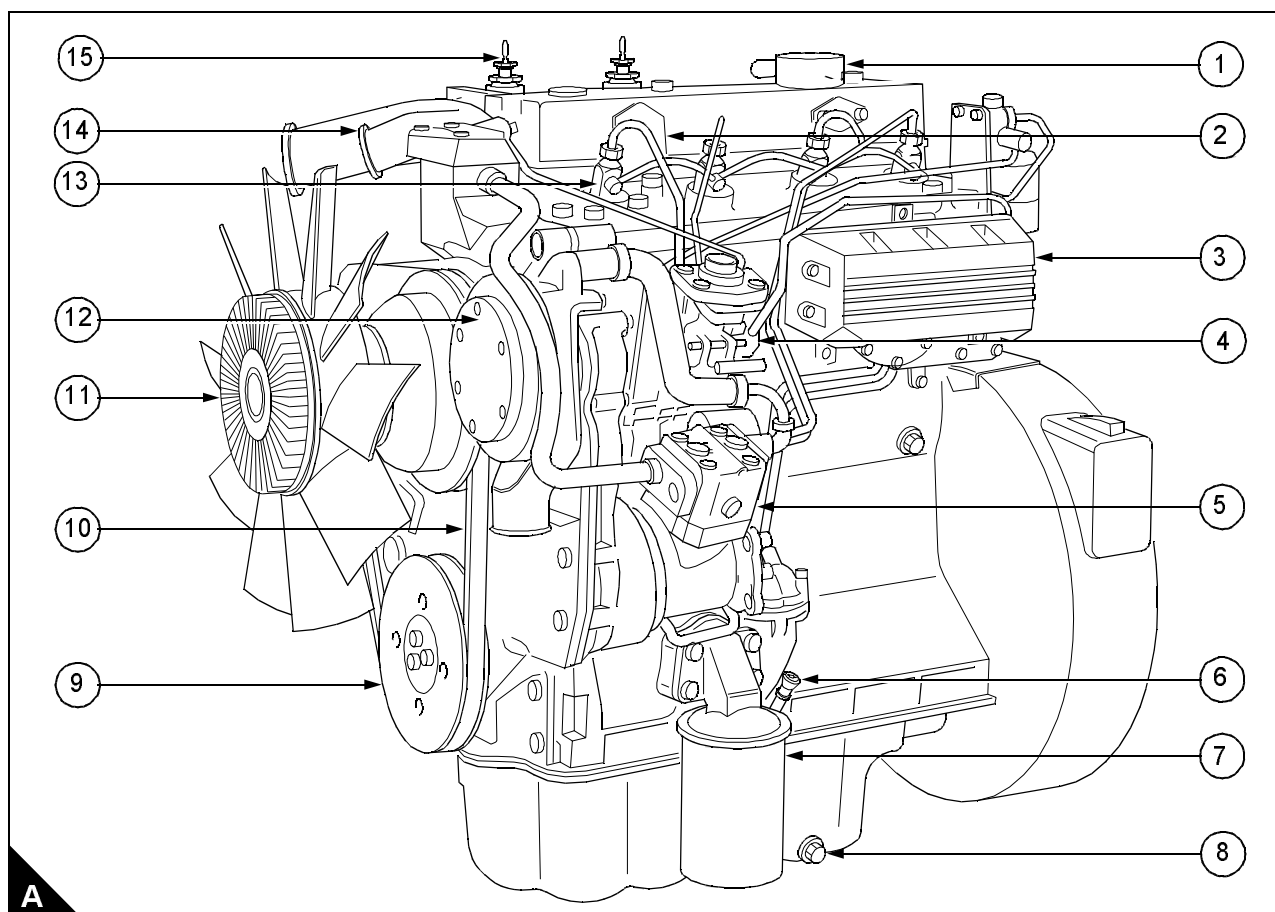
Introduction

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

Location of engine parts

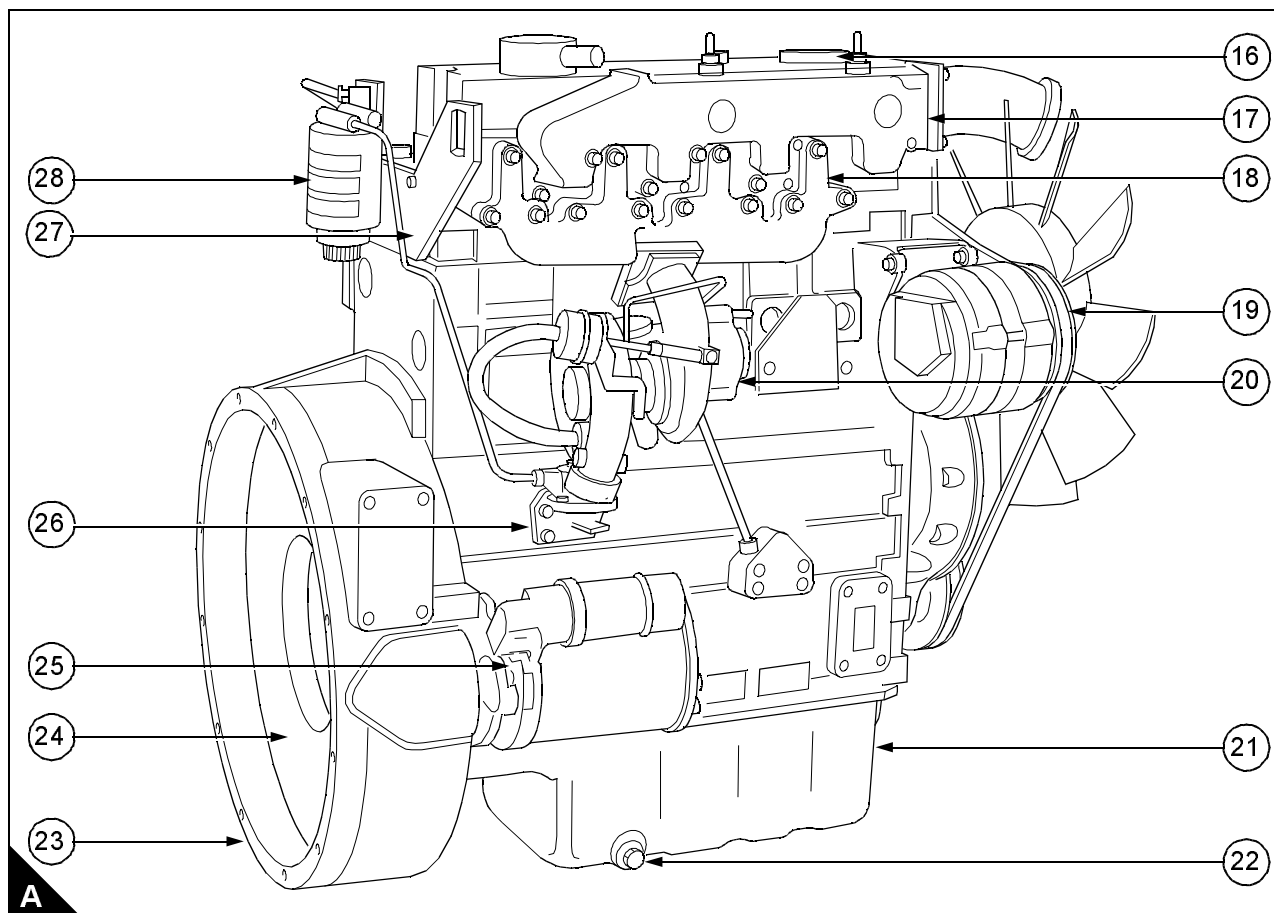
Front and left side of the engine

- | | |
|----------------------------------|----------------------|
| 1 Engine breather | 9 Crankshaft pulley |
| 2 Front lift bracket | 10 Drive belt |
| 3 Lubricating oil cooler | 11 Fan |
| 4 Fuel injection pump | 12 Coolant pump |
| 5 Compressor (If fitted) | 13 Atomiser |
| 6 Lubricating oil dipstick | 14 Coolant outlet |
| 7 Lubricating oil filter | 15 Cold start device |
| 8 Drain plug for lubricating oil | |



Rear and right side of the engine

- | | |
|-----------------------------------|----------------------|
| 16 Filler cap for lubricating oil | 23 Flywheel housing |
| 17 Induction manifold | 24 Flywheel |
| 18 Exhaust manifold | 25 Starter motor |
| 19 Alternator | 26 Fuel lift pump |
| 20 Turbocharger | 27 Rear lift bracket |
| 21 Lubricating oil sump | 28 Fuel filter |
| 22 Drain plug for lubricating oil | |



3

Operation instructions

How to start the engine

Several factors affect engine start, for example:

- The power of the batteries
- The performance of the starter motor
- The viscosity of the lubricating oil
- The installation of a cold start system.

The fuel injection pump is fitted with a cold start device which automatically advances the fuel injection when the engine is cold.

Diesel engines need an extra cold starting aid if they are to start in very cold conditions. Normally, your vehicle or your machine will be fitted with the correct equipment for your region of operation.

Perkins engines can be equipped with various cold starting systems. For the Phaser engine one of these systems may be fitted:

Fuelled starting aid

An electrically operated device which ignites a specific amount of diesel fuel in the induction manifold in order to heat the induction air.

Port heaters

These electrical devices are fitted in the induction manifold and heat the induction air. They are operated automatically when the starter motor is engaged. When these devices are fitted, the start procedure for a cold engine is the same as that given for a cold engine start without starting aids.

Start Pilot

A hand pump is used to inject a cold start fluid into the induction manifold through an atomiser. The cold start fluid ignites at a lower temperature than diesel fuel. The cold start fluid is contained in a separate reservoir. Certain models use a push button to actuate a solenoid which releases the cold start fluid from an aerosol container.

KBi

This system uses an aerosol container filled with a cold start fluid. The fluid is released by a solenoid, which is operated by a push button. The cold start fluid is sprayed into the induction manifold through a nozzle. The cold start fluid ignites at a lower temperature than diesel fuel.

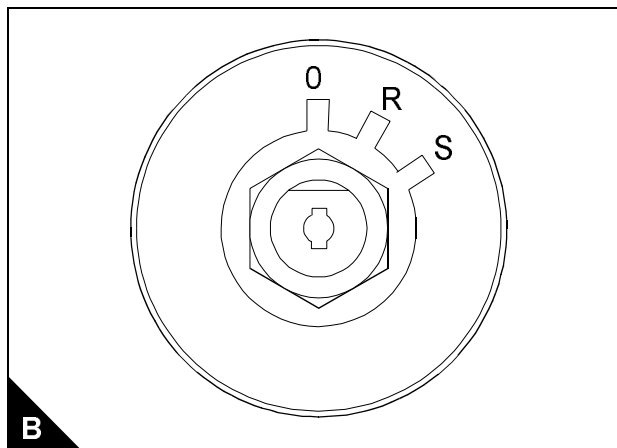
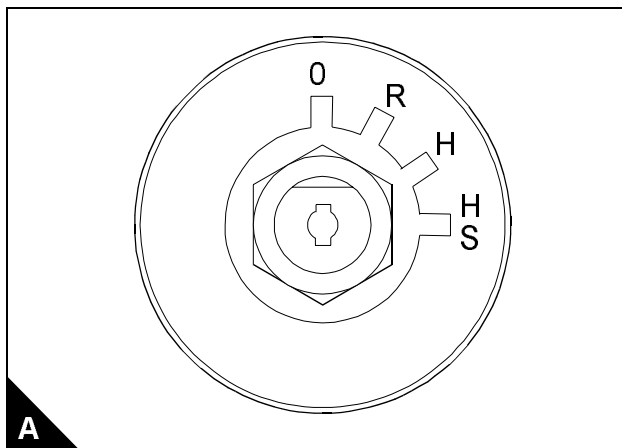
Cautions:

- *Do not operate the engine at high speeds without a load.*
- *If the engine has not run for several weeks, see **Caution** on page 5.*

How to start a warm engine

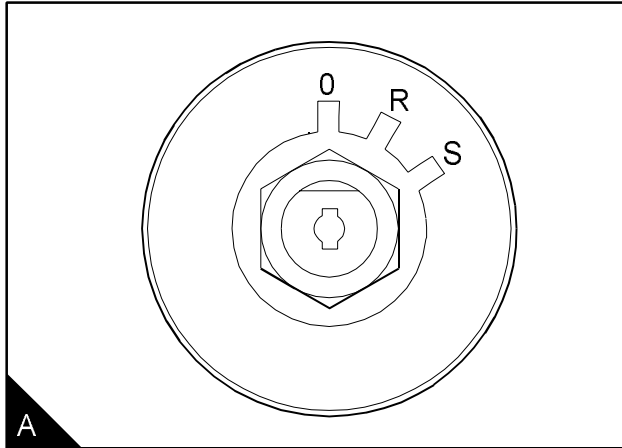
- 1 If the engine is equipped with a manual stop control, ensure that it is in the "run" position.
- 2 Adjust the engine speed control to the quarter open position.
- 3 Turn the start key to the "HS" or "S" position (A) or (B) to engage the starter motor.
- 4 Allow the start key to return to the "R" position, as soon as the engine starts.

Always ensure that the engine and starter motor are stationary before the starter motor is engaged again.



How to start a cold engine without starting aids

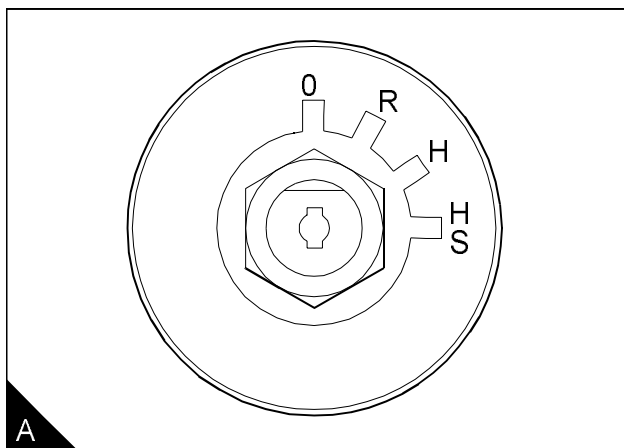
- 1 If the engine is equipped with a manual stop control, ensure that it is in the "run" position.
- 2 Adjust the engine speed control to the maximum speed position.
- 3 Turn the start key to the "S" position (A) to engage the starter motor. Allow the key to return to the "R" position, when the engine starts. Then adjust the engine speed control to get an even idle speed.
- 4 If the engine does not start in 30 seconds, allow the start key to return to the "R" position for another 30 seconds. Then engage the starter motor again for a maximum period of 30 seconds.



How to start a cold engine with the fuelled starting aid

Caution: *Ether type fuels must not be used at the same time as a fuelled starting aid.*

- 1 If the engine is equipped with a manual stop control, ensure that it is in the "run" position.
- 2 Turn the start key to the "H" position (A) and keep it there for 15 seconds.
- 3 Adjust the engine speed control to the maximum speed position.
- 4 Turn the start key to the "HS" position in order to engage the starter motor. Allow the start key to return to the "R" position, when the engine starts. Then adjust the engine speed control to give an even idle speed.
- 5 If the engine does not start in 15 seconds, turn the start key to the "H" position and hold it there for 10 seconds. Then engage the starter motor again.



How to start a cold engine with manually operated Start Pilot

Caution: Start Pilot equipment must not be used with heater type starting aids such as the fuelled starting aid.

Do not use the hand pump until the starter motor is engaged. The amount of fluid which is necessary for an engine start will be found by experience.

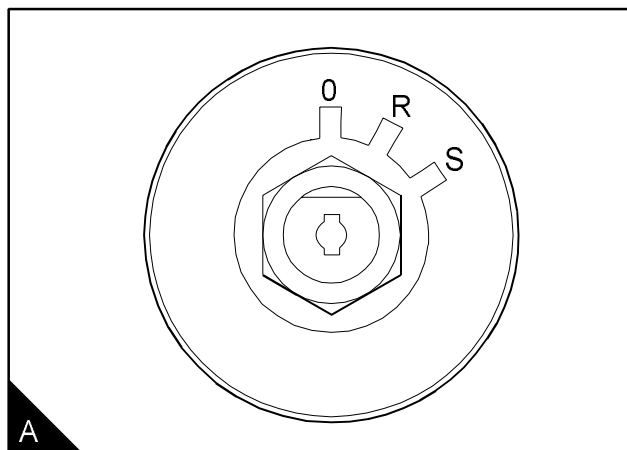
- 1 If necessary, fill the reservoir with fluid. Lift the cover of the reservoir and press the can, head down, onto the filler plug. Hold it squarely until the fluid fills the bowl to the maximum mark.
- 2 If the engine is equipped with a manual stop control, ensure that it is in the "run" position.
- 3 Adjust the engine speed control to the maximum speed position.
- 4 Turn the start key to the "S" position (A) in order to engage the starter motor. Hold the start key in this position for a maximum of 30 seconds and operate the hand pump during this period. When the engine starts, release the start key to the "R" position and adjust the engine speed control to get an even idle speed.
- 5 If the engine does not start in 30 seconds, allow the start key to return to the "R" position for another 30 seconds. Then engage the starter motor and operate the hand pump again.

In certain conditions, it is necessary to inject a little more fluid after the engine has started in order to ensure that the engine continues to run.

The air filter at the outer end of the pump must be inspected from time to time. If necessary, it must be washed in kerosene.

The inside surface of the cylinder can be lightly lubricated with a thin lubricating oil.

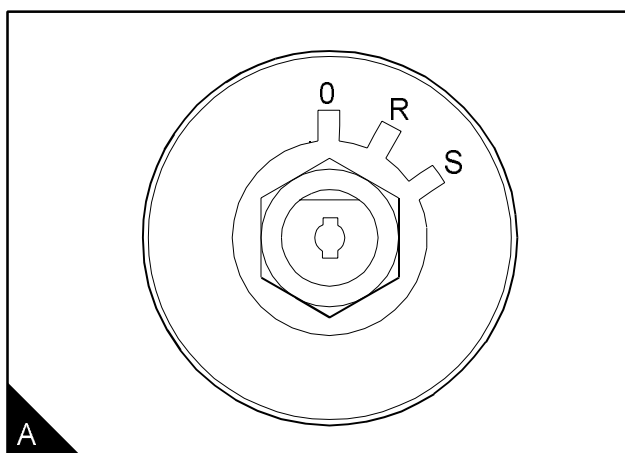
The nozzle can be removed from the induction manifold and washed in kerosene, if necessary. Use the direction mark on the nozzle body to ensure that the nozzle is fitted in its original position.



How to start a cold engine with KBi or electrically operated Start Pilot

Caution: KBi equipment must not be used with heater type cold starting aids such as the fuelled starting aid.

- 1 If necessary, renew the screw type canister. Ensure that the sealing washer remains in position when the new canister is fitted. Each container has a safety valve.
- 2 If the engine is equipped with a manual stop control, ensure that it is in the "run" position.
- 3 Adjust the engine speed control to the maximum speed position.
- 4 Turn the start key to the "S" position (A) in order to engage the starter motor.
- 5 When the engine turns, press the starting aid button for a maximum period of 2 seconds. If the engine does not start after the first 2 second application, keep the starter motor engaged. After 5 seconds, press the button again for 2 seconds.
- 6 Allow the start switch to return to the "R" position, when the engine starts. Then adjust the engine speed control to get an even idle speed. In certain conditions it is necessary to inject a little more fluid after the engine has started, in order to ensure that the engine continues to run.

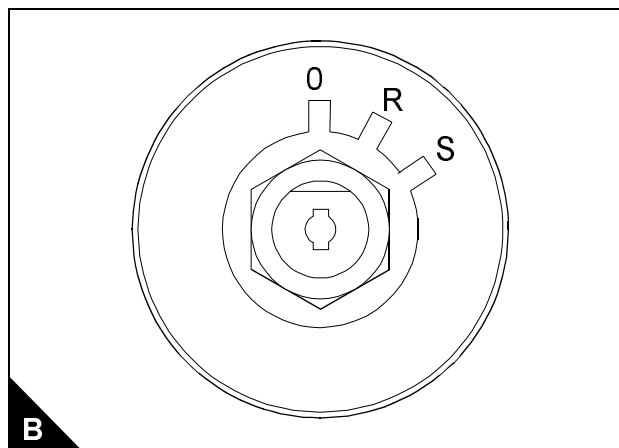
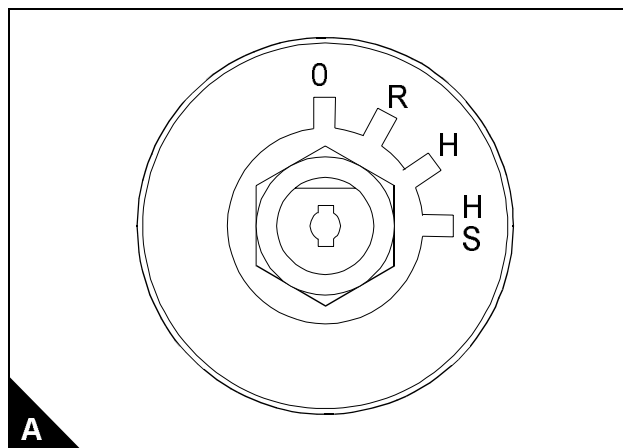


How to stop the engine

Caution: It is recommended that a turbocharged engine is run at approximately 1000 rev/min at a reduced load for 2-3 minutes before it is shut down. This will allow the turbocharger to cool.

Adjust the engine speed control to the minimum position.

According to the equipment fitted, either turn the engine start key to the "O" position (A) or (B), or operate the manual stop control. If a manual stop control is used, ensure that the control returns to the "run" position after the engine has stopped. Also ensure that the engine start key is turned to the "O" position.



Adjustment of the engine speed range

The idle or the maximum speed settings must not be changed by the engine operator, because this can damage the engine or transmission. The warranty of the engine can be affected if the seals on the fuel injection pump are broken during the warranty period by a person who is not approved by Perkins.

Running-in

Cautions:

- Do not operate the engine at high speeds without a load.
- Do not overload the engine.

A gradual running-in of a new engine or an exchange engine is not necessary. Prolonged operation at light loads during the early life of the engine can cause lubricating oil to enter the exhaust system. Maximum load can be applied to a new engine as soon as the engine is put into service and the coolant temperature has reached a minimum of 60 °C (140 °F).

The engine will benefit if the load is applied as soon as possible after the engine is put into service.

Turbocharged engines

Because of the power characteristics of the turbocharged engines it is necessary to maintain a high engine speed when you climb a gradient. To ensure that the engine is not overloaded at low engine speeds engage a lower gear.

Altitude

Perkins can give the percentage of fuel reduction necessary if details of the engine application and ambient conditions are given. Changes to the settings of the fuel injection pump must be made by a Perkins distributor or by an approved distributor for the fuel injection pump.

4

Preventive maintenance

Preventive maintenance periods

Caution: *On short distance operation with frequent starts and stops the hours of operation are more important than the distance.*

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.

Schedules

The schedules which follow must be applied at the interval (kilometres, miles, or months) which occur first.

- | | |
|---|---|
| A First service at 1000/2000km (600/1200 miles) or 20/40 hours | E Every 20000 km (12,500 miles) 400 hours or 12 months |
| B Every day or every 8 hours | F Every 2000 hours |
| C Every 10000 km (6,250 miles) 200 hours or 6 months | G Every 100000 km (62,500 miles) 2000 hours |
| D Every 15000 km (9,250 miles) 300 hours or 9 months | H Atomiser maintenance |

A	B	C	D	E	F	G	Operation
●	●						Check the amount of coolant
				●			Check the specific gravity of the coolant ⁽²⁾ ⁽³⁾
●		●					Check the tension and the condition of the drive belt
	●						Check the engine for leakage of oil and coolant
				●			Clean the sediment chamber and the strainer of the fuel lift pump
		●					Check for water in the pre-filter ⁽¹⁾ , (or earlier if your fuel supply is contaminated)
				●			Renew the canister of the fuel filter
						●	Atomiser maintenance ⁽³⁾ , see "Atomiser maintenance" on page 28
●							Ensure that the idle speed is checked and adjusted, if it is necessary ⁽³⁾
	●						Check the amount of lubricating oil in the sump
	●						Check the lubricating oil pressure at the gauge ⁽¹⁾
			●				Renew the engine lubricating oil ⁽⁴⁾ ⁽⁵⁾
			●				Renew the canister of the lubricating oil filter ⁽⁵⁾
					●		Renew the gauze element of the engine breather system
							Empty the dust bowl of the air filter
	●						- extremely dusty conditions
		●					- normal conditions
				●			Clean or renew the air filter element, if it has not been indicated earlier
		●			●		Ensure that the turbocharger impeller and turbocharger compressor casing are cleaned ⁽³⁾
							Clean the compressor air filter ⁽¹⁾
		●			●		Ensure that the exhauster or compressor ⁽¹⁾ is checked ⁽³⁾
							Check all electrical cables and connections ⁽⁶⁾
●					●		Ensure that the valve tip clearances of the engine are checked and, if necessary, adjusted ⁽³⁾
					●		Ensure that the alternator, the starter motor are checked ⁽³⁾

(1) If one is fitted.

(2) Check the specific gravity every 12 months and renew the antifreeze every 2 years. If a coolant inhibitor is used instead of antifreeze, it should be renewed every 6 months. If combustion gases are released into the coolant circuit, the coolant must be renewed.

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

(4) The oil change interval will change with the amount of sulphur in the fuel (see "Fuel specification" on page 41). The interval to change the canister of the lubricating oil filter is not affected.

(5) The lubricating oil and canister change is increased to 25000 km (15,500 miles) or 12 months if lubricating oil to specification **API CG4 / ACEA E3** is used.

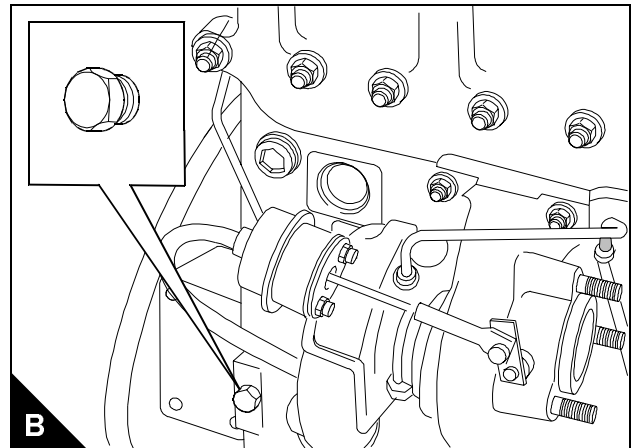
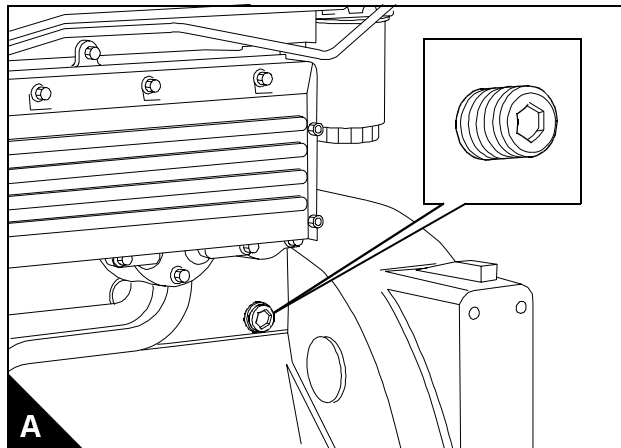
(6) Caution: Serious damage to the engine will occur if there is a failure in the electrical circuit for the cold start advance. The engine will run continuously with the timing fully advanced.

How to drain the cooling system

Warnings!

- *Discard the used coolant in a safe place and in accordance with local regulations.*
- *Do not drain the coolant while the engine is still hot and the system is under pressure because dangerous hot coolant can be discharged.*
- *Refer to your equipment supplier's handbook for the application to fill the coolant system. If coolant is to be added to the circuit during service, allow the engine to cool before the coolant is added. Remove the filler cap slowly as dangerous coolant could be discharged if the coolant is still hot and the system under pressure.*

- 1 Ensure that the vehicle or machine is on level ground.
- 2 Remove the filler cap of the coolant system.
- 3 Remove the brass drain plug from the side of the cylinder block (A or B) in order to drain the engine. Ensure that the drain hole is not restricted.
- 4 Open the tap or remove the drain plug at the bottom of the radiator in order to drain the radiator. If the radiator does not have a tap or drain plug, disconnect the hose at the bottom of the radiator.
- 5 Flush the coolant system with clean water.
- 6 Fit the hoses to the top of the cooler and tighten the clips.
- 7 Fit the drain plugs and the filler cap. Close the radiator tap or connect the radiator hose.



How to check the specific gravity of the coolant

For mixtures which contain inhibited ethylene glycol

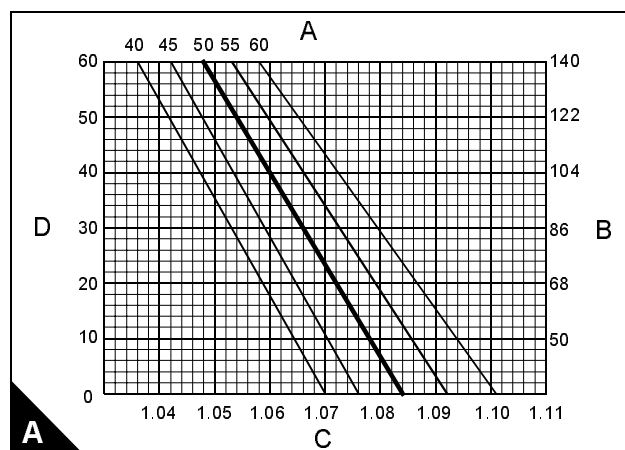
- 1 Ensure that the machine is on level ground.
- 2 Operate the engine until it is warm enough to open the thermostat. Continue to run the engine until the coolant has circulated the cooling system.
- 3 Stop the engine.
- 4 Allow the engine to cool until the temperature of the coolant is below 60 °C (140 °F).

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

- 5 Remove the filler cap of the cooling system.
- 6 Drain some coolant from the cooling system into a suitable container.
- 7 Use a special coolant hydrometer that will check the temperature and the specific gravity of the coolant, follow the manufacturer's instructions. If a special coolant hydrometer is not available, put a hydrometer and a separate thermometer into the antifreeze mixture and check the readings on both instruments. Compare the readings with the chart (A).
- 8 Adjust the strength of the mixture as necessary.

Note: If it is necessary to fill or replenish the coolant system in service, mix the coolant to the correct strength before it is added to the coolant system.

Perkins POWERPART antifreeze with a concentration of 50% will give protection against frost to a temperature of -35 °C (-31 °F). It will also give protection against corrosion. This is especially important when there are aluminium components in the coolant circuit.



Specific gravity chart

A = Percentage antifreeze by volume

B = Mixture temperature in °F

C = Specific gravity

D = Mixture temperature in °C

How to check and adjust the drive belt(s)

To check

Renew a belt if it is worn or damaged. If twin belts are fitted, they must be renewed together.

To ensure maximum belt life, it is recommended that a belt tensioner gauge is used to check the belt tension.

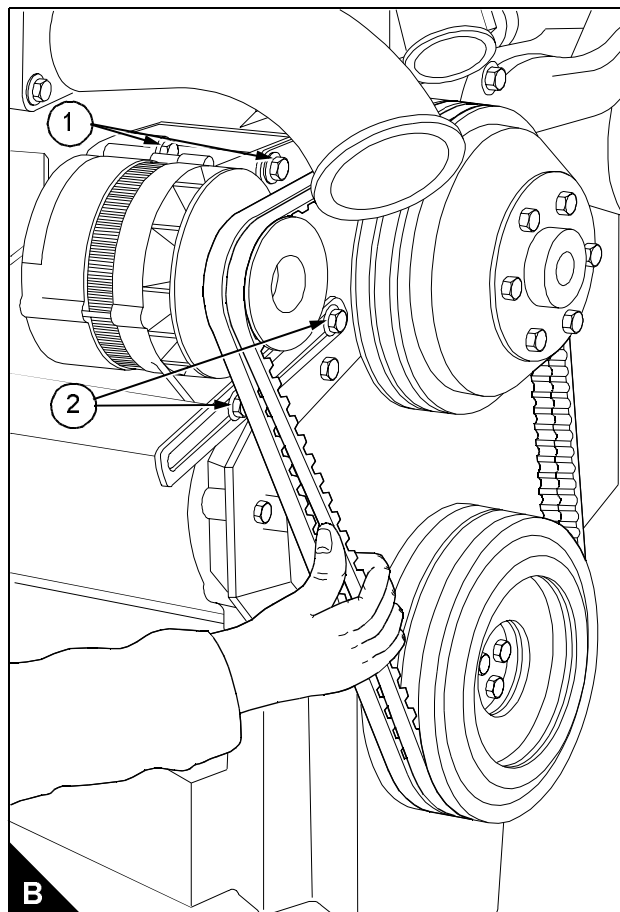
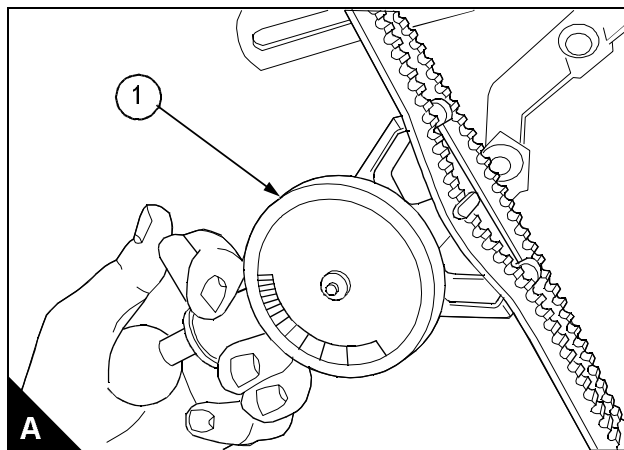
Fit the gauge (A1) at the centre of the longest free length and check the tension. If a "Burroughs" gauge is used, the correct tension is 355 N (80 lbf) 36 kgf. If the tension is 220 N (50 lbf) 22 kgf or below, adjust it to 355 N (80 lbf) 36 kgf as indicated below:

If a gauge is not available, press down the belt with the thumb at the centre of the longest free length and check the deflection (B). With moderate thumb pressure - 45N (10 lbf) 4,5 kgf - the correct deflection of the belt is 10 mm ($\frac{3}{8}$ in).

If twin belts are fitted, check/adjust the tension on the tighter belt.

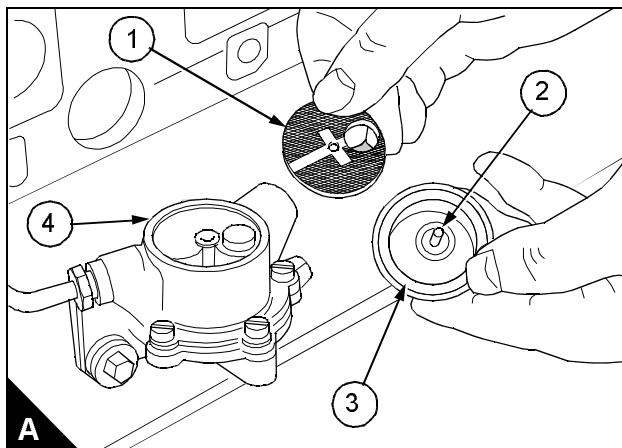
To adjust belt tension

- 1 Loosen the pivot fasteners (B1) of the alternator and the adjustment link fasteners (B2).
- 2 Change the position of the alternator to give the correct tension. Tighten the pivot fasteners of the alternator and the adjustment link fasteners.
- 3 Check the belt tension again to ensure that it is still correct. If a new belt is fitted, the belt tension must be checked again after the first 20 hours of operation.



How to clean the gauze strainer of the fuel lift pump

- 1 Release the fastener (A2) and remove the cover and the joint (A3) from the top of the fuel lift pump (A4). Remove the gauze strainer (A1).
- 2 Wash carefully all of the sediment from the lift pump body.
- 3 Clean the gauze strainer, the joint and the cover.
- 4 Assemble the lift pump. Use a good joint and ensure that the lift pump body and the cover are fitted together correctly, because leakage at this point will let air into the fuel system.
- 5 Eliminate the air from the fuel system, see "How to eliminate air from the fuel system" on page 32.



Fuel pre-filter

If a pre-filter is fitted between the fuel tank and the engine. Check the filter bowl for water at regular intervals and drain as necessary.

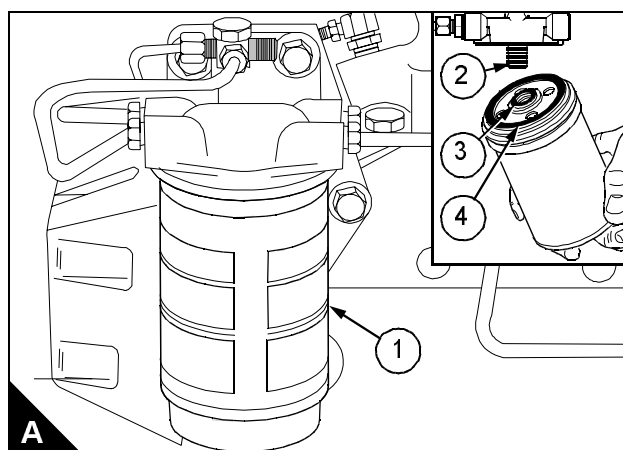
How to renew the canister of the fuel filter

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

Cautions:

- It is important that only the genuine Perkins parts are used. The use of a wrong canister or element can damage the fuel injection pump.
- Do not allow dirt to enter the fuel system. Before a connection is disconnected, clean thoroughly the area around the connection. After a component has been disconnected, fit a suitable cover to all open connections.
- The pre-filter and main filter canisters must be renewed at the same time.

- 1 Thoroughly clean the outside surfaces of the fuel filter assembly (A). Loosen the drain device at the bottom of the filter, if one is fitted and allow the water/fuel to drain into a suitable container.
- 2 Use a strap wrench or similar tool to loosen the filter canister (A1). Remove and discard the canister.
- 3 Ensure that the threaded adaptor (A2) is secure in the filter head and that the inside of the head is clean.
- 4 Ensure that the two seals (A3) and (A4), which are supplied with the new canister, are in position on top of the canister.
- 5 Lightly lubricate the seals of the new canister with clean fuel. Fit the new canister to the filter head and tighten by hand only.
- 6 Eliminate the air from the fuel filter, "How to eliminate air from the fuel system" on page 32.



Atomiser maintenance

Caution: A faulty atomiser must be renewed by a person who has had the correct training.

Regular maintenance of the atomisers is not necessary. The atomiser nozzles should be renewed and not cleaned, and renewed only if an atomiser fault occurs. The major problems that may indicate that new nozzles are needed are listed below:

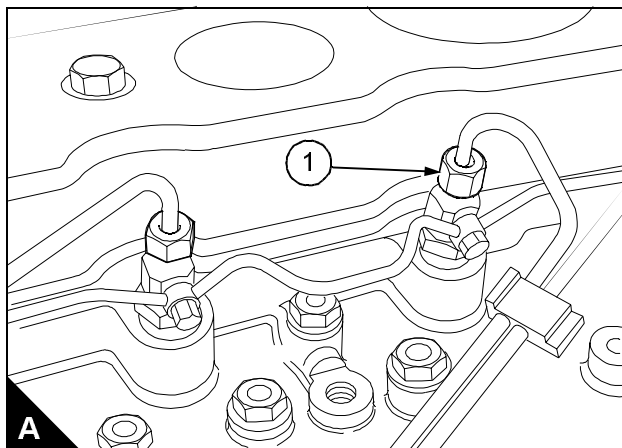
- Engine will not start or is difficult to start
- Not enough power
- Engine misfires or runs erratically
- High fuel consumption
- Black exhaust smoke
- Engine knocks or vibration
- Excessive engine temperature

Atomiser fault

Warnings!

- If your skin comes into contact with high- pressure fuel, obtain medical assistance immediately.
- Keep away from moving parts during engine operation. Some moving parts cannot be seen clearly while the engine runs.

In order to find which atomiser is defective, operate the engine at a fast idle speed. Loosen and tighten the union nut (A1) of the high-pressure fuel pipe at each atomiser. Do not loosen the union nut more than half a turn. When the union nut of the defective atomiser is loosened, it has little or no effect on the engine speed.



How to remove an atomiser

Cautions:

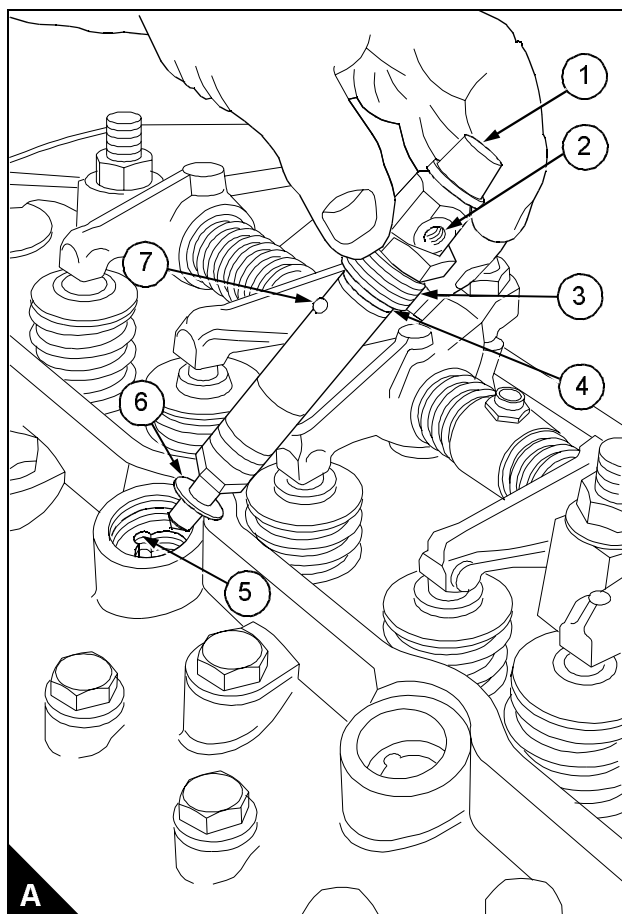
- Atomisers must be removed and fitted by a person with the correct training.
- Do not allow dirt to enter the fuel system. Before a connection is disconnected, clean thoroughly the area around the connection. After a component has been disconnected, fit a suitable cover to all open connections.

1 Remove the fuel leak-off pipe from the connection (A2).

2 Remove the union nuts of the high-pressure pipe from the atomiser and from the fuel injection pump. Do not bend the pipe. If necessary, remove the pipe clamps. Fit a plastic cap (A1) to cover the fuel inlet connection.

Caution: Remove and discard the seat washer (A4). If the original seat washer remains in the recess for the atomiser, the nozzle protrusion will be incorrect when a new seat washer is added.

3 Release the clamp nut (A3) and remove the atomiser and its seat washer from the recess in the cylinder head.



How to fit an atomiser

Special requirements

Consumable products	
Description	Part number
POWERPART atomiser thread sealant	21825474

Cautions:

- Atomisers must be removed and fitted by a person with the correct training.
- Do not allow dirt to enter the fuel system. Before a connection is disconnected, clean thoroughly the area around the connection. After a component has been disconnected, fit a suitable cover to all open connections.

1 Thoroughly clean the threads of the gland nut (A3) and the cylinder head.

Caution: Do not allow any thread sealant to get below the gland nut threads.

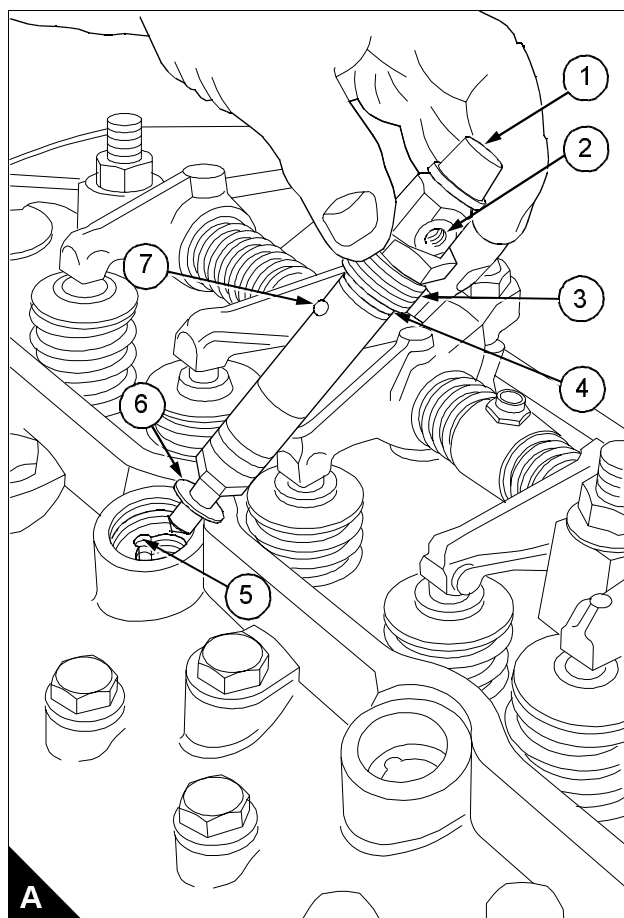
2 Ensure that the wire clip (A4) is in position. Put a 2 mm (0.08 in) bead of POWERPART atomiser thread sealant onto the first two threads of the gland nut. The bead should extend approximately 6 mm (0.24 in) around each of the threads. Ensure that the sealant does not contact the body of the atomiser.

Caution: Remove and discard the original seat washer (A6). If the original seat washer remains in the recess for the atomiser, the nozzle protrusion will be incorrect when a new seat washer is added.

Put the new seat washer (A6) into the seat recess in the cylinder head.

Put the atomiser in position, ensure that the location ball (A7) is fitted in the groove (A5) correctly. Carefully engage the threads of the gland nut (A3) with the threads in the cylinder head.

Caution: Do not move the thread after it has been tightened, the seal that is made when torque has been applied will be broken and leakage past the atomiser seat may occur.



Continued

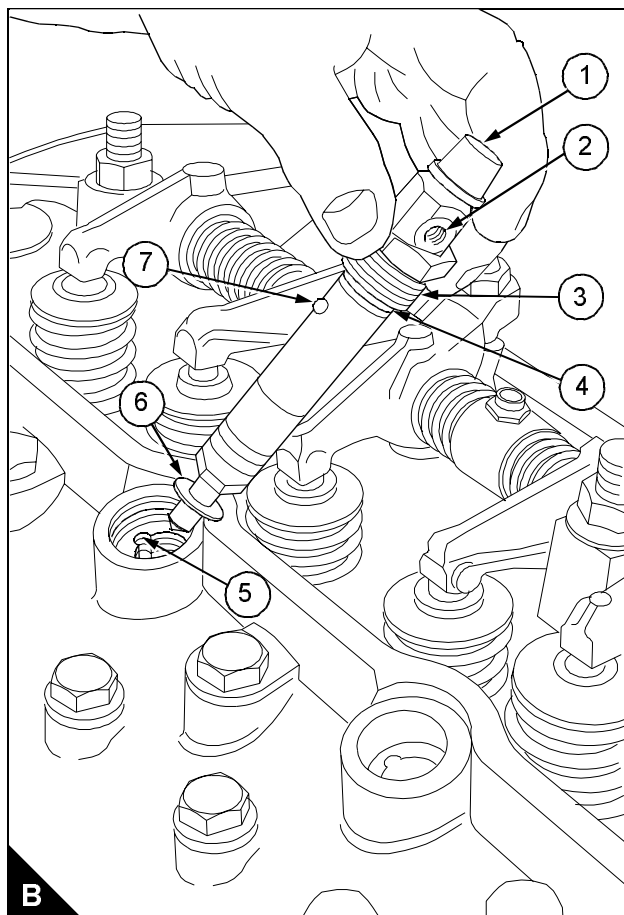
Tighten the nut gradually and evenly to 40 Nm (30 lbf ft) 4,1 kgf m. As the nut is tightened the atomiser will rotate clockwise as the ball moves in the slot, this is acceptable. Remove any excess thread sealant.

Caution: Do not tighten the union nuts of the high- pressure pipes more than the recommended torque. If there is a leakage from the union nut, ensure that the pipe is correctly aligned with the atomiser inlet. Do not tighten the atomiser union nut more, as this can cause a restriction at the end of the pipe, and can affect fuel delivery.

3 Remove the plastic cap (B1) and fit the high- pressure fuel pipe and tighten the union nuts to 22 Nm (16 lbf ft) 2,2 kgf m. If necessary, fit the pipe connections.

4 Renew the sealing washers and fit the leak-off pipe to the leak off connection (B2). Tighten the banjo bolt to 9,5 Nm (7,0 lbf ft) 1,0 kgf m.

5 Operate the engine and check for leakage of fuel and air.



How to eliminate air from the fuel system

Warning! If your skin comes into contact with high- pressure fuel, obtain medical assistance immediately.

If air enters the fuel system, it must be removed before the engine can be started.

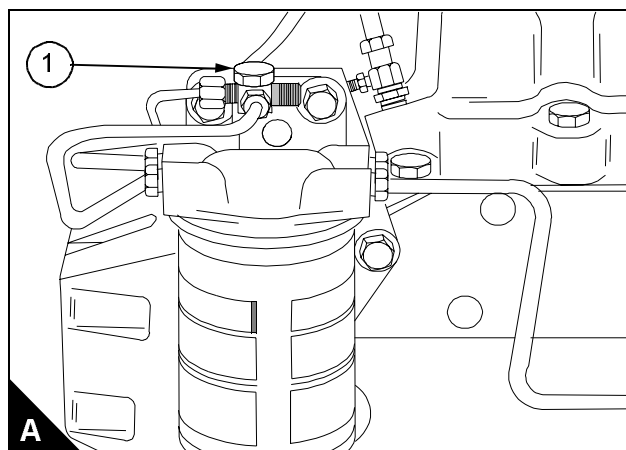
Air can enter the system if:

- The fuel tank is drained during normal operation.
- The low-pressure fuel pipes are disconnected.
- A part of the low-pressure fuel system leaks during engine operation.

In order to eliminate air from the fuel system, proceed as follows:

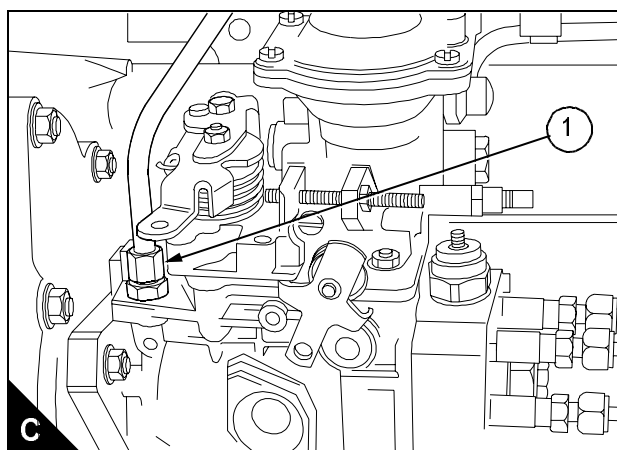
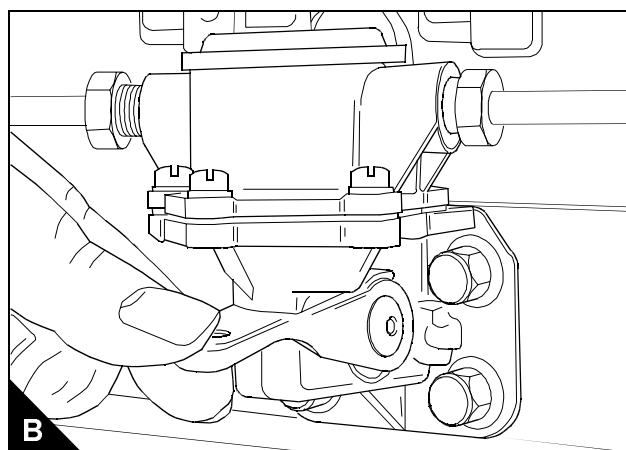
Caution: If the fuel system is empty or if the canister of the fuel filter have been renewed, it will be necessary to eliminate air from the fuel system, especially the fuel injection pump.

1 Loosen the banjo bolt (A1) on the top of the filter head. If a vent plug is fitted, loosen the vent plug instead.



2 Operate the priming lever of the fuel lift pump (B) until fuel, free from air, comes from the banjo bolt. Tighten the banjo bolt. If the drive cam of the fuel lift pump is at the point of maximum lift, it will not be possible to operate the priming lever. In this situation, the crankshaft must be rotated one revolution.

3 Loosen the union nut of the fuel inlet pipe (C1). Operate the priming lever of the fuel lift pump until fuel, free from air, comes from the loose connection. Tighten the union nut.



Continued

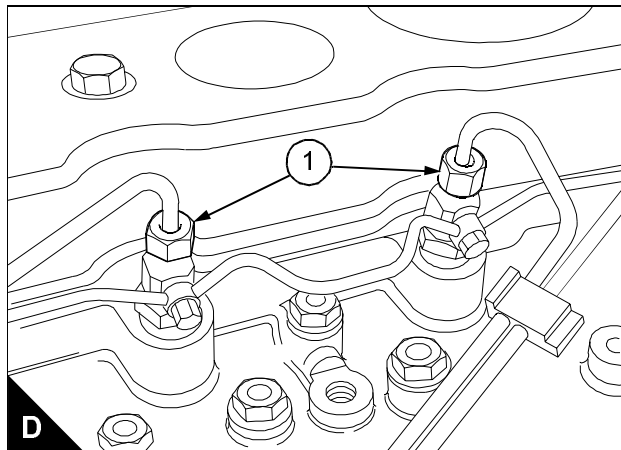
4 Loosen the high-pressure connections at two of the atomisers (D1).

Caution: Do not tighten the union nuts of the high-pressure pipes more than the recommended torque tension. If there is a leakage from the union nut, ensure that the pipe is correctly aligned with the atomiser inlet. Do not tighten the atomiser union nut more, as this can cause a restriction at the end of the pipe. This can affect the fuel delivery.

5 Put the electrical system switch to the "ON" position, see "How to start the engine" on page 13. Ensure that the manual stop control, if one is fitted, is in the "run" position. Operate the starter motor until fuel, free from air, comes from the pipe connections. Tighten the high-pressure pipe connections to 22 Nm (16 lbf ft) 2,2 kgf m. Return the switch to the "OFF" position.

6 The engine is now ready to start.

If the engine runs correctly for a short time and then stops or runs roughly, check for air in the fuel system. If there is air in the fuel system, there is probably a leakage in the low pressure system.



How to renew the lubricating oil of the engine

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

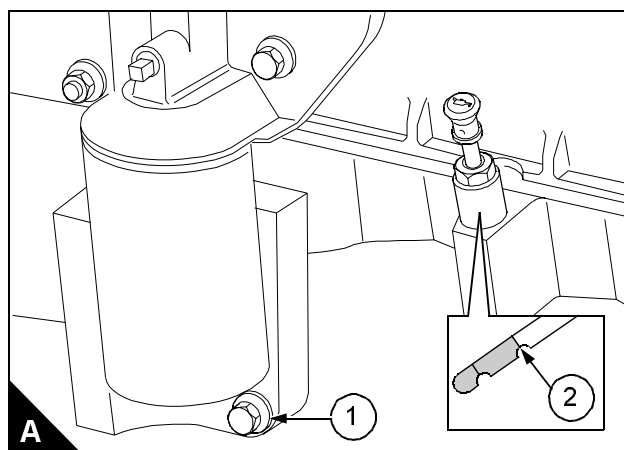
Caution: Ensure that the application is on a level surface to ensure an accurate reading on the dipstick.

1 Operate the engine until it is warm.

2 Stop the engine. Remove the sump drain plug (A1) and its "O" ring and drain the lubricating oil from the sump. Ensure that the "O" ring is not damaged. Fit the drain plug and its "O" ring and tighten the plug to 34 Nm (25 lbf ft) 3,5 kgf m.

Caution: Do not fill the sump past the notch (mark) (A2) on the dipstick as this can have an adverse affect on the performance of the engine or damage the engine. Excess lubricating oil must be drained from the sump.

3 Fill the sump to the mark (A2) on the dipstick with new and clean lubricating oil of an approved grade, see "Lubricating oil specification" on page 42.



How to renew the canister of the lubricating oil filter

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

Cautions:

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

1 Put a tray under the filter to retain spilt lubricating oil.

2 Remove the filter canister with a strap wrench or similar tool. Ensure that the adaptor (A1) is secure in the filter head. Discard the canister.

3 Clean the filter head.

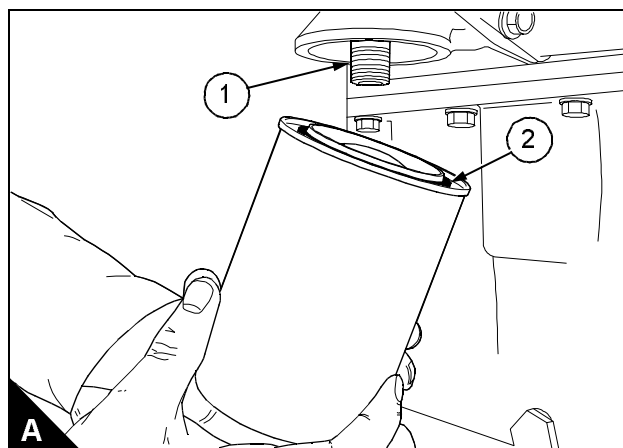
4 Add clean engine lubricating oil to the new canister. Allow the oil enough time to pass through the filter element.

5 Lubricate the top of the canister seal (A2) with clean engine lubricating oil.

6 Fit the new canister and tighten it by hand only. Do not use a strap wrench.

Ensure that there is lubricating oil in the sump. On turbocharged engines ensure that the engine will not start and operate the starter motor until oil pressure is obtained. To ensure that the engine will not start, either put the manual stop control in the "stop" position or disconnect the electrical stop control of the fuel injection pump. Oil pressure is indicated when the warning light is extinguished or by a reading on the gauge.

7 Operate the engine and check for leakage from the filter. 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 engine breather

1 Release the hose clips and remove the breather cover (A1).

Note: It is not necessary to remove the body of the breather (A4) from the rocker cover to provide access to the gauze.

2 Remove and discard the plastic gauze (A2).

3 Clean the body of the breather in clean kerosene.

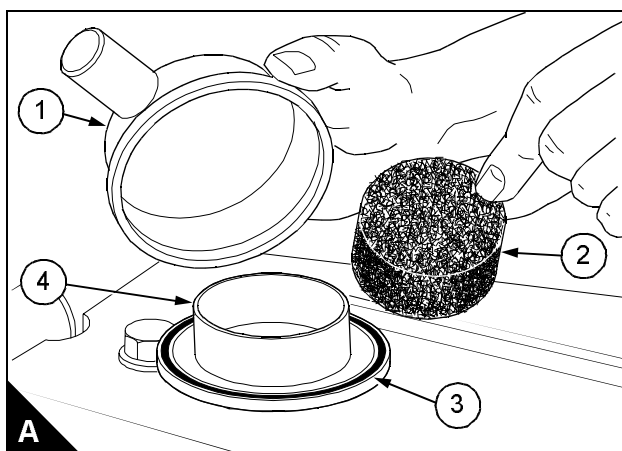
4 If necessary, renew the "O" ring seal (A3).

5 Check that the inside of the breather pipe is clean. If the pipe is not clean, release the flange setscrews and remove the pipe. Wash the pipe with kerosene and dry it with low pressure air.

6 Fit the cover to the breather body, ensure that it is securely fitted.

7 Fit the breather pipe and fasten the hose clips.

Note: The body of the breather is fastened to the rocker cover by a screw thread. If it becomes necessary to renew the breather assembly, a "C" spanner can be applied to the lugs on the bottom of the body to release the thread.

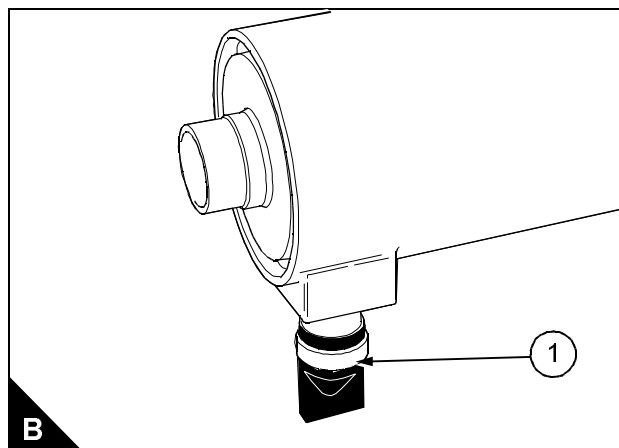
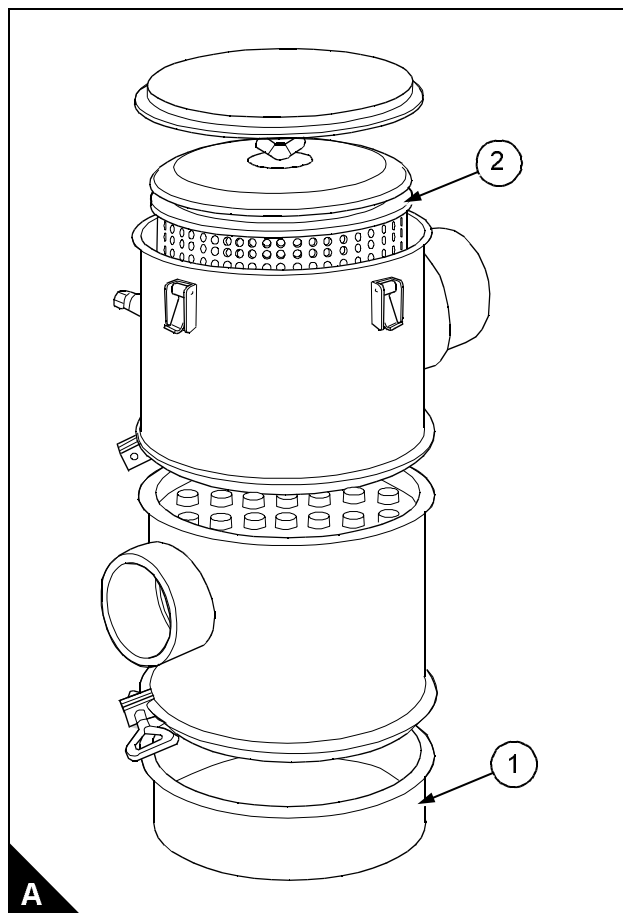


Air filter

Environmental conditions have an important effect on the frequency at which the air filter needs service.

Certain air filters have a separate dust bowl (A1) which must be cleaned at intervals. The amount of dust in the bowl shows if it has been removed at the correct time for the conditions of operation. Do not let dust completely fill the bowl, because this will reduce the life of the filter element (A2). Certain air filters have automatic dust valves (B1) through which dust is expelled from the filter. The rubber dust valve must be kept clean. Ensure that the sides of the valves close completely together and that they can separate freely.

If a restriction indicator is fitted, see "Restriction indicator" on page 38, it will indicate precisely when the air filter element needs service. This prevents the premature removal of the filter element which causes extra cost or late removal of the element which can cause loss of engine power. The filter element must be cleaned or renewed according to the manufacturers recommendations.

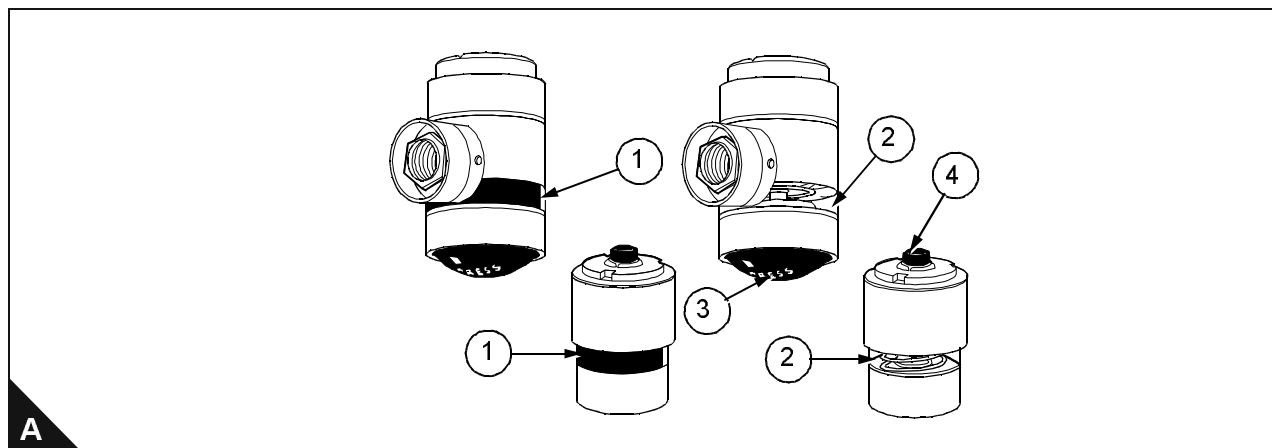


Restriction indicator

The restriction indicator for these engines must work at a pressure difference of 508/558 mm (20/22 in) of water gauge. It is fitted on the air filter outlet or between the air filter and the induction manifold.

When the red warning indicator (A1) is seen through the clear panel (A2) after the engine has stopped, the air filter element must be removed for service.

After a clean element has been fitted, press the rubber bottom (A3) or the button (A4) of the restriction indicator to reset the red warning indicator.



How to check the valve tip clearances

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

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

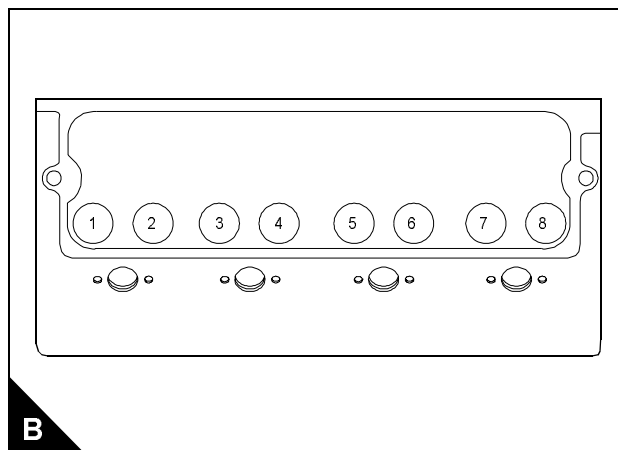
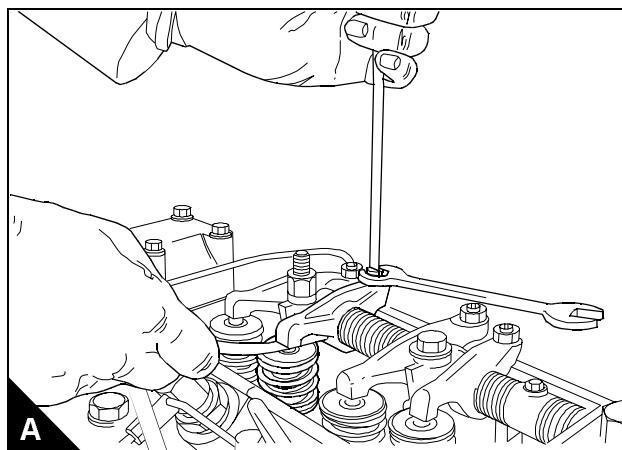
Note: Number 1 cylinder is at the front of the engine.

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

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

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

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



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

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5

Engine fluids

Fuel specification

To get the correct power and performance from your engine, use good quality fuel. The recommended fuel specification for Perkins engines is Diesel BS EN590 indicated below:

Cetane number	45 minimum
Viscosity	2/4.5 centistokes at 40 °C
Density	0,820/860 kg/litre at 15 °C
Sulphur	0.05% of mass, maximum
Distillation	85% at 350 °C

Cetane number indicates ignition performance. A fuel with a low cetane number can cause cold start problems and affect combustion.

Viscosity is the resistance to flow and engine performance can be affected if it is outside the limits.

Density: A lower density reduces engine power, a higher density increases engine power and exhaust smoke.

Sulphur: A high amount of sulphur (not normally found in Europe, North America or Australasia) can cause engine wear.

Percentage of sulphur in the fuel (%)	Oil change interval
<0.5	Normal
0.5 to 1.0	0.75 of normal
>1.0	0.50 of normal

Distillation: This is an indication of the mixture of different hydrocarbons in the fuel. A high ratio of light-weight hydrocarbons can affect the combustion characteristics.

Low temperature fuels

Special winter fuels may be available for engine operation at temperatures below 0 °C. These fuels have a lower viscosity and also limit the wax formation in the fuel at low temperatures. If wax formation occurs, this could stop the fuel flow through the filter.

If you need advice on adjustments to an engine setting or to the lubricating oil change periods which may be necessary because of the standard of the available fuel, consult your nearest Perkins distributor.

Aviation kerosene fuels

Caution: Aviation kerosene fuels are more flammable than diesel fuel and need careful storage. Ensure that the relevant safety precautions are conformed to.

These fuels can be used, but they can affect engine performance. It is recommended that you consult the Perkins Technical Service Department at Peterborough.

Lubricating oil specification

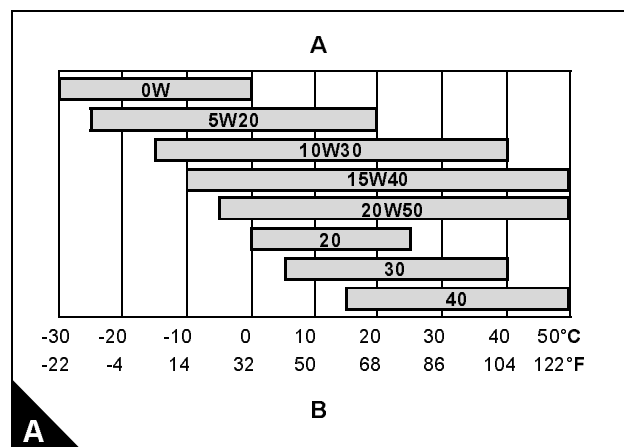
If you need advice on adjustments to an engine setting or to the lubricating oil change periods which may be necessary because of the standard of available fuel, consult your nearest Perkins distributor or the Perkins Technical Service Department.

Use only a good quality lubricating oil to the specification:

API CF4 / ACEA E2 or API CG4 / ACEA E3

The type of lubricating oil to be used may be affected by the quality of the fuel which is available. For further details see "Fuel specification" on page 41 and the preventive maintenance "Schedules" on page 22.

Always ensure that the correct viscosity grade of lubricating oil is used for the ambient temperature range in which the engine will run as shown in the chart (A) and in the table below.



Viscosity chart

A = Recommended viscosity grades

B = Ambient temperature

Coolant specification

The quality of the coolant which is used can have a great effect on the efficiency and life of the cooling system. The recommendations indicated below can help to maintain a good cooling system and to protect it against frost and/or corrosion.

If the correct procedures are not used, Perkins cannot be held responsible for damage caused by frost or corrosion.

Cautions:

- *An antifreeze which contains the correct inhibitor must be used at all times to prevent damage to the engine by corrosion, because of the use of aluminium in the coolant circuit.*
- *If frost protection is not necessary, it is still extremely important to use an approved antifreeze mixture because this gives a protection against corrosion and also raises the boiling point of the coolant.*
- *If the approved antifreeze mixture is not available, add a correct mixture of corrosion inhibitor to the water. If the correct inhibitor is not used, the engine will be damaged by corrosion. If there is doubt about the corrosion inhibitor to be used, It is recommended that you consult the Perkins Service Department, Peterborough.*

Note: If combustion gases are released into the coolant circuit, the coolant must be renewed after repair of the fault.

The antifreeze which is recommended for this engine is the latest POWERPART Antifreeze, see "POWERPART recommended consumable products" on page 6. This antifreeze contains the correct corrosion inhibitor which is especially suitable for this engine.

If it is possible, use clean soft water in the coolant.

The quality of the antifreeze coolant must be checked at least once a year, for example, at the beginning of the cold period. The coolant must be renewed every two years.

The antifreeze mixture must consist of equal quantities of antifreeze and water. The corrosion inhibitor in the antifreeze will be diluted if a concentration of less than 50% of antifreeze is used.

Concentrations of more than 50% of antifreeze may have an adverse effect on the performance of the coolant.

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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, 14, 15, 17	13, 34, 35, 36, 37, 38, 40, 42, 43, 44
The engine is difficult to start	5, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 19	13, 34, 36, 37, 38, 40, 42, 43, 44
Not enough power	8, 9, 10, 11, 12, 16, 17, 18, 19, 20, 21	13, 34, 36, 37, 38, 39, 42, 43, 44, 61, 63, 64
Misfire	8, 9, 10, 12, 15, 20, 22	13, 34, 36, 37, 38, 39, 40, 41, 43
High fuel consumption	11, 15, 17, 18, 19, 21, 22	13, 34, 36, 37, 38, 39, 40, 42, 43, 44, 63
Black exhaust smoke	11, 15, 17, 19, 21, 22	13, 34, 36, 37, 38, 39, 40, 42, 43, 44, 61, 63
Blue or white exhaust smoke	4, 15, 21, 23, 65	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, 15, 17, 20, 22, 23, 65	13, 36, 37, 40, 42, 44, 46, 52, 53, 60
The engine runs erratically	7, 8, 9, 10, 11, 12, 15, 16, 18, 20, 22, 23	13, 34, 38, 40, 41, 44, 52, 60
Vibration	18, 20, 27, 28	13, 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, 15, 19, 27, 29, 30, 32	13, 34, 36, 37, 39, 52, 55, 56, 57, 64
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	

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 filter/cleaner or air induction system.
- 12 Air in fuel system.
- 13 Fault in atomisers or atomisers 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.
- 19 Restriction in exhaust pipe.
- 20 Engine temperature is too high.
- 21 Engine temperature is too low.
- 22 Valve tip clearances are incorrect.
- 23 Too much oil or oil of wrong specification used in wet type oil cleaner.
- 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 leaks or fault in exhaust.
- 34 Fault in fuel injection pump.
- 35 Broken drive on fuel injection pump.
- 36 Timing of fuel injection pump is incorrect.
- 37 Valve timing is incorrect.
- 38 Bad compression.
- 39 Cylinder head gasket leaks.
- 40 Valves are not free.
- 41 Wrong high-pressure pipes.
- 42 Worn cylinder bores.
- 43 Leakage between valves and seats.
- 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.

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- 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 (if there is one fitted).
 - 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 (turbocharged engines).
 - 64 Turbocharger waste-gate does not work correctly (if there is one fitted).
 - 65 Faulty cold start switch/faulty wiring.

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