



User's Handbook

Perkins 4006-23TAG3A

Perkins 4000 Series Inline diesel engine

4006-23TAG1A
4006-23TAG2A
4006-23TAG3A



Contents

1 General information

Introduction	1
General safety precautions	3
Viton seals	4
How to care for your engine	4
Engine preservation	5
POWERPART recommended consumable products	7
Engine identification	9
Engine data	10
Coolant system data	10
Fuel system data	10
Governors data	10
Lubrication system data	11
Induction system data	11
Exhaust system data	11
Flywheel data	11
Flywheel housing data	11
Crankshaft data	11
Dry weight data	11
Engine mounting bolts	11
Electrical system data	12
Protection data	12

2 Engine views

Location of engine parts	13
--------------------------------	----

3 Operation instructions

How to start the engine	15
Normal engine start	17
How to stop the engine	18
Light load operation	19

4 Maintenance

Maintenance periods	21
Maintenance and overhaul schedule	22
How to drain the cooling system	24
How to fill the cooling system	25
How to drain the water sediment	27
How to check the tension of the alternator belt	28
How to check the tension of the fan belts	29
How to renew the engine lubricating oil	30
How to renew the lubricating oil filters	31
How to change the main fuel filter canisters	32
How to adjust the bridge piece and set valve clearance	33
How to clean the crankcase breather element	35

5 Engine fluids

Fuel specification	37
Lubricating oil specification	37
Coolant specification	38
Warranty	38

6 Engine fault diagnosis

Introduction	39
Problems and possible causes	40
List of possible causes	41

1

General information

Introduction

The Perkins 4006-23 TAG1A, TAG2A and TAG3A engines for electric applications are the latest developments from Perkins Engines Company Limited, a world leader in the design and manufacture of high performance diesel and gas engines.

The purpose of this User's Handbook is to enable the operator to carry out preventive maintenance on the engine.

The appropriate section in the User's Handbook should be read fully and completely understood prior to the start of the work.

The information contained within the User's Handbook is based on such information as was available at the time of going to print. In line with Perkins Engines Company Limited policy of continual development and improvement that information may change at any time without notice. The engine user should therefore ensure that they have the latest information before the work is started.

Certain overhaul operations are not advised without the use of special tools, and those operators who are not equipped to undertake major repairs are urged to consult their Perkins distributor.

When the engine is not in operation, ensure that all covers, blank flanges, doors, etc., are fitted to prevent the ingress of dirt, etc.

Please quote the engine type and serial number with all your enquiries. This will help us to help you. The type and serial number are on a plate fitted to the crankcase, see "Engine identification" on page 9.

If any doubt exists in regard to the installation, or application of the engine, the Installation Manual should be consulted. For further advice contact the Applications Department at Perkins Engines Company Ltd. Oil change intervals may be changed due to operational experience and by agreement with Perkins Engines company and are subject to oil analysis being carried out at regular intervals.

To ensure that you use the relevant information for your specific engine type, see "Engine data" on page 10.

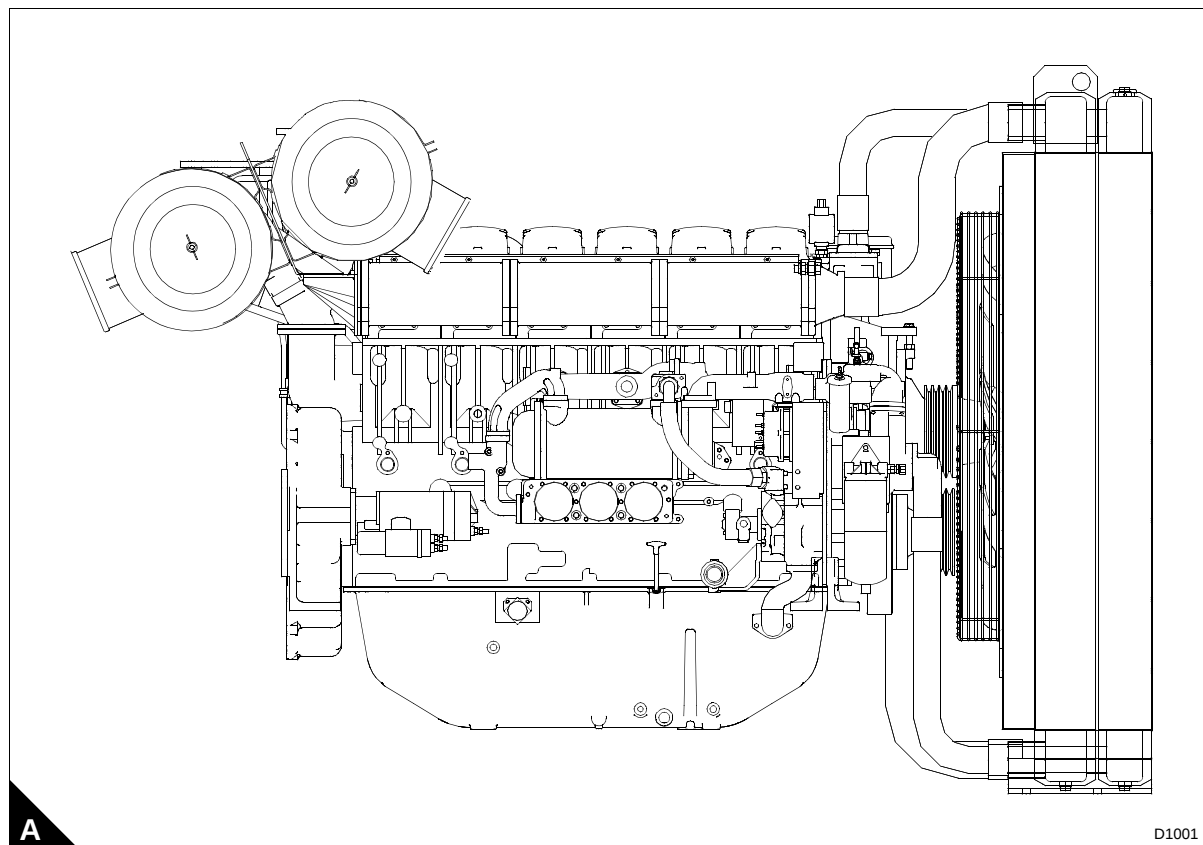
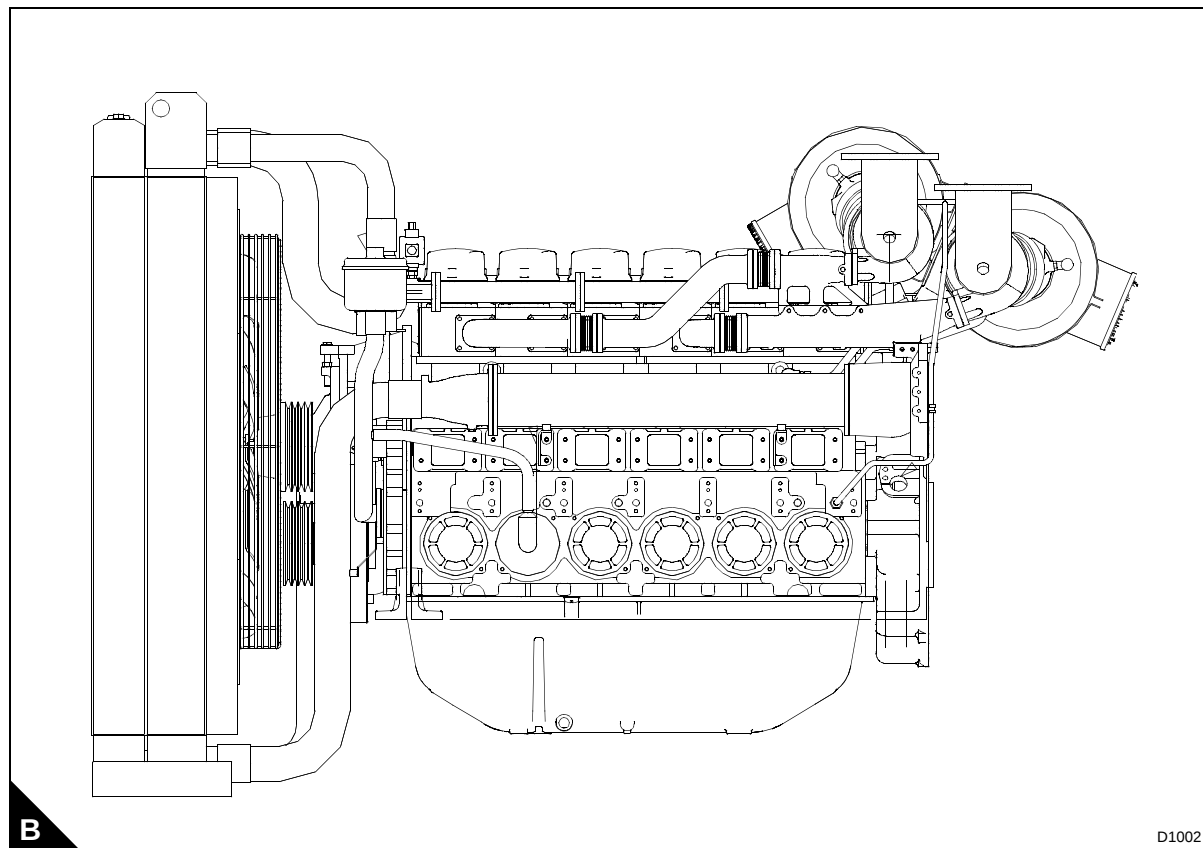
The "left side" and "right side" of the engine are as seen from the flywheel end.

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.

Model engine 4006-23 right hand side**Model engine 4006-23 left hand side**

General 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 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.
- Do not smoke when you are in the working area of the engine.
- Disconnect the battery terminals before a repair is made to the electrical system.
- 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.
- Ensure that the exhaust system from the engine is supported.
- 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.
- 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.
- Ensure that all personal protection equipment for your head, ears, eyes and feet etc, are used when you are in the working area of the engine.
- 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.

Continued

- 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.
- Fit only genuine Perkins parts, failure to do so can damage the engine and may effect the warranty.
- 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.
- Always use lift equipment of the approved type and of the correct capacity to lift heavy engine components. Never work alone when you operate lift equipment.

Viton seals

Viton is used by many manufacturers and is a safe material under normal conditions of operation.

Some seals used in engines and in components fitted to these engines are made of Viton.

If Viton is burned, a product of this burnt material is an acid which is extremely dangerous. Never allow this burnt material to come into contact with the skin or with the eyes.

If it is necessary to come into contact with components which have been burnt, ensure that the precautions which follow are used:

- Ensure that the components have cooled.
- Use neoprene gloves and discard the gloves safely after use.
- Wash the area with calcium hydroxide solution and then with clean water.
- Disposal of components and gloves which are contaminated must be in accordance with local regulations.

If there is contamination of the skin or eyes, wash the affected area with a continuous supply of clean water or with calcium hydroxide solution for 15 to 60 minutes. **Obtain immediate medical attention.**

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 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.

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 the "Maintenance schedule". If the engine is operated in a very dusty environment or other adverse conditions, certain maintenance intervals will have to be reduced.

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

Engine preservation

Notes:

- There are three grades of preservation listed below, (together with their applications) for complete engines and associated equipment, such as radiators, silencers, spares etc.
- For all recommended preservatives contact the Applications Department at Perkins Engines company.

Preservation level 'A'

Commercial specification for UK/European shipment giving up to 6 months for diesel and 12 months for gas engines shipping and storage protection when transported by container or lorry.

Preservation level 'B'

Additional to Level 'A' for overseas shipment giving 12 months shipping and storage protection. This treatment should be adequate under normal enclosed storage conditions of -15 °C to +55 °C and up to 90% relative humidity for up to 12 months.

Preservation level 'C'

Additional to Level 'B' for UK or overseas shipment when prolonged storage and protection is required for up to 5 years in tropical temperate, or arctic climates. Also meets preservation to MOD NES 724 Level 'J' for UK/Europe when stored in unheated buildings, or in the open under waterproof covers.

Preservation level 'A'

Commercial specification for UK/European shipment giving up to 6 months for diesel and 12 months for gas engines shipping and storage protection when transported by container or lorry.

- 1 The oil and fuel used on engine test give satisfactory protection for six months after despatch from the factory
- 2 The coolant systems shall be flushed through with corrosion inhibited anti-freeze at 50% dilution, see "Coolant specification" on page 38.
- 3 After the engine is painted to the appropriate standard, all bright surfaces and unpainted metal shall be treated with the recommended preservative, brushing quality. (This includes control linkages etc).
- 4 All openings in the engine, (including points where pipework has been removed and air cleaner inlets etc) shall be sealed with plugs or blank flanges.

Preservation level 'B'

Additional to Level 'A' for overseas shipment giving 12 months shipping and storage production (for diesel engines).

- 1 The oil used on engine test gives satisfactory protection for 12 months after despatch from the factory.
- 2 The complete fuel system shall be drained including filters, unit injector circuit and fuel tank. This fuel shall then be replaced by the recommended preservative fluid.
- 3 The engine shall then be run on the recommended preservative fluid for 5 minutes at idling speed, ensure the preserving fluid is circulated via the fuel return connection.
- 4 The engine must be accelerator 2 times briefly to a high idle speed to ensure complete circulation of the preserving fluid, which then remains in the system after the engine has stopped. Further rotation of the engine components is to be avoided.
- 5 The engine oil is then to be drained from the sump.
- 6 The cooling system shall be drained and flushed through with corrosion inhibited anti-freeze at 50% dilution with water, see "Coolant specification" on page 38.
- 7 After the engine is painted to the appropriate standard, all bright surfaces and unpainted metal are to be treated with the recommended preservative, brushing quality. (This includes control linkages etc).
- 8 All openings in the engine (including points where pipework has been removed and air cleaner inlets etc) shall be sealed with plugs or blank flanges.
- 9 Generator or pump sets etc should have their additional apertures sealed in similar ways.

Continued

Preservation level 'C'

Additional to Level 'B' for UK or overseas shipment when prolonged storage and protection is required for up to 5 years in tropical temperate, or arctic climates. Also meets preservation to MOD NES 724 Level 'J' for UK/Europe when stored in unheated buildings or in the open under waterproof covers.

Note: Item numbers: 3,4,5 and 6 do not apply to gas engines.

- 1 After engine test the oil shall be drained from the sump, filter and oil cooler.
- 2 Refill with the recommended preservative oil.
- 3 The complete fuel system shall be drained including filters, unit injector circuit and fuel tank. This fuel shall be replaced with the recommended preservative fluids.
- 4 The engine shall then be run on the recommended preservative fluid for 5 minutes at idling speed, ensure the preserving fluid is circulated via the fuel return connection.
- 5 During this period, 2 brief accelerations to a high idle speed must be made to ensure complete circulation of the preserving fluid.
- 6 The preserving fluid is to remain in the fuel system and further rotation of the engine components is to be avoided.
- 7 The engine oil is then to be drained.
- 8 The cooling system shall be flushed through with corrosion inhibited anti-freeze at 50% dilution, see "Coolant specification" on page 38.
- 9 The coolant pump impellor shall be sprayed with the recommended preservative oil film rust preventative.
- 10 After the engine is painted to the appropriate standard all bright surfaces and unpainted metal are to be treated with the recommended preservative, brushing quality (this includes control linkages etc).
- 11 Inlet and exhaust manifolds shall have the recommended preservative vapour phase inhibitor placed in them before they are sealed normally.
- 12 Air filters to be sprayed inside with the recommended preservative oil.
- 13 Plastic plugs are to be fitted to fuel entry points, coolant connections, spare instrument holes in panels and air filter inlets.
- 14 Exhaust outlet is to be fitted with steel blanking plate.
- 15 Coolant hoses are to be treated with silicone grease and wrapped or sleeved with black polythene (silicone rubber hoses need not be treated).
- 16 Drive belts are to be removed, wrapped in wax paper and packed in black polythene with silica gel as desiccant.
- 17 Starter, alternator, switches, instruments, sensors and wiring are to be sprayed with the recommended preservative silicone grease.
- 18 Pulleys, flywheel, starter ring, pinion etc shall be protected by dipped or painted with the recommended preservative oil film rust preventative.
- 19 The flywheel housing shall be fitted with a steel blanking plate.
- 20 Control panels are to have desiccants placed inside.
- 21 The complete engine assembly shall then be sprayed with the recommended preservative wax film rust preventative.

The degree of preservation is to be recorded on the Engine Specification and Test Certificate attached to each engine on despatch.

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 ELC (Extended Life Coolant).

ELC is pre-mixed and protects the cooling system against frost and corrosion. Part number 21820181.⁽¹⁾

POWERPART Easy flush

Cleans the cooling system. Part number 21825001.

POWERPART Gasket and flange sealant

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

POWERPART Gasket remover

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

POWERPART Griptite

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

POWERPART Hydraulic threadseal

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

POWERPART Industrial grade super glue

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

POWERPART Lay-Up 1

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

POWERPART Lay-Up 2

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

POWERPART Lay-Up 3

Protects outside metal parts. Part number 1734115.

POWERPART Metal repair putty

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

POWERPART Pipe sealant and sealant primer

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

Continued

POWERPART Radiator stop leak

For the repair of radiator leaks. Part number 21820127.

POWERPART Retainer (high strength)

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

POWERPART Retainer (oil tolerant)

To retain components which have an interference fit, but are in contact with oil. Part number 21820608.

POWERPART Safety cleaner

General cleaner in an aerosol container. Part number 21820128.

POWERPART Silicone adhesive

An RTV silicone adhesive for application where low pressure tests occur before the adhesive sets. Used for sealing flange where oil resistance is needed and movement of the joint occurs. Part number 21826038. ⁽²⁾

POWERPART Silicone RTV sealing and jointing compound

Silicone rubber sealant which prevents leakage through gaps. Part number 1861108. ⁽²⁾

POWERPART Stud and bearing lock

To provide a heavy duty seal to components that have a light interference fit. Part number 21820119 or 21820120.

POWERPART Threadlock and nutlock

To retain small fasteners where easy removal is necessary. Part number 21820117 or 21820118.

POWERPART Universal jointing compound

Universal jointing compound which seals joints. Part number 1861117. ⁽²⁾

⁽¹⁾ Powerpart (ELC) is not recommended for the 4006-23 engine or the 1300 Series.

⁽²⁾ These product are not recommended for the 4006-23 engine.

Engine identification

The 4006-23 engine consists of a range of six cylinder engines. This range has three basic engine types, TAG1A, TAG2A and TAG3A.

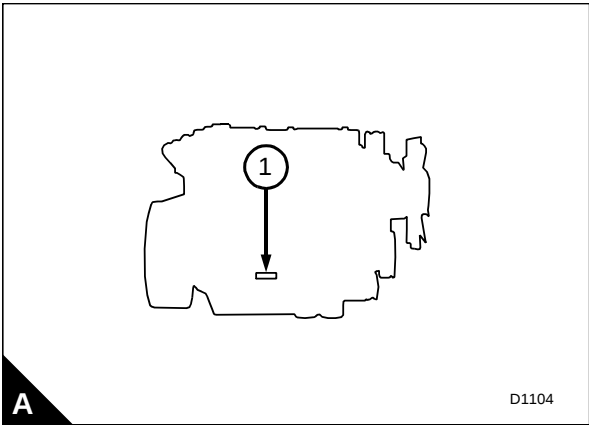
In this User's Handbook, the different engines are identified by their engine number and their type as shown below:

A typical example of an engine number: DGB 060081 U0017 B

Engine number identification	
D	Made in Stafford
G	Application code
B	Engine type
06	Number of cylinders
0081	Fixed build number
U	United Kingdom
0017	Number of engines built
B	Year that the engine was built

Engine type	
A	4006-23TAG1A
B	4006-23TAG2A
D	4006-23TAG3A

The position of the plate for the engine number (A1).



Engine data

Number of cylinders	6
Cylinder arrangement	Vertical, In line
Cycle	Four stroke compression ignition
Direction of rotation	Clockwise from the front
Nominal bore	160 mm (6.299 in)
Stroke	190 mm (7.48 in)
Compression ratio	13:1
Cubic capacity	22,92 litres (1398.66 in ³)
Firing order	1, 5, 3, 6, 4, 2
Cylinder number 1	Furthest from flywheel
Valve tip clearances cold:	
- Inlet	0,40 mm (0.016 in)
- Exhaust	0,40 mm (0.016 in)

Coolant system data

Recommended coolants to conform to	"Coolant specification" on page 38
Total coolant capacity	105 litres (23 gal)
Engine shut down temperature	105 °C (221 °F)
Thermostat opening temperature	71 °C (159.8°F)
System pressure	50 kpa to 70 kpa (0,5 to 0,7 bar)
Coolant jacket heater:	
Heater	1 x 2 kw

Fuel system data

Recommended fuel to conform to	Class A2
Relief valve setting	276 kpa (40 lb/in ²)
Injector nozzle pressure	230 atm
Injection equipment	Combined unit injector
Filter/water separator	Canister type
Fuel lift pump	Maximum suction head 2,5 metres
1500 RPM flow rate	660 litres per hour
1800 RPM flow rate	810 litres per hour

Governors data

Type	Digital electronic
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Lubrication system data

Recommended oil APICG4 15W/40

Wet sump, external engine mounted oil pump.

Total oil capacity with oil cooler and filter 122,7 litres (27 gal)

Sump capacity dipstick minimum 90,9 litres (20 gal)

Sump capacity dipstick maximum 113,6 litres (25 gal)

Minimum oil pressure to the bearings, at rated speed. 200 kpa (28 lb/in²)

Crankcase pressure 25 mm watergauge

Maximum oil temperature to the bearings 105 °C (221 °F)

Normal oil temperature to the bearings 80 °C (176 °F)

Lubricating oil filters. canister type

Induction system data

Twin air filters (element type) std filters

Maximum air intake depression 381 mm H₂O (28 mm Hg)

Air restriction indicator setting 380 mm H₂O

Turbocharger MHI x 2

Exhaust system data

Manifold type Dry

Exhaust outlet size (internal) 152,4 mm 5.999 in

Mating flange Tag1A, Tag2A and Tag3A BS4 1 x 10" Table "D"

Mating flange Tag1A, Tag2A and Tag3A 2 x 6" Table "D"

Exhaust back pressure TAG1A 7 kpa (0,07 bar)

Exhaust back pressure TAG2A 6 kpa (0,06 bar)

Exhaust back pressure TAG3A 6 kpa (0,06 bar)

Flywheel data

SAE size 18 in

Number of teeth on the gear ring. 190

Flywheel housing data

SAE size 0

Crankshaft data

Maximum overhung weight on rear bearing 1000 kg

Damper Tag1A, Tag2A and Tag3A 1 x 18 in

Note: A different type of damper may be fitted, for more information contact your Perkins Dealer/Distributor.

Dry weight data

Engine dry weight 2524 kg

Engine wet weight 2663 kg

Engine mounting bolts

Bolt size 20 mm

Bolt number 6

Electrical system data

Type	Insulated return
Alternator output	40 amps at a stabilized output of 28 volts
Starter motor power	7,5 kW
Number of teeth on the starter motor pinion	12
Battery capacity cold cranking	540 amps
Number of batteries	2 x 12 volt

Protection data

Caution: Before resetting protection equipment, it must be established whether special settings (for that individual engine) have been specified in the engine sales contract. This is particularly important with all high water temperature settings.

Shutdown switches

High Oil temperature alarm	110 °C (230 °F)
High Oil temperature shutdown	115 °C (239 °F)
Low oil pressure alarm	2.06 bar (30 lb/in ²)
Low oil pressure shutdown	1.93 bar (28 lb/in ²)
High water temperature 71°C Thermostat alarm	103 °C (217.4 °F)
High water temperature 71°C Thermostat shutdown	105 °C (221 °F)

Caution: The above standard settings do not supersede any settings specified in the engine sales contract.

Overspeed	15% on 1500 rev/min
Overspeed	7% on 1800 rev/min

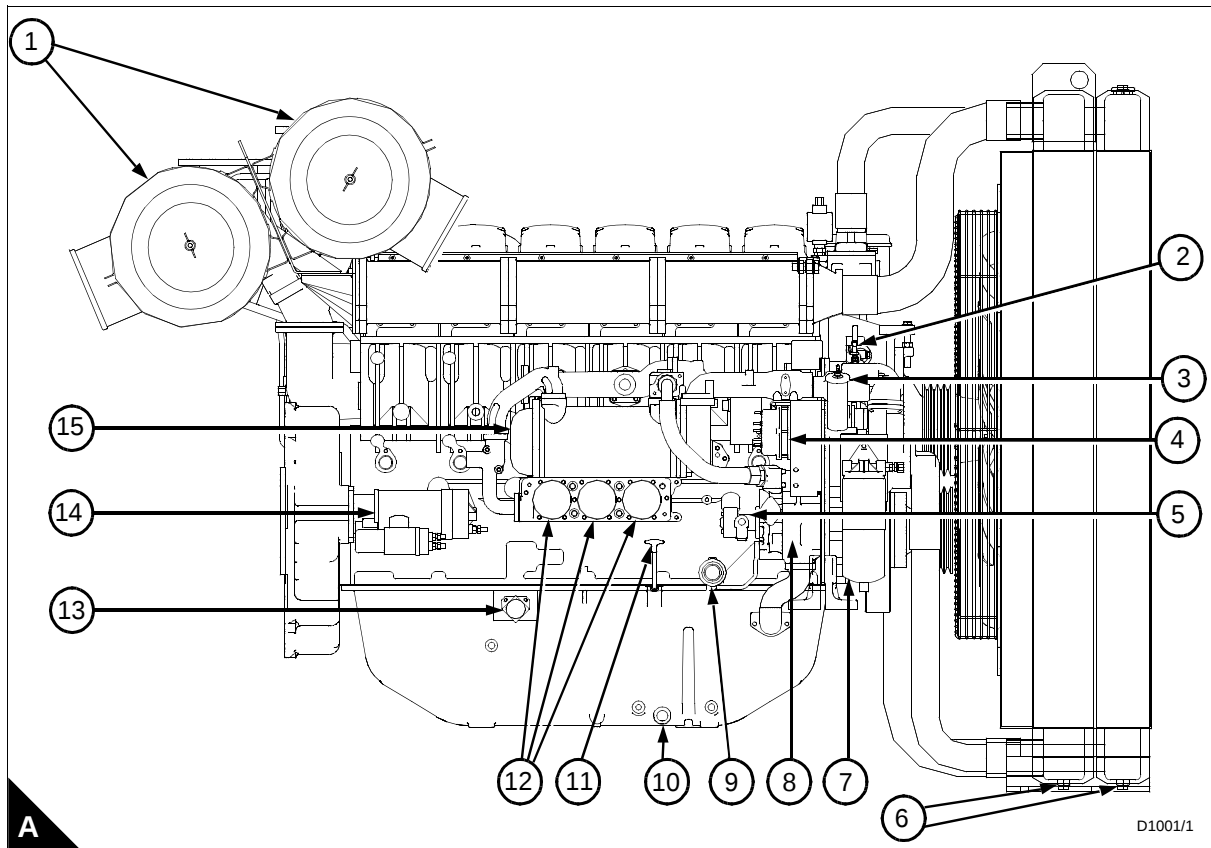
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Engine views

Location of engine parts

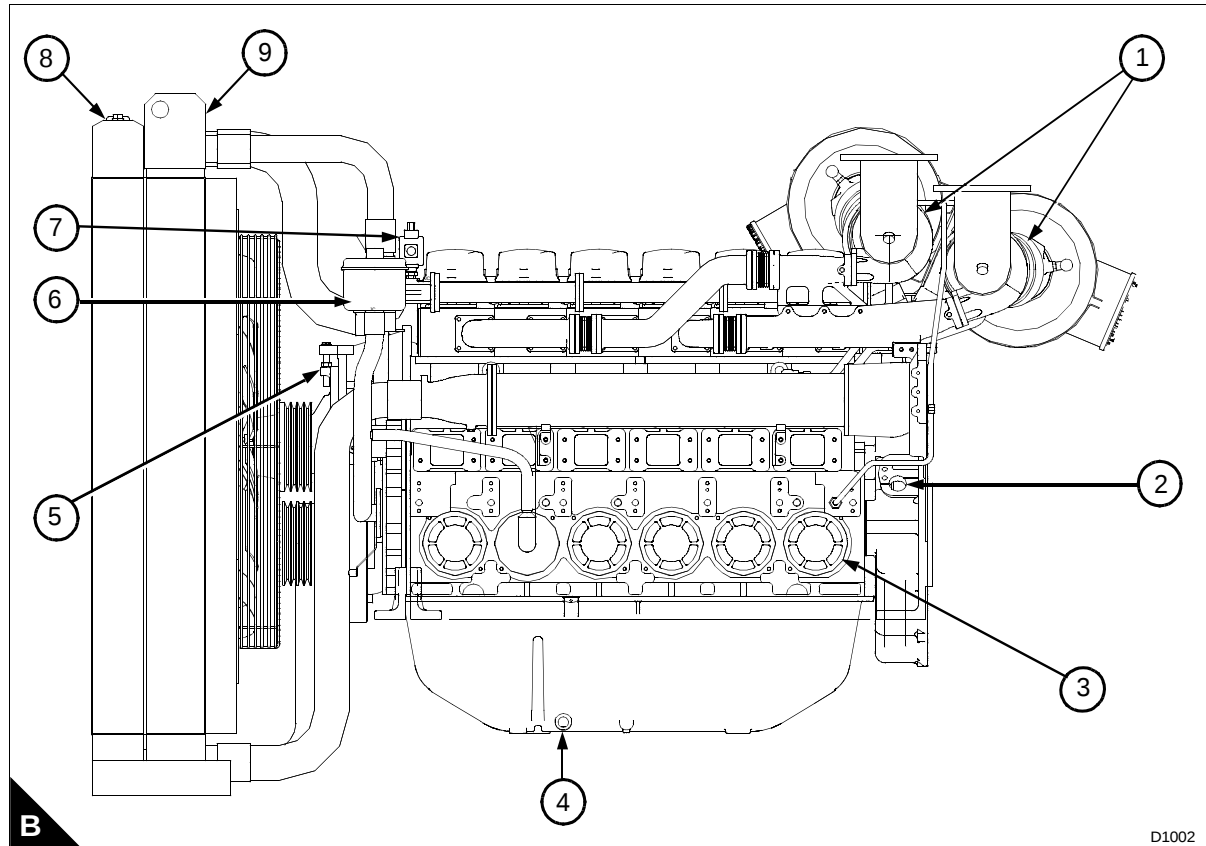
Right hand side of the 4006-23 engine

- | | |
|--------------------------------------|---------------------------------------|
| 1 Twin air filters | 9 Fuel hand prime pump |
| 2 Governor lever | 10 Drain plug for the lubricating oil |
| 3 Filler cap for the lubricating oil | 11 Lubricating oil dipstick |
| 4 24 Volt alternator | 12 Lubricating oil filters |
| 5 Fuel lift pump | 13 Starter relay |
| 6 Radiator drain plugs | 14 24 Volt Starter motor |
| 7 Fuel filter/water separator | 15 Lubricating oil cooler |
| 8 Engine oil pump | |



Left hand side of the 4006-23 engine

- | | |
|-------------------------------|----------------------------|
| 1 Twin turbochargers | 6 Engine breather |
| 2 View hole for timing mark | 7 Engine protection switch |
| 3 Crankshaft inspection cover | 8 Air to air charge cooler |
| 4 Sump drain plug | 9 Radiator |
| 5 Drive belt tension screw | |



3

Operation instructions

How to start the engine

Several factors affect engine start, for example:

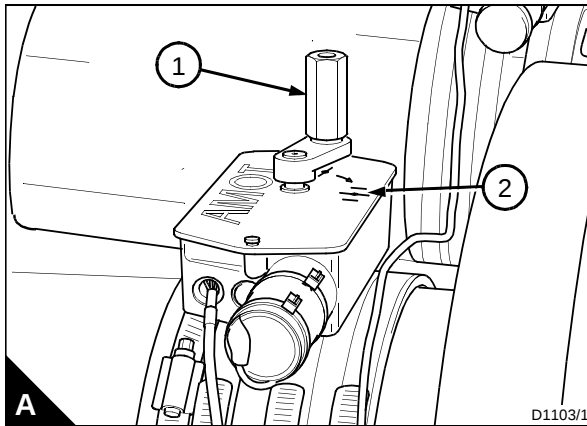
- The power of the batteries
- The performance of the starter motor
- The viscosity of the lubricating oil
- The type of engine start switch
- The type of engine stop arrangement.

Note: The type of start switch and stop arrangement shown in this chapter are a Perkins option.

Initial start

Cautions:

- *Before the engine is started for the first time, or if the engine has stood idle for more than three months, the crankshaft and turbocharger bearings must be primed.*
- *Do not start the engine under load.*
- *The air shut off valves (if fitted) must be in the open position (A2) to start the engine.*



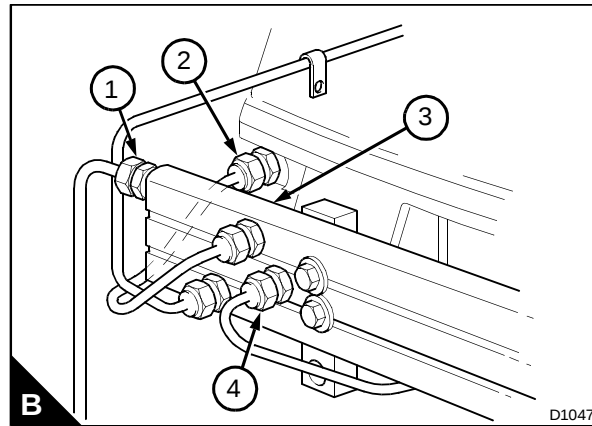
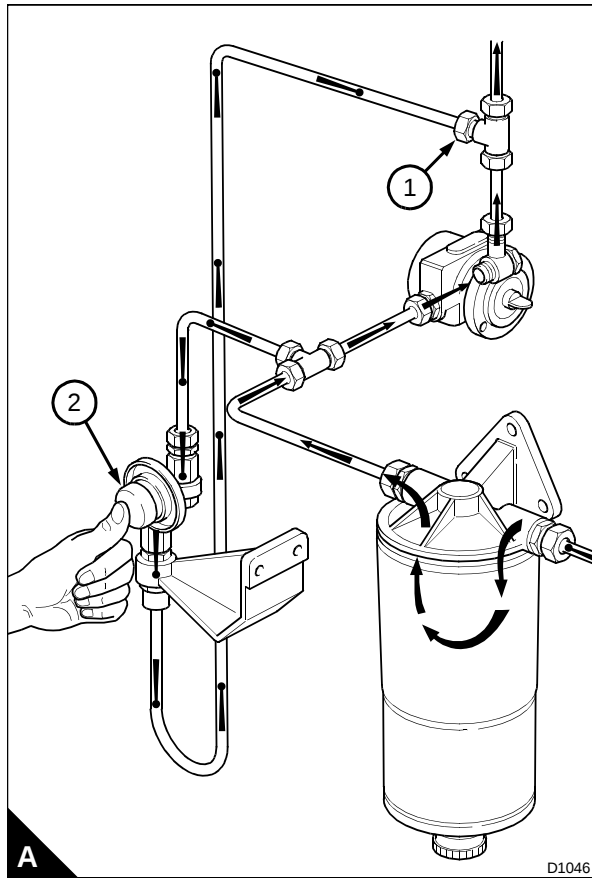
Note: Each air shut off valve has two positions. (A1) closed and (A2) open.

- Prime the fuel system
- Check that the air shut off valves are in the open position
- Prime the oil system
- Start the engine with no load.

How to prime the fuel system

Caution: Clean away all fluid before the engine is started.

- 1 Turn on the fuel feed from the day tank and loosen the union on the tee-piece (A1).
- 2 Operate the priming pump (A2) until fuel free from air flows from the union, tighten the union (A1) securely.

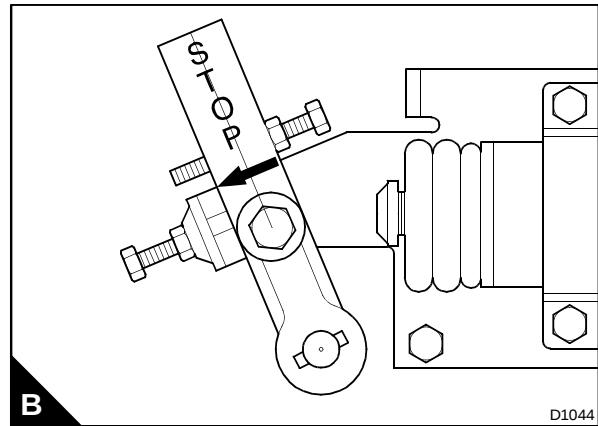
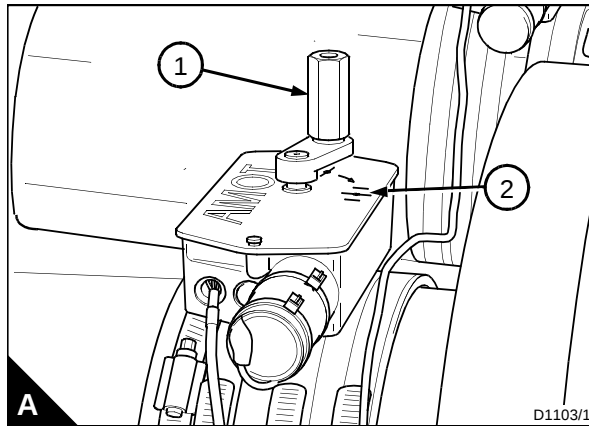


- 3 Loosen the union on the fuel feed pipe (B1) at the flywheel end of the fuel rail (B3). Operate the priming pump (A2), until fuel free from air flows from the union, tighten the union (B1) securely.
- 4 Loosen the union (B2) and the fuel return union (B4). Operate the priming pump (A2) until fuel free from air flows from the unions, tighten the unions securely.

Note: One cylinder will be primed and a amount of fuel will have reached other cylinders. After the oil system is primed, the engine will run in this condition if a little unevenly until air is fully vented from the system.

How to prime the engine oil system

- (A1) Shut off valve set in the closed position.
 - (A2) Shut off valve set in the open position.
- 1 If fitted, check that the air shut-off valves are set in the open position (A2).
 - 2 Hold the governor lever in the stop position (B).

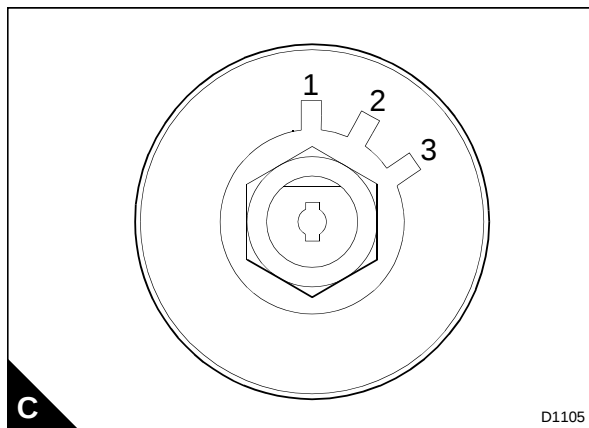


3 Turn the start key to position (C3) to engage the starter motor. Prime the lubricating system through the oil filters until approximately 0,3 bar (5 lb/in²) is indicated on the oil pressure gauge. Continue to pump the oil for a further 10 seconds to ensure that oil has reached the turbochargers.

4 Turn the start key to the stop position (C1).

5 Release the governor lever.

Note: The engine is now ready to start.

**Normal engine start****Cautions:**

- Do not start the engine under load.
- The air shut off valves must be in the open position (A2) to start the engine.

Note: Perkins recommend that the engine is run every month.

- 1 Ensure that the engine load is disengaged.
- 2 Check that the shut-off valves are in the open position (A2).
- 3 Turn the start key to the position (C3) to engage the starter motor.

Continued

4 If the engine does not start after 10 seconds allow the start key to return to the 2 position for 20 seconds, then engage the starter motor again.

Note: After the engine has started check the oil pressure gauge.

5 If the engine fails to start after the third time, see "Problems and possible causes" on page 40.

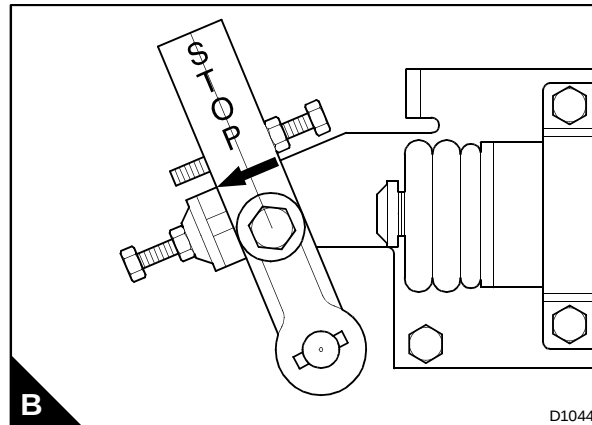
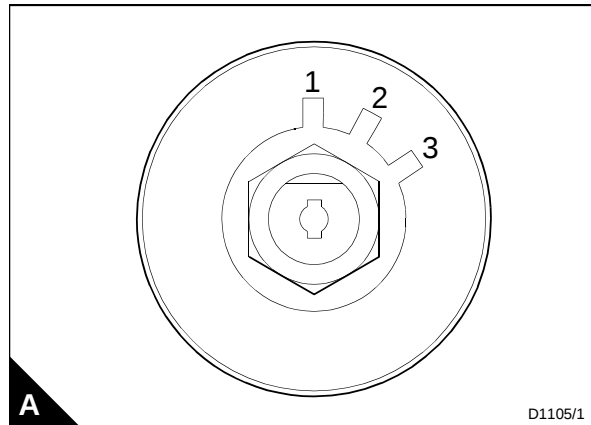
How to stop the engine

Cautions:

- Allow the engine to run for 3 to 5 minutes with no load, to remove the heat away from the turbochargers, bearings, and seals before the engine is stopped. Failure to do this may damage your engine.
- If the engine is stopped due to the operation of the air shut off valves, the cause must be checked immediately.

Turn the start key to position (A1). This will automatically stop the engine.

The engine can be stopped manually by the stop control lever. Hold the lever in the stop position (B) until the engine is stopped.



Light load operation

Cautions:

- *Do not run the engine excessively at low speeds or loads. If the engine is not in use shut it down.*
- *Excessive idle of the engine will result in only partly burnt fuel. This will cause high carbon build-up on the injector nozzles, valves, pistons and rings. Also unburnt fuel will wash the lubricating oil from the cylinder bores and dilute the oil in the sump. This can cause loss of lubrication of the bearings and result in a engine seizure.*

If an engine is operated on a load less than 25-30% of its rated output, certain symptoms will be observed which may give cause for concern. The usual results of this operation is heavier than normal lubricating oil consumption, and oil leaks from the air and exhaust manifolds. This condition is particularly evident on standby generator set applications, where a weekly exercise of no load is common practice. These concerns are due to the fact that:

- 1 Turbocharger oil seals are not fully effective on light load, which results in oil being delivered together with the air into the engine air manifolds.
- 2 The cylinder temperatures are too low to ensure the complete combustion of all the fuel delivered.

This results in a oil leak from the exhaust manifold junction seals. A further result is that of abnormal carbon build-up on the valves, piston crowns and the exhaust ports. The normal service interval see, "Maintenance periods" on page 21 between top overhauls may be reduced. Fuel dilution of the lubricating oil will also occur. It is recommended that the following precautions are observed:

- 1 To run on a light load should be avoided or reduced to the minimum period. If a weekly action of no load is carried out, the running period should be kept down to 10 minutes, or until the battery charging rate returns to normal.
- 2 Every year the engine or generator set should be run on full load for four hours, to burn off the build up of carbon in the engine and exhaust system. This may require the use of a 'dummy load'. The load should be built up gradually from zero over a four hour run. On standby sets, air filter elements should be changed annually. Oil and fuel filter elements should be changed every six months. The fuel injectors should be checked every 2 years.

4

Maintenance

Maintenance periods

Use the procedures in this chapter to maintain your engine in accordance with the maintenance schedule.

These maintenance periods apply only to engines that are operated with fuel, lubricating oil and coolant that conform to the specifications given in this handbook.

Maintenance and overhaul schedule

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

- | | | | |
|----------|------------------------------|----------|-------------------|
| A | Daily | D | Every 5000 hours |
| B | Every 500 hours or 12 months | E | Every 7500 hours |
| C | Every 12 months | F | Every 15000 hours |

A	B	C	D	E	F	Operation
●						Check the coolant level
●						Check the lubricating oil level
●						Check the restriction indicators for the air filters and, when necessary, renew the filter elements
●						Drain all water/sediment from the primary fuel filter
●						Visual inspection of the engine systems
	●					Renew the lubricating oil and the lubricating oil filters
	●					Renew the canister of the main fuel filter
	●					Clean the crankcase breather filter
	●					Check the condition and the tension of all drive belts
	●					Inspect/renew the coolant hoses and clips
	●					Check that the air charge cooler and radiator matrix are clean and free from debris
	●					Adjust bridge pieces and check valve clearances ⁽¹⁾
		●				Drain and flush the coolant system and renew coolant mixture
		●				Check the engine protection devices ^{(1) (2)}
		●				Inspect the engine mountings
			●			Ensure that the fuel injectors are checked and correct or renewed if necessary ^{(1) (2)}
				●		Inspect the turbocharger ^{(1) (2)}
				●		Inspect the alternator ^{(1) (2)}
				●		Inspect the starter motor ^{(1) (2)}
				●		Inspect coolant pump ^{(1) (2)}
					●	Inspect the crankshaft vibration damper ^{(1) (2)}

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

⁽²⁾ For further information refer to the relevant workshop manual.

Continued

Note: For parts that are supplied by customer use the supplier recommendations:

- Check the battery electrolyte level
- Drain water/ sediment from fuel tank
- Clean water trap sediment.

Note: For information on the cylinder head overhaul and major overhaul, refer to the relevant workshop manual.

Cylinder head overhaul	
Hours	Duty
10000	Base load
7500	Prime load
1000	Stand by duty

Major overhaul	
Hours	Duty
20000	Base load
15000	Prime load
2000	Stand by duty

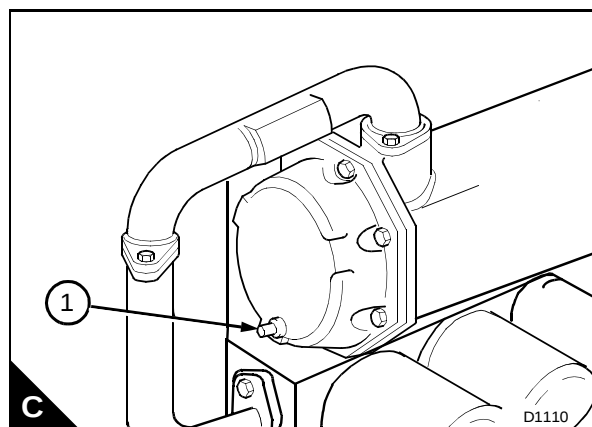
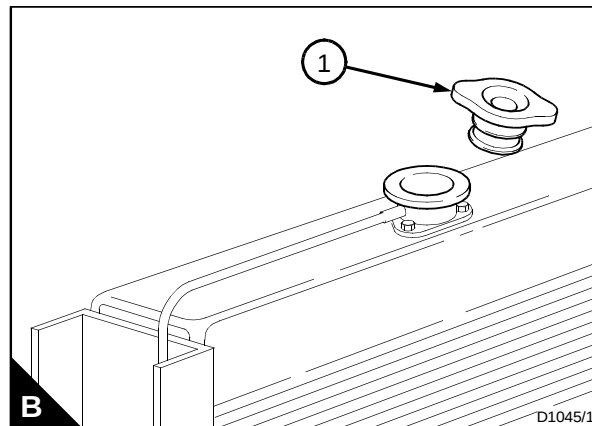
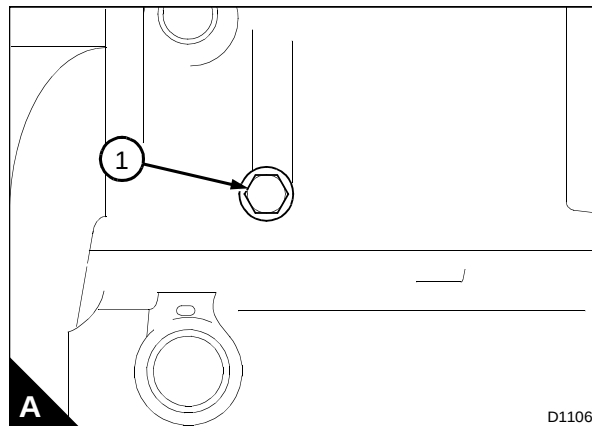
How to drain the cooling system

Warnings!

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

Caution: To prevent frost damage, ensure that all of the coolant is removed from the engine. This is important if the system is drained after it has been flushed with water, or if an antifreeze solution which is too weak to protect the system from frost has been used.

- 1 Put a suitable container below the drain plugs.
- 2 Remove the filler cap (B1) from the coolant system.
- 3 Open the tap or remove the drain plug at the bottom of the radiator in order to drain the radiator.
- 4 Remove the drain plug (A1) from the side of the cylinder block in order to drain the engine. Ensure that the drain hole is not restricted.
- 5 Open the drain tap on the oil cooler (C1).
- 6 Flush the coolant system with clean water.
- 7 Fit the drain plug (A1) and tighten to 68 Nm (50,5 lbf ft) 6.9 kgf m.
- 8 Close the drain tap (C1).
- 9 Fit the radiator cap and fit the radiator plug or close the radiator tap if fitted.



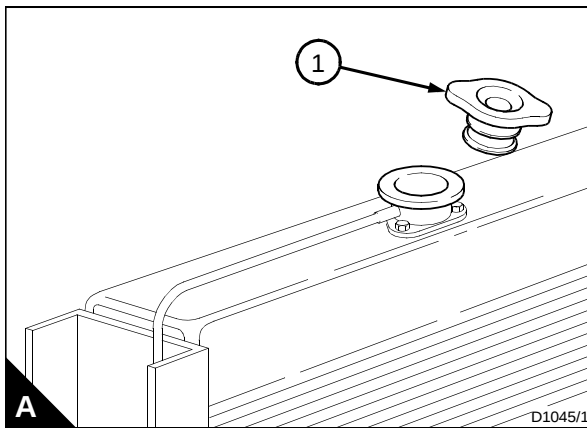
How to fill the cooling system

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

Cautions:

- The use of plain drinking water is not recommended because of the chemical reactions which can result in corrosion and furring-up of the cooling system. A solution of either water and anti-freeze or water and corrosion preventative must be used, see "Coolant specification" on page 38.
- If coolant is added to the circuit during service, it must consist of the same original mixture as used to fill the system. For details of the correct coolant to be used in the system, see "Coolant specification" on page 38.

- 1 Check that all the coolant system drain plugs are fitted correctly.
- 2 Rotate the radiator cap (A1) anti-clockwise and remove the radiator cap from the radiator.
- 3 Fill the system with the correct coolant.
- 4 Fit the radiator cap (A1) and run the engine off load until the thermostat opens.
- 5 Allow the engine to cool. Remove the radiator cap (A1) and top up the system to 25 mm (1") below the top of the filter neck.
- 6 Fit the radiator cap.



Note: After installation and before the first engine start, remove the radiator cap by rotating it anti-clockwise. Fill the cooling system with the required coolant. Run the engine off-load for one minute to ensure that the system is completely filled, then stop the engine and top up the system to 25 mm (1") below the top of the filter neck then replace the cap.

How to change the air filter

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

Cautions:

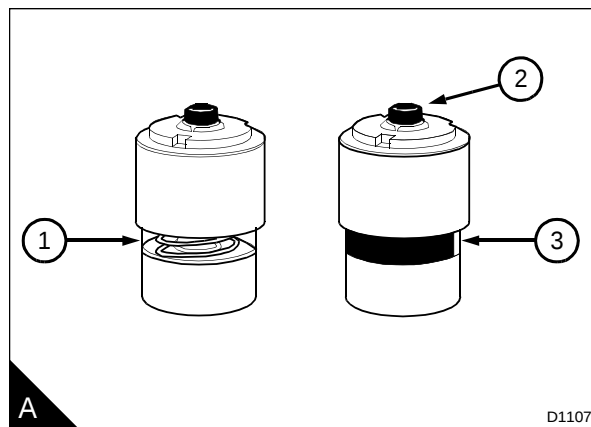
- Do not operate the engine if there is a blockage in the air filter or the induction hose.
- The air filter element is a non-serviceable item, do not clean the element.
- Never blow dirt out of the filter housing. This may introduce dirt into the induction system. The housing must be removed to be cleaned.

Note: Environmental conditions have an important effect on the frequency at which the air filters need to be serviced.

How to check the air restriction indicator

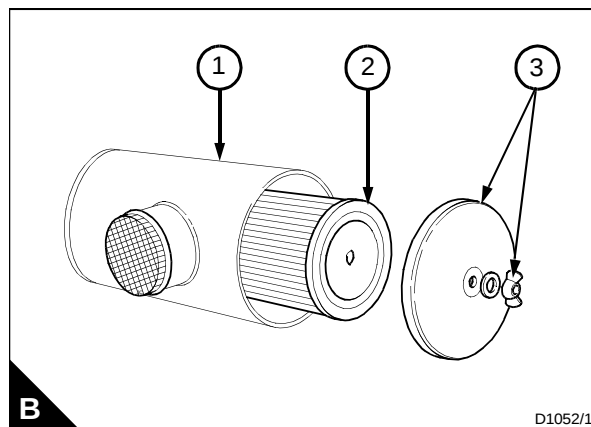
Note: The middle section of the restriction indicator (A1) will remain clear while the air cleaner is in a serviceable condition. When the filter reaches its contamination limit the restriction indicator will sense the change in manifold pressure and middle section (A3) will change to red. At this point the air filter must be changed.

When the air filters have been changed in order to reset the indicators operate the button (A2).



Standard air filters

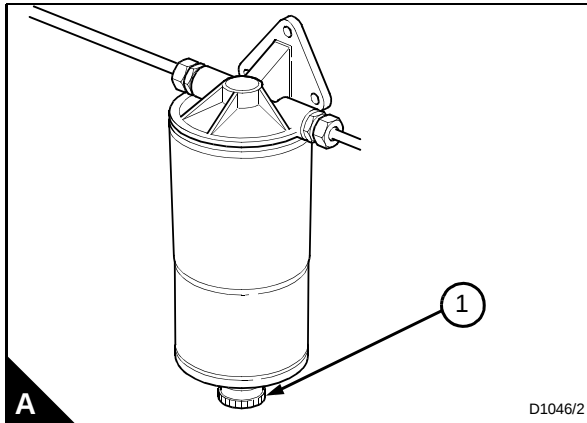
- 1 Remove the wing nut and the end cover (B3) together.
- 2 Remove the element (B2) and discard.
- 3 Fit the new element into the filter housing (B1).
- 4 Fit the end cover onto the filter housing (B1) and tighten the wing nut securely. Check that end cover is correctly aligned.



How to drain the water sediment

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

- 1 Stop the engine.
- 2 Put a suitable container under the sediment bowl to retain the fluid.
- 3 Loosen the drain plug (A1) and allow the fluid to drain.
- 4 When clean fuel can be seen, tighten the drain plug (A1) by hand.
- 5 Remove the container.

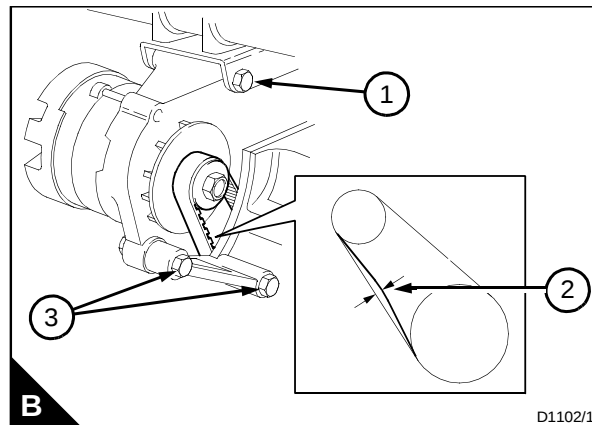
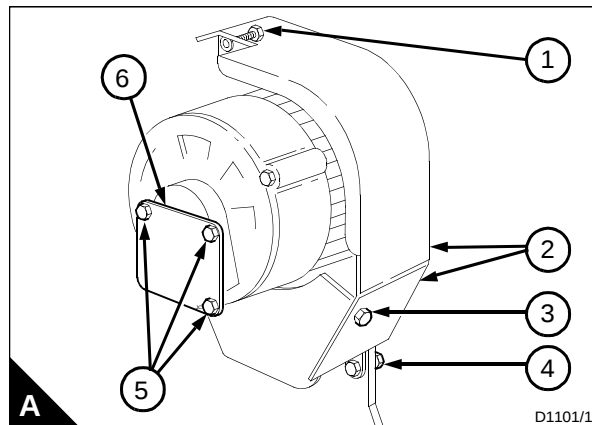


How to check the tension of the alternator belt

Warning! Disconnect the batteries and any other power that can start the engine.

Note: The alternator guard is a 3 piece item.

- 1 Remove the three bolts (A5) from the plate (A6) and remove the plate.
- 2 Remove the bolt (A3).
- 3 Remove the top bolt (A1) and the bottom bolt (A4) and remove the two parts of the guard (A2).
- 4 To check the belt tension, apply 15,6 N (3.5 lbf) 1,5 kgf of pressure midway between the two pulleys (B2). The correct deflection of the belt is 1,5 mm (0.0625 in).
- 5 Adjust the belt if necessary.
- 6 Fit the guard assembly and tighten all the bolts securely.
- 7 Connect the power supply to the starter motor.



How to adjust the alternator drive belt

- 1 Remove the guard assembly from the alternator.
- 2 Loosen the pivot bolt (B1) and loosen the link adjuster bolts (B3).
- 3 Adjust the alternator belt to the required tension.
- 4 Tighten the bolts (B1) and (B2) securely.
- 5 Fit the guard and tighten all the bolts securely.
- 6 Connect the power supply to the starter motor.

How to check the tension of the fan belts

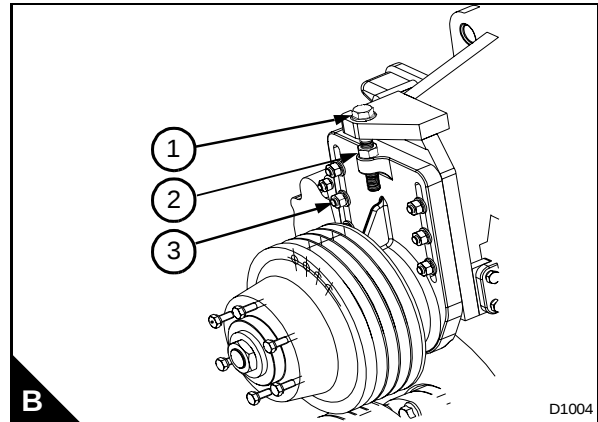
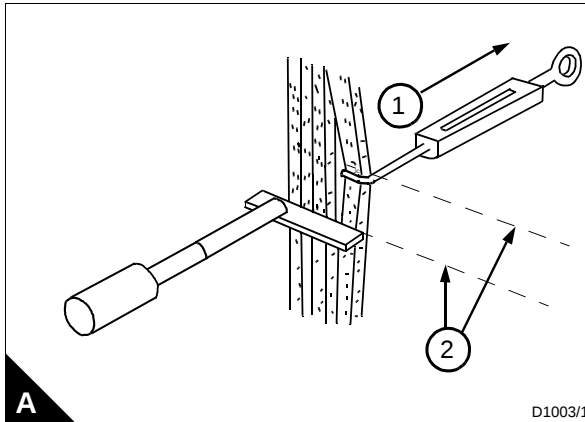
Warning! Disconnect the batteries and any other power that can start the engine.

Cautions:

- The maximum force of 49 N (11.02 lbf) 5 kgf must be used on a new fan belt for the first twenty four hours.
- Do not fit one fan belt, always fit the fan belts in a set.

Apply a force of 31 to 49 N (6.97 - 11.02 lbf) 3,16 - 5 kgf to each of the fan belts separately (A1). Apply this force to the longest free length of the belt between the crankshaft pulley and the fan pulley.

The correct deflection of the fan belt (A2) is 4,2 mm (0.165 in).



How to adjust the fan belts

- 1 Remove the fan guards.
- 2 Loosen the 6 nuts (B3) and loosen the lock nut (B2).
- 3 To increase the tension of the fan belt rotate the adjusting screw (B1) clockwise. To loosen the tension of the fan belt rotate the adjusting screw anti-clockwise.
- 4 When all the belts are at the correct tension, tighten the 6 nuts (B3) to 85 Nm (62.7 lbf ft) 8,6 kgf m and tighten the locking nut (B2).
- 5 Check that the fan belt tension is correct on each belt.
- 6 Fit the fan guards.
- 7 Connect the power supply to the starter motor.

How to renew the engine lubricating oil

Warnings!

- Discard the used lubricating oil in a safe place and in accordance with local regulations.
- Do not exceed the correct level of lubricating oil in the sump. If there is too much lubricating oil, the excess must be drained to the correct level.

Note: The lubricating oil can be drained from the left or the right hand side of the engine oil sump.

- 1 Operate the engine until it is warm. Stop the engine.
- 2 Put a suitable container below the drain plug of the lubricating oil sump.

Note: The engine oil sump will hold approximately 113,6 litres (25 gal) of lubricating oil.

- 3 Remove the sump drain plug (A2) and its sealing washer and drain the lubricating oil from the sump into the container.

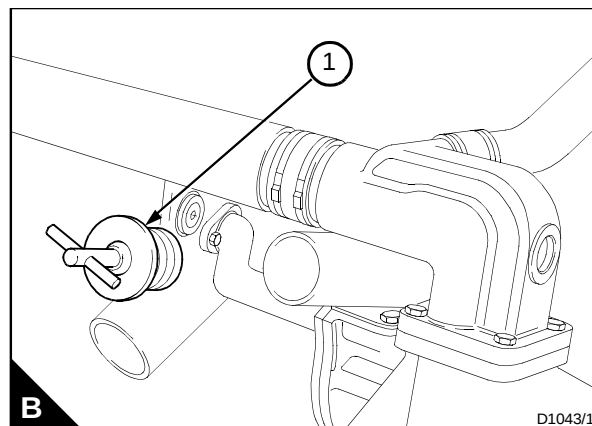
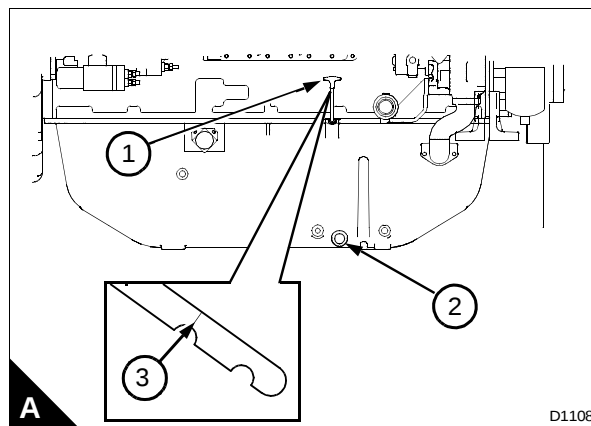
- 4 Ensure that the sealing washer is not damaged. Fit the drain plug and its sealing washer. Tighten the plug to 68 Nm (50 lbf ft) 6,9 kgf m.

- 5 Remove the filler cap (B1).

- 6 Fill the sump to the mark (A3) on the dipstick with new and clean lubricating oil of an approved grade, see "Lubricating oil specification" on page 37.

- 7 Fit the oil filler cap (B1).

- 8 Remove the container and discard the old lubricating oil.



How to renew the lubricating oil filters

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

Caution: It is important that only genuine Perkins parts are used. The use of a canister that is not a genuine Perkins part may damage the engine and the warranty.

1 Put a suitable container below the lubricating oil filter.

Note: A oil filter will hold approximately 5 litres (1 gal) of lubricating oil.

2 Remove the filter canister (A3) with a suitable strap wrench. Discard the canister.

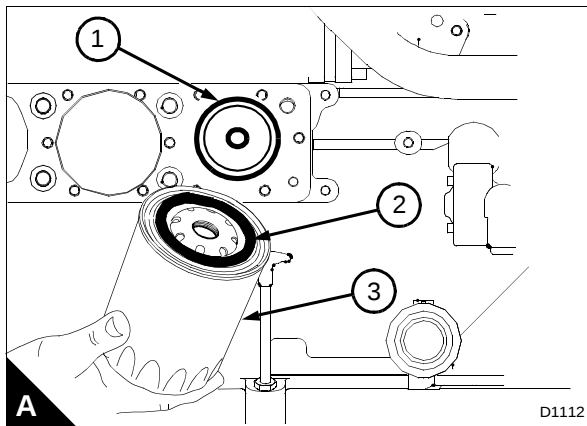
3 Clean the filter head (A1).

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

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

Caution: All three oil filters must be changed as a set.

6 Remove the container and discard the old lubricating oil.



Note: After all the oil filters have been fitted, check that the air shut off valves are in the open position and prime the oil system, see "How to prime the engine oil system" on page 17. Do not start the engine.

7 With the starter motor disengaged, check the oil level on the dipstick and add more oil into the sump if necessary.

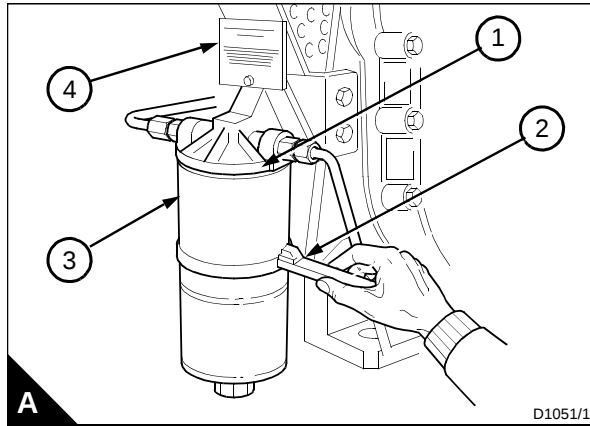
8 Run the engine off load and check for oil leaks from the oil system.

How to change the main fuel filter canisters

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

Caution: It is important that only genuine Perkins parts are used. The use of a canister that is not a genuine Perkins part may damage the fuel system and the warranty.

- 1 Thoroughly clean the filter head (A1) and the canister (A3).
- 2 Put a suitable container under the fuel filter assembly.
- 3 Use a suitable strap wrench (A2) to remove the canister. Discard the canister.
- 4 Lubricate the top of the new canister seal with clean fuel oil.



Caution: The plate (A4) contains information on how to drain the fuel filter canister. It also has information on when to change the filter canister. Before the filter is changed refer to the maintenance schedule.

- 5 Fit the new fuel filter canister and tighten it by hand only.
- 6 Prime the fuel system, see "How to prime the fuel system" on page 16.
- 7 Remove the container.
- 8 Run the engine and check for leaks.

How to adjust the bridge piece and set valve clearance

Warning! Disconnect the batteries and any other power that can start the engine.

Cautions:

- The bridge piece must be adjusted before the valve adjustment is made.
- Check that there is a clearance between the bridge piece and the inlet and exhaust rockers.

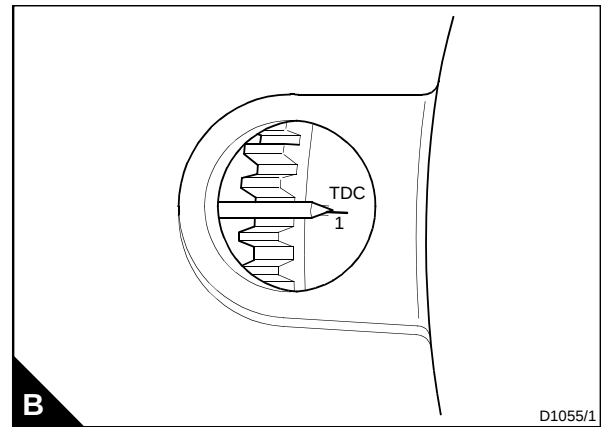
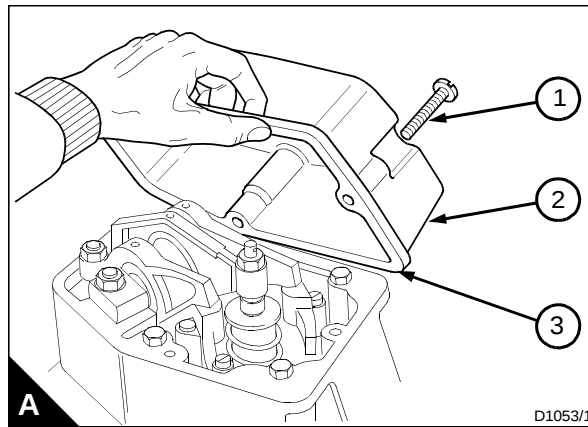
How to adjust the bridge piece

To help rotate the crankshaft a special tool (table 1) can be fitted.

Special requirements

Table 1	
Special tools	
Description	Part number
Engine cranking device	SE253

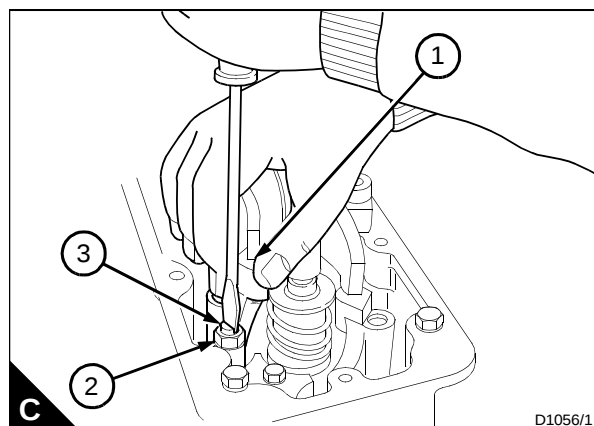
- 1 Remove the setscrews (A1). Remove the rocker cover (A2) and discard the cover joint (A3).
- 2 Rotate the engine to the required position, given in table 2.



Note: Use the inspection hole (B) in the flywheel housing to find TDC number one and number six.

Table 2		
Top dead centre TDC	Cylinder No. of valve on the rock	Set bridge piece and valve clearance on cylinder No.
1	6	1
5	2	5
3	4	3
6	1	6
2	5	2
4	3	4

Continued



3 Check that there is clearance on both valves.

4 Loosen the lock nuts on each of the bridge pieces (C2).

Note: Each rocker set has two bridge pieces, both must be adjusted.

5 Turn the adjuster (C3) out until the fixed side of the bridge piece rests on its valve.

6 Hold the top edge of the bridge piece (C1) and turn the adjuster screw (C3) down until it contacts the valve.

Caution: When the contact is made with the valve, the valve must not move. Only the gap between the valve tip and the bridge piece must be removed.

7 Tighten the lock nut (C2) to a torque of 50 Nm (35 lbf ft) 5,1 kgf m. Do not allow the adjuster screw (C3) to move.

Note: The valve clearance can now be set.

How to adjust the valve clearance

Note: The inlet and exhaust valve clearance is 0,4 mm (0.016 in)

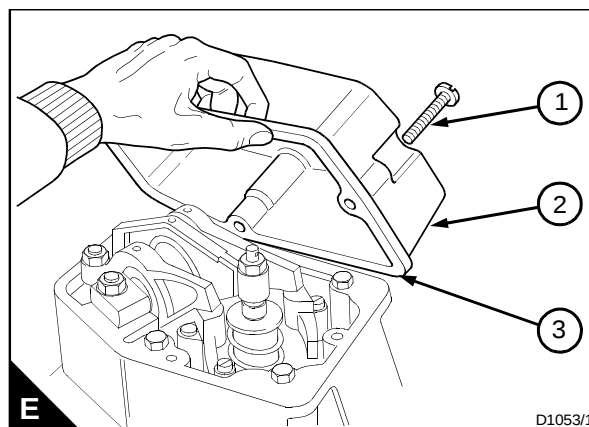
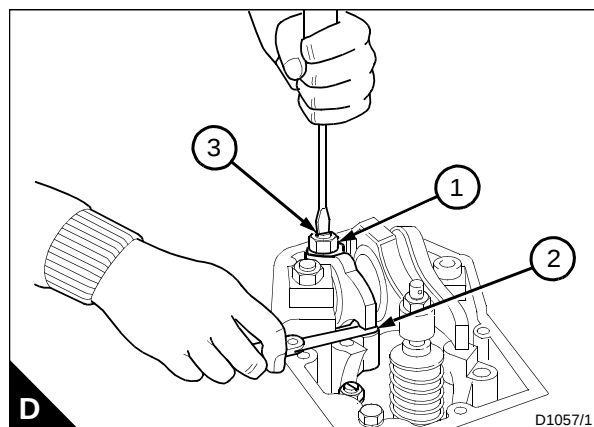
1 Check the valve clearance.

2 To set the valve clearance, loosen the lock nut (D1).

3 Put the feeler gauge (D2) between the rocker and bridge piece.

4 Turn the adjuster (D3) up or down to make the feeler gauge a slide fit.

5 Tighten the lock nut (D1) to a torque of 50 Nm (35 lbf ft) 5 kgf m. Do not allow the adjuster screw (D3) to move.



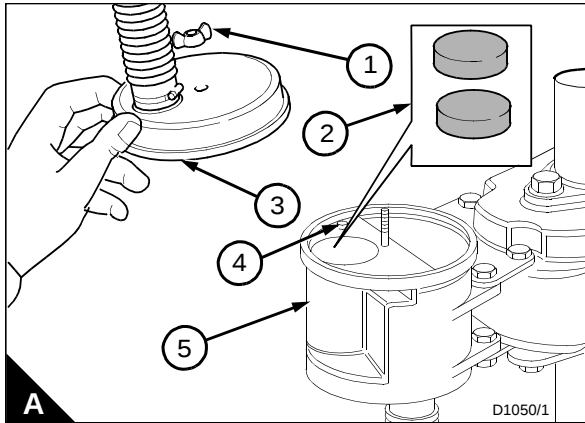
6 Check that the valve clearance is correct. Fit a new rocker cover joint (E3) and fit the rocker cover (E2).

7 Fit the setscrews (E1) and torque to 4 Nm (2.9 lbf ft) 0,4 kgf m.

How to clean the crankcase breather element

Warning! Disconnect the batteries and any other power that can start the engine.

- 1 Remove the wing nut (A1) and remove the breather cover (A3). Check the seal around the cover, renew if necessary.
- 2 Remove the filter elements (A2) from the breather body (A5).
- 3 Wash the elements in a suitable fluid. Dry the elements and inspect them, renew if necessary.
- 4 Fit the filter elements (A2) into the breather body (A5).
- 5 Fit the cover (A3) and check that the cover is fitted onto the dowel (A4) correctly.
- 6 Tighten the wing nut (A1) securely.
- 7 Connect the power supply to the starter motor.



5

Engine fluids

Fuel specification

Diesel fuel must conform to one of these specifications:

BS 2869: Class A2 1998.

BS EN 590 2000

A general fuel requirement is that the maximum sulphur content is 0.5%.

Fuel cleanliness

The modern, high pressure fuel injection system used on the 4006-23 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 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, Stafford.

Lubricating oil specification

Cautions:

- *Excessive periods of idling or repeated cold starts should be avoided, as they will cause excessive dilution of the oil by fuel, more frequent oil changes, and a dangerously lower flash point of the oil.*
- *Should there be a lubricating oil supply problem, or if the fuel contains more than 0.5% sulphur, consult Perkins Engines Company Limited, Stafford.*

The lubricating oil used in the 4006-23 engine must be a 15W 40 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 therefore is that API CG-4 is an acceptable oil and API CH-4 is the preferred oil.

Coolant specification

Cautions:

- If the correct procedures are not used, Perkins cannot be held responsible for damage caused by frost or corrosion.
- 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.
- 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.
- When ambient temperatures above 43 °C (109 °F) are anticipated, clean soft water with 1% of POWERPART inhibitor 21825735 must be used instead of antifreeze to ensure maximum cooling performance from the cooling system.

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

Caution: mixtures containing methanol are not approved.

The coolant approved 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.

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 year.

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.

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

Water quality

Use clean soft water in the coolant.

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

soft water	
Chlorides	less than 80 PPMV
Sulphates	80 PPMV
Total hardness	less than 200 PPMV
Acidity	pH of 7 to 7,5

Note: 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.

Warranty

Caution: 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

Engine fault diagnosis

Introduction

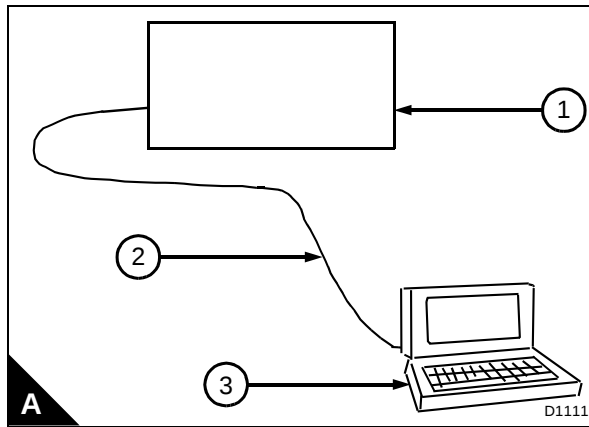
Caution: Do not use mobile phones within 2 meters of the engine as the transmitted signal can affect the electronic digital governor.

This fault diagnosis chart covers mechanical defects which may occur with the engine. It must be used in conjunction with electronic service tools.

To find problems within the engine and its systems it will be necessary to refer to the 4000 series service tool. For more information refer to the workshop manual.

Service tool connections

- (A1) Engine mounted digital governor
- (A2) Service tool harness
- (A3) PC



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

List of possible causes

- | | | | |
|----|--|----|---|
| 1 | Battery capacity low | 43 | Leakage between valves and seats |
| 2 | Bad electrical connections | 44 | Piston rings are not free or they are worn or broken |
| 3 | Fault in starter motor | 45 | Valve stems and/or guides are worn |
| 4 | Wrong grade of lubricating oil | 46 | Crankshaft bearings are worn or damaged |
| 5 | Starter motor turns engine too slowly | 47 | Lubricating oil pump is worn |
| 6 | Fuel tank empty | 48 | Relief valve does not close |
| 7 | spare | 49 | Relief valve does not open |
| 8 | Restriction in a fuel pipe | 50 | Relief valve spring is broken |
| 9 | Fault in fuel lift pump | 51 | Fault in suction pipe of lubricating oil pump |
| 10 | Dirty fuel filter element | 52 | Piston is damaged |
| 11 | Restriction in air induction system | 53 | spare |
| 12 | Air in fuel system | 54 | Flywheel housing or flywheel is not aligned correctly |
| 13 | Fault in fuel injector | 55 | Fault in thermostat or thermostat is of an incorrect type |
| 14 | Alternator belt loose | 56 | Restriction in coolant passages |
| 15 | Fault in alternator | 57 | Fault in coolant pump |
| 16 | Restriction in fuel tank vent | 58 | Valve stem seal is damaged |
| 17 | Wrong type or grade of fuel used | 59 | Restriction in sump strainer |
| 18 | Restricted movement of engine speed control | 60 | Valve spring is broken |
| 19 | Restriction in exhaust pipe | 61 | Lubricating oil seal of turbocharger leaks |
| 20 | Engine temperature is too high | 62 | Air leak in Induction system |
| 21 | Engine temperature is too low | 63 | Faulty engine digital electronic governor |
| 22 | Incorrect valve tip clearances | | |
| 23 | Fan belts loose | | |
| 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 | | |
| 34 | Injection timing incorrect | | |
| 35 | spare | | |
| 36 | spare | | |
| 37 | Valve timing is incorrect | | |
| 38 | Bad compression | | |
| 39 | Cylinder head gasket leaks | | |
| 40 | Valves are not free | | |
| 41 | spare | | |
| 42 | Worn cylinder bores | | |