# Perkins 2000 Series

Models 2006SI and 2006TSI

# USER'S HANDBOOK

## 6 cylinder spark ignited engines for industrial applications

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## This publication is divided into six chapters:

## 1 General information

## 2 Engine views

## 3 Operation instructions

## 4 Preventive maintenance

## 5 Engine systems

## 6 Fault diagnosis

**The following pages contain a detailed table of contents**

# Contents

## 1 General information



## 2 Engine views

# 3 Operation instructions



# 4 Preventive maintenance



# 5 Engine systems

# 6 Fault diagnosis

# 1

# General information

## Introduction

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

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

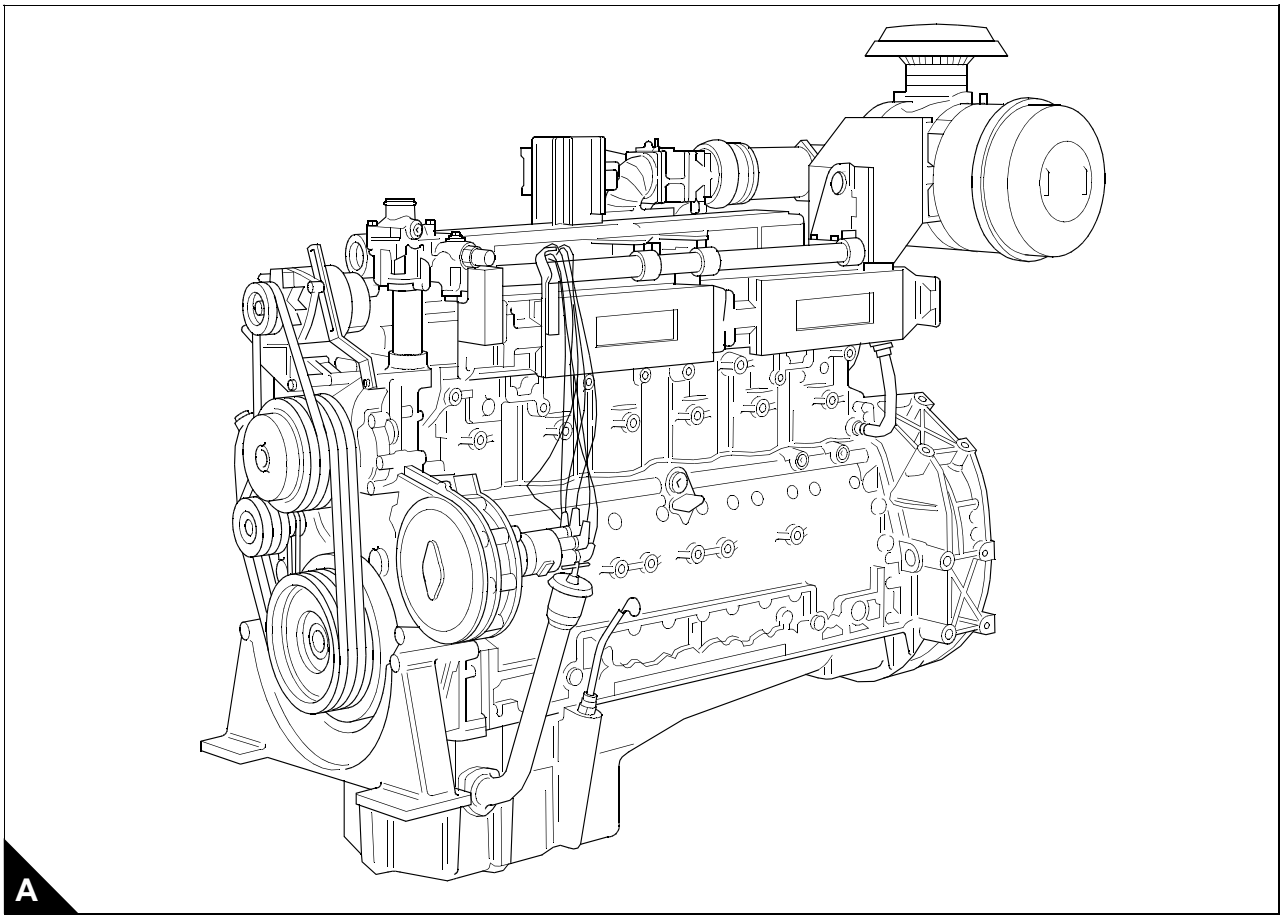
To ensure that you use the correct information for your specific engine type, refer to "Engine identification" on page 5.

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.



A

## Safety precautions

**These safety precautions are important.**

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

- Do not use salt water or any other coolant which can cause corrosion in the cooling system.
- Do not change the specification of the engine. Do not allow sparks or fire near the batteries (especially when the batteries are on charge) as the gases from the electrolyte are highly flammable. The battery fluid is dangerous to the skin and especially to the eyes.
- Keep away from naked flames, hot exhaust pipes and sparks when working with gaseous fuels and when conducting fuel tests.
- Do not smoke when you are on or near the gas pipes or system.
- Do not replenish the gas supply while the engine runs.
- Disconnect the battery terminals before you make a repair to the electrical system.
- Beware of electric shocks from the high tension current in the ignition system. Shocks from this system can propel limbs into moving machinery.
- Never clean, add lubricating oil to, or adjust the engine while it runs (unless you have had the correct training, when extreme caution must be used to prevent injury).
- 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.
- Fuel and oil pipes **must** be inspected for cracks or damage before they are fitted to the engine.
- Discard used lubricating oil in a safe place to prevent contamination.
- Only one person must control the engine. Ensure that the engine is operated only from the control panel or from the operator's position.
- Do not make any adjustments that you do not understand.
- Ensure that the engine is not in a position to cause a concentration of toxic emissions.
- Other people must be kept at a safe distance while the engine is operated.
- Do not permit loose clothing or long hair near parts which move.
- Keep away from parts which move during engine operation.

***Warning!*** *The fan cannot be seen clearly while the engine runs.*

- Do not operate the engine if one or more of the safety guards have been removed.
- Do not remove the coolant caps while the engine is hot and while the coolant is under pressure, because dangerous hot coolant can be discharged.
- 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.
- Fit only genuine Perkins parts.

## How to care for your engine

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

To obtain the best performance and the longest life from your engine, you must ensure that the maintenance operations are done at the intervals given in Chapter 4, Preventive maintenance.

If the engine is operated in very dusty or other adverse conditions, certain maintenance intervals will have to be reduced. Change the filter elements and lubricating oil regularly to ensure that the inside of your engine remains clean.

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

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

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

## Engine preservation

All new or reconditioned engines leaving the factory have been treated with corrosion inhibitors to Perkins standards. Each engine may be stored under cover, in dry conditions, for a period of up to 12 months from the date of despatch from the factory, without the need for further inhibition.

Should the storage period exceed 12 months, the engine must be thoroughly examined and re- inhibited. For further details contact Perkins Engines Company Limited.

## Parts and service

If a problem occurs with your engine or with the components fitted to it, contact the Service Department at Perkins Engines Company Limited.

For information of the supply of replacement parts and arrangements for ordering, contact:

Perkins Parts Limited
Frank Perkins Way
Northbank Industrial Estate
Irlam
Manchester
M44 5PP
Telephone: 0161 776 5000
Fax: 0161 776 5200

## Training

Courses on the service and overhaul of the 2000 Series range of engines are available at the factory. For details, apply to:

The Customer Training Centre
Perkins Engines Company Limited
Shrewsbury
SY1 3NX
England.

## Service Bulletins

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

## Engine identification

The 2000 Series engine is a six cylinder, in-line unit, which can be normally aspirated or turbocharged. It is supplied in various power ratings, depending on the application and the calorific value of the gas supply.

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

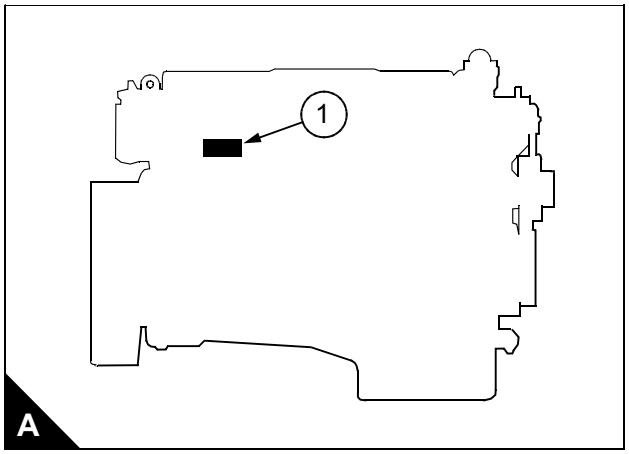
For early engines, a typical engine number is: **8E28013U 59426T**, which consists of these codes:

| | |
|---|---|
| **8E** | Engine family |
| **28013** | Engine number |
| **U** | Country of manufacture |
| **59426** | Build line number |
| **T** | Year of manufacture |

Engines produced after August 1994, have a new engine number system. For these engines, a typical engine number is **SIC060057U951234A** which consists of these codes:

| | |
|---|---|
| **SI** | Engine application |
| **C** | Engine type |
| **06** | Number of engine cylinders |
| **0057** | Engine specification number |
| **U** | Country of manufacture |
| **951234** | Build line number |
| **A** | Year of manufacture |

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



## General engine data

| | | |
|---|---|---|
| **Type** | Liquid cooled, four stroke, six cylinder in-line, spark ignited engine | |
| **Bore** | 130,17 mm (5.125 in) | |
| **Stroke** | 152,4 mm (6.00 in) | |
| **Capacity** | 12,17 litres (742.64 $in^3$) | |
| **Compression ratio** | 12:1 Naturally aspirated (Natural gas)<br>10:1 Turbocharged (Natural gas) | |
| **Rotation** | Anti-clockwise, viewed on flywheel | |
| **Cylinder firing order** | 1, 4, 2, 6, 3, 5 | |
| **Cylinder numbering** | From front (fan end) to rear (flywheel end) | |
| **Valve tappet clearance - Naturally aspirated and turbocharged** | | |
| Inlet | 0,254 mm (0.010 in) hot or cold | |
| Exhaust | 0,508 mm (0.020 in) hot or cold | |
| **Engine weight** | **Naturally aspirated** | **Turbocharged** |
| With air cooled exhaust manifold | Dry - 1082 kg (2385 lb)<br>Wet - 1125 kg (2480 lb) | |
| With water cooled exhaust manifold | Dry - 1090 kg (2403 lb)<br>Wet - 1350 kg (2976 lb) | Dry - 1100 kg (2425 lb)<br>Wet - 1360kg (2998 lb) |

## Cooling system data

| | | |
|---|---|---|
| **Total coolant capacity (engine only)** | **Naturally aspirated** | **Turbocharged** |
| With air cooled exhaust manifold | 20,4 litres (4.5 UK gallons) | |
| With water cooled exhaust manifold | 28,0 litres (6.16 UK gallons) | 29,0 litres (6.38 UK gallons) |
| **System pressure cap setting** | Maximum 70 $kN/m^2$ (10 $lbf/in^2$) to suit installation | |
| **Operating temperature (at sea level)** | Normal running 78 to 95 °C (172 to 203 °F) | |
| **Maximum operating temperature** | 103 °C (217.4 °F) | |
| **Thermostat (where fitted)** | Triple-element wax capsule type with radiator by-pass | |
| **Heat exchanger (oil-to-coolant)** | Single unit, baffled and finned tube pack, with part coolant by-pass | |
| **Coolant pump** | Belt driven centrifugal type | |
| **Protection switch settings** | Warning - 100 °C (212 °F)<br>Shutdown - 106 °C (222.8 °F) | |

## Fuel system data

| | |
|---|---|
| **Gas supply pressure** | 1,96 to 4,90 $kN/m^2$ (200 to 500 mm $H_2O$ at full rated flow). An engine can be modified to operate on a gas pressure different from that quoted above; for details please contact Perkins Engines Company Limited. |
| **Gas carburettor** | |
| Naturally aspirated | Deltec 100 - II |
| Turbocharged | Deltec 140 - II |
| **Zero pressure regulator** | Diaphragm type Krom Schreoder GI 40<br>(GI 25 on early engines) |
| **Governor (optional)** | Electronic type |

## Ignition system data

### Naturally aspirated

| | |
|---|---|
| **Type** | Electronic contactless distributor |
| **Primary voltage** | 12 volts |
| **Polarity** | Negative earth |
| **Distributor** | ‘Hall effect', Lucas 42638 43D4 1291 |
| **Amplifier** | Sealed unit, Lucas 60041013 DAB 100 |
| **Ignition coil** | Lucas DLB105B - 12V, inductive type |
| **Spark plugs** | Champion RC 78 PYP 16 mm AF hexagon, long reach type |
| **Spark plug gap** | 0,30 mm (0.012 in) |
| **Spark plug leads** | 7 or 8 mm suppressed carbon ignition wire<br>(Later engines: spark plug leads with core of copper and suppression in the spark plug connectors) |
| **Ignition harness** | Supplied complete with 6-way connectors |
| **Ignition timing** | As stamped on the data plate |

### Later ignition system which replaces that shown above

**Notes:**

- Must only be used in sets shown and not interchanged with any other.
- Engines equipped with these items are identified by the engine specification number 8E28421

| | |
|---|---|
| **Distributor** | Contactless, Hall effect, Lucas 42590A |
| **Ignition module** | Lucas sealed unit DAB 111 |
| **Ignition coil** | Lucas inductive type DLB 198 |

### Turbocharged and later naturally aspirated engines

| | |
|---|---|
| **Type** | Fairbanks Morse IQ 250 |
| **Primary voltage** | 24 volts |
| **Polarity** | Negative earth |
| **Amplifier** | Separate |
| **Ignition coil** | One per cylinder |
| **Timing method** | Sensors at starter ring and camshaft disc |
| **Spark plug type** | Champion RC 78 PYP 16mm AF hexagon |
| **Spark plug gap** | 0,30 mm (0.012 in) |
| **Spark plug leads** | 8 mm spark plug leads with core of copper and suppression in the spark plug connectors |
| **Ignition harness** | Supplied complete with 6 way connectors |
| **Ignition timing** | As stamped on the data plate |

## Lubrication system data

| | |
|---|---|
| **Type** | Wet sump |
| **Oil capacity** | |
| **Naturally aspirated (standard sump)** | Sump capacity 25 litres (5.5 UK gallons)<br>Total engine capacity 29,5 litres (6.5 UK gallons)<br>Sump minimum 18,2 litres (4.0 UK gallons) |
| **Turbocharged and later naturally aspirated engines** | Sump capacity 82 litres (18.0 UK gallons)<br>Total engine capacity 86.5 litres (18.6 UK gallons)<br>Sump minimum 73 litres (16.0 UK gallons) |
| **Oil pump** | Spur gear driven, gear type single unit pump |
| **Oil pressure** | 345 to 483 kN/$m^2$ (50 to 70 lbf/$in^2$) at rated speed<br>Minimum at rated speed 207 kN/$m^2$ (30 lbf/$in^2$) |
| **Oil filters** | Two spin-on expendable canisters with integral by-pass valves operating in parallel |
| **Pressure relief valve** | Spring and plunger type housed in oil pump body |

## Induction system data

| | |
|---|---|
| **Air filter** | 12 inch, 2 stage, dry type |
| **Maximum air intake restriction** | Clean filter - 255 mm (10 in $H_2O$)<br>Dirty filter - 635 mm (25 in $H_2O$) |
| **Turbocharger** | Holset H2D water cooled bearing housing |

## Electrical equipment

| | |
|---|---|
| **Type** | Insulated return |
| **Alternator** | Prestolite (Butec) belt driven, 32 amps and 28 volts |
| **Starter motor** | Prestolite (Butec) flange mounted MS1A 24 volt |

## Engine protection equipment

Depends on specification. Certain protection devices may be incorporated in the system which will stop the engine or prevent it from starting if a fault occurs or is present. Often an "Annunciator" is incorporated in the switch panel which will indicate the fault.

It is usual for low oil level, low oil pressure, high coolant temperature, low coolant level and low coolant pressure to be covered. The specification of your engine may have all or some of these devices.

# 2

# Engine views

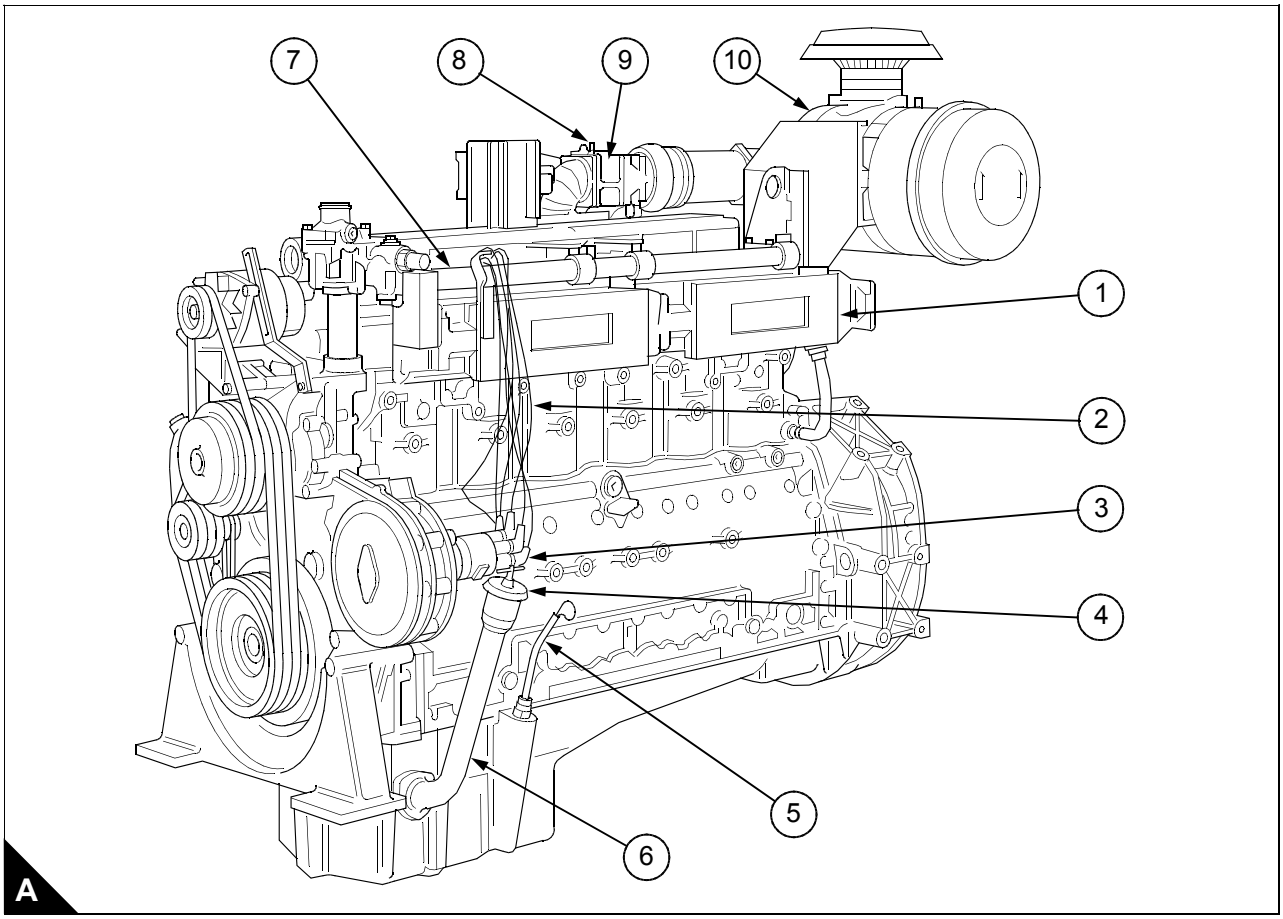
## Introduction

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

## Location of engine parts - naturally aspirated engines

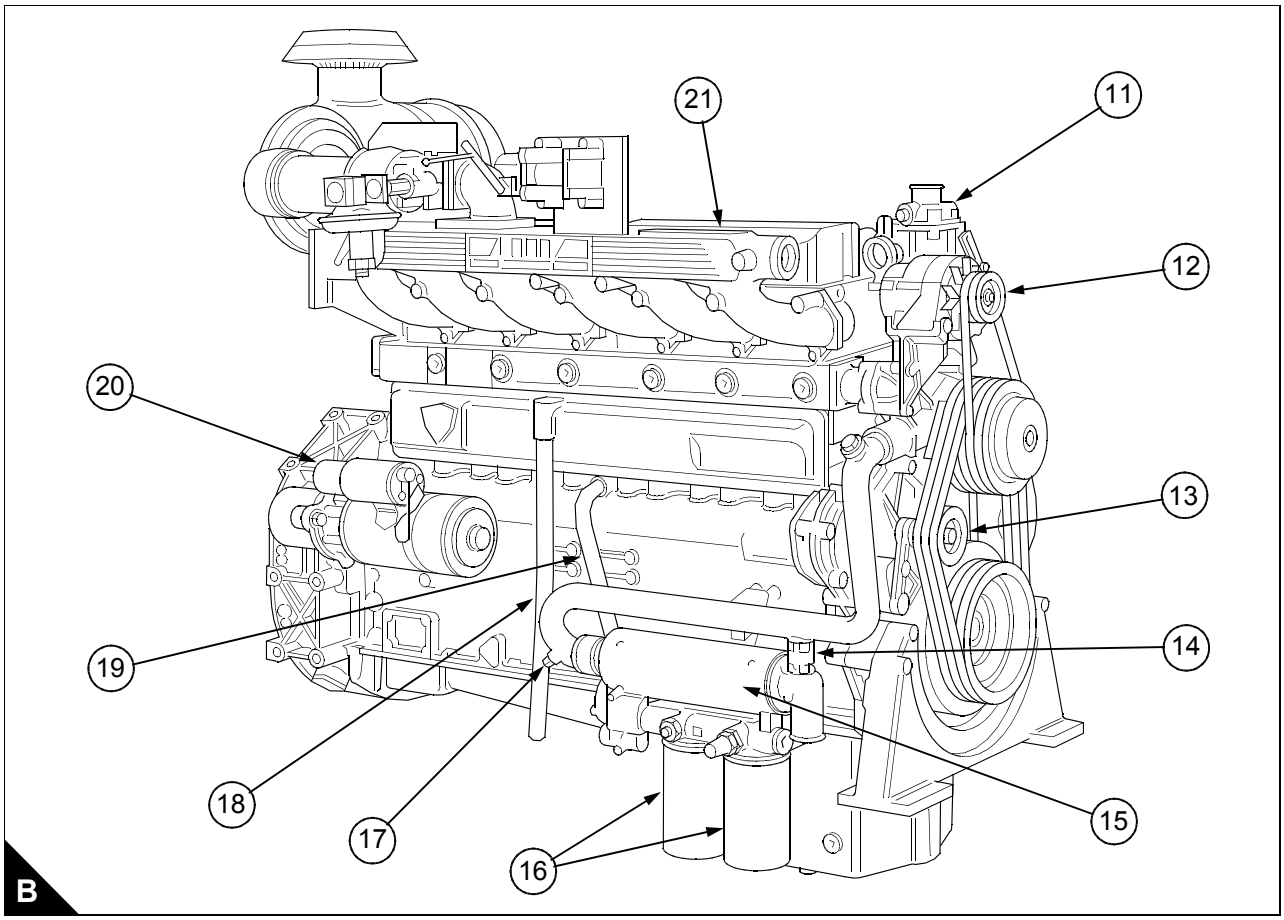
**Front and left side view of engine (A)**

1 Exhaust manifold
2 Spark plug leads
3 Distributor
4 Oil filler cap
5 Dipstick and tube
6 Oil filler tube
7 Coolant rail
8 Mixture adjusting screw (MAS)
9 Carburettor
10 Air cleaner



**Front and right side view of engine (B)**

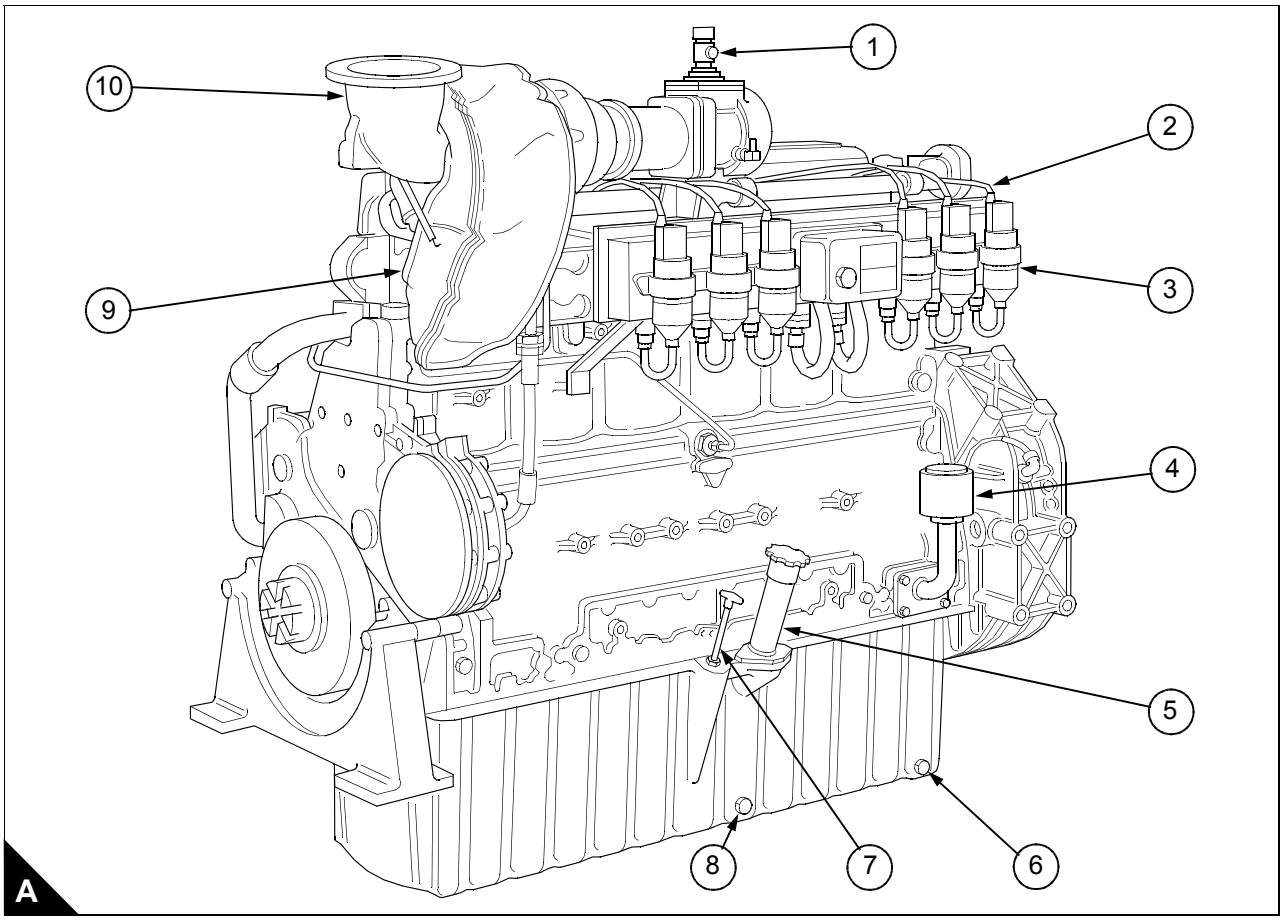
11 Thermostat
12 Alternator
13 Belt tensioner
14 Coolant by-pass
15 Oil cooler
16 Oil filter canister (2)
17 Coolant drain plug
18 Breather pipe
19 Lubricating oil feed to main gallery
20 Starter motor
21 Inlet manifold



## Location of engine parts - turbocharged engines

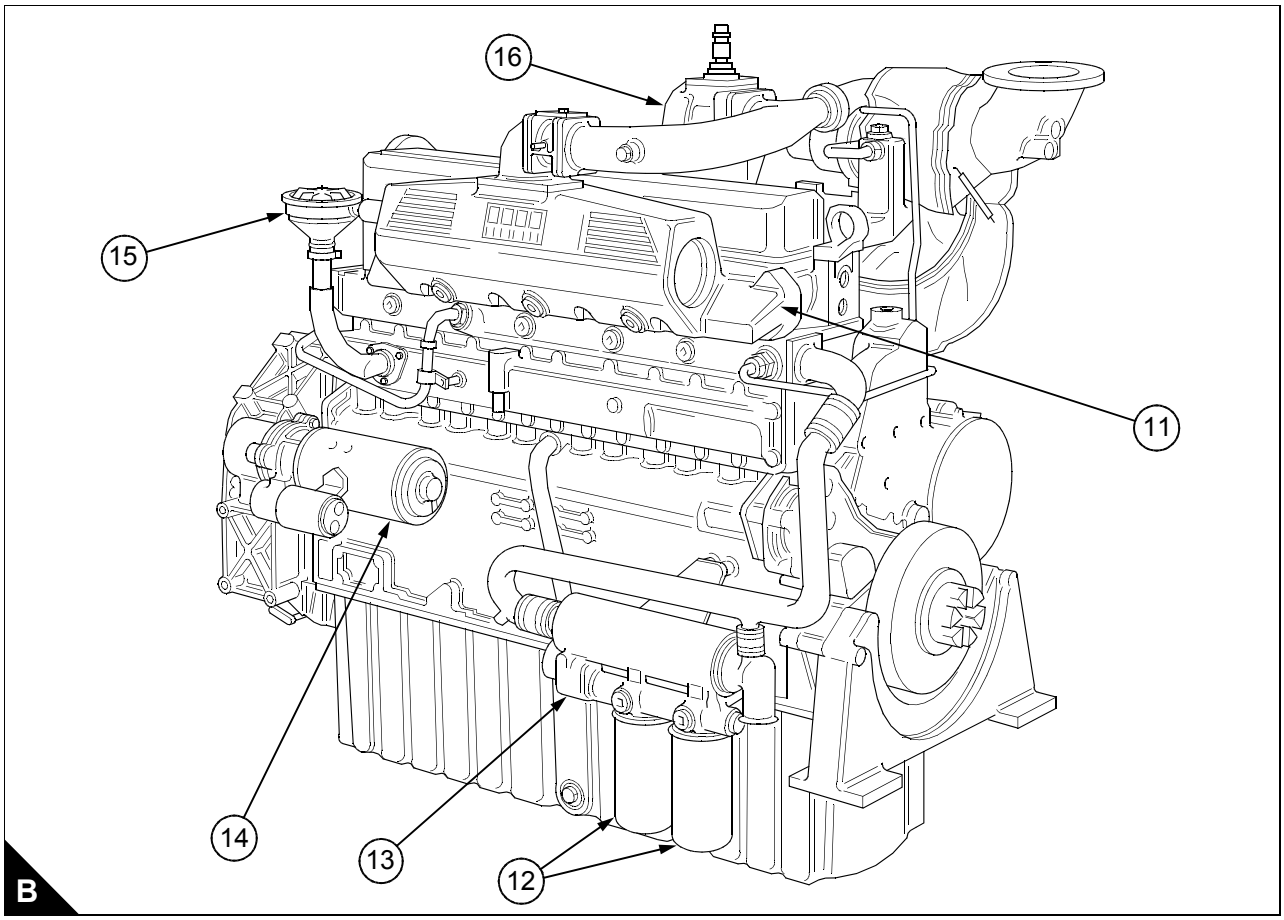
**Front and left side view of engine (A)**

1 Mixture adjusting screw (MAS)
2 Spark plug leads
3 Ignition coils
4 Crankcase air inlet filter
5 Oil filler tube and cap
6 Oil drain plug
7 Dipstick and tube
8 Ancillary equipment tapping
9 Turbocharger and insulating cover
10 Exhaust outlet



**Front and right side view of engine (B)**

11 Inlet manifold
12 Oil filter canister
13 Oil cooler
14 Starter motor
15 Crankcase ventilator valve
16 Air/fuel mixer, main adjusting screw and throttle (butterfly)



# 3

# Operation instructions

## Routine procedure with a new or an overhauled engine

Gas quality and type will have a major effect on the performance and reliability of the engine. It is imperative that all Perkins spark ignited engines are commissioned by Perkins approved installers, to ensure correct and safe operation of the equipment.

Refer to Chapter 5, Engine systems which outlines the safeguards required for the fuel and lubricating oil systems.

**1** Check that all wrappings and sealing blanks have been removed.

**2** Refit any components removed for storage or transportation.

**3** Ensure that all coolant and lubricating oil drain plugs are securely fitted.

**4** Dependent on installation, connect the remote control linkages, pressure gauge pipework, air intake duct and electrical wiring.

**5** Connect the gas supply and exhaust pipework ensuring that all valves and filters are correctly positioned and operating.

**6** Fill the coolant system with the approved coolant mixture, see "Coolant" on page 38.

**7** Fill the sump to the upper mark on the dipstick with the correct grade of lubricating oil, see "Lubricating oil specification" on page 40.

**8** Lubricate all control linkages and check for freedom of movement.

**9** Prime the turbocharger, see "To prime the turbocharger" on page 14.

**Note:** Every new or reconditioned engine supplied by Perkins Engines Company Limited, Shrewsbury, is run in before delivery to the customer.

## Routine starting

**Daily checks before initial start**

**1** Where a radiator is fitted check that the coolant level is about 76 mm (3 in) below the filler neck, or as otherwise specified in the equipment manufacturer's manual. Top up, if necessary, with the correct coolant. Investigate any marked loss of coolant.

**2** Check the oil level in the engine sump. Replenish, as necessary, to the H mark on the dipstick. Use the correct grade of oil.

***Caution:*** *Do not overfill.*

**3** For a turbocharged engine which has not run for a long period the turbocharger must be primed.

**To prime the turbocharger**

Clean the area around the connection for the oil feed on top of the bearing housing. Remove the pipe connection from the turbocharger or the plug if fitted. The clip which supports the pipe and the lower connection may have to be loosened to allow the top of the pipe to be moved.

Add 0,2 litre ($^1/_3$ pint) of clean engine oil to the turbocharger. Fit the connection or plug. Tighten the plug or connections and the clip securely.

**Starting procedure**

Perform daily service checks detailed above, then proceed as follows:

**1** Move the gas tap (if fitted) to the ON or OPEN position.

**2** Turn the ignition switch to ON, this will open the gas solenoids and energise the ignition electrical circuit.

**3** Press the starter button, or turn the key further to the START position to activate the starter motor. Hold in the START position for a period of 3 to 5 seconds when the engine will start.

## Running the engine

The following precautions will help to ensure a long and trouble-free life for the engine.

**1** Do not subject the engine to high speeds and loads until working temperature is reached.

**2** Avoid long periods of idling or "OFF LOAD" running.

**3** Do not allow engine speeds to exceed the rated maximum. Over-speeding will shorten engine life and can result in component failure.

## Stopping the engine

Run the engine "OFF LOAD" for a short period. Move the ignition key to the OFF position.

# 4

# Preventive maintenance

## Preventive maintenance periods

These preventive maintenance periods are general in application. Check the periods given by the manufacturer of the equipment in which the engine is installed.

The servicing intervals may be reduced at the discretion of operators to suit local conditions but must NOT be extended without the written consent of Perkins Engines Company Limited as required by the Perkins Guarantee.

It is good maintenance to check for leakage and loose fasteners at each service.

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

**Schedules**

The schedules which follow must be applied at the recommended interval as shown.

**Engines in normal use**

Engines in this category are those which are in use for an aggregate of more than 400 hours in twelve months. Refer to the appropriate schedules on page 16 and page 18.

**Engine in intermittent use**

Engines in this category are those which are in use for an aggregate of less than 400 hours in twelve months. Refer to the appropriate schedules on page 17 and page 19.

## Schedule for naturally aspirated engines in normal use

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

**A** - Every 10 hours or daily

**B** - Every 500 hours or 12 months

**C** - Every 1000 hours

| A | B | C | Operation |
|---|---|---|---|
| ● | | | Check the amount of coolant in the radiator |
| ● | | | Check the level of the lubricating oil in the sump |
| ● | | | Check the gas supply pressure |
| ● | | | Check the lubricating oil pressure at the gauge **(2)** |
| ● | | | Check the restriction indicator for the air filter. Renew the filter element if the indicator shows red |
| | ● | | Check the condition and tension of all drive belts **(2)** |
| | ● | | Check the specific gravity and the pH value of the coolant |
| | ● | | Renew the lubricating oil **(3)** |
| | ● | | Renew the canisters of the lubricating oil filter and the rotor of the by-pass filter **(2)** |
| | ● | | Check that the radiator is clean and free from debris |
| | ● | | Check and reset or change the spark plugs |
| | ● | | Renew crankcase breather filter and clean the crankcase breather **(2)** |
| | | ● | Ensure that the tappet setting clearances are checked and adjusted if it is necessary **(1) (4)** |

**(1)** By a person who has had the correct training.
**(2)** If fitted.
**(3)** The selection of suitable lubricants should be made in co-operation with a reputable oil company, who can offer the necessary oil sample analysis support to ensure successful lubrication of spark ignited engines. Analysis results will determine the service period which could be less than the 500 hour service period. Refer to Chapter 5, Engine systems for details.
**(4)** After the first 500 hours on a new and overhauled engine.

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

- Drain and flush the coolant system and renew the coolant mixture.
- Check the distributor cap for cracks or ‘tracking’ and the condition of the high tension leads.
- Change the air filter element.
- Ensure that the alternator, starter motor etc and protection switches are checked or serviced as necessary **(1)**.

## Schedule for naturally aspirated engines in intermittent use

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

**A** - Monthly

**B** - Every 200 hours or 12 months

| A | B | Operation |
|---|---|---|
| ● | | Check the amount of coolant in the radiator |
| ● | | Check the level of the lubricating oil in the sump |
| ● | | Check the gas supply pressure |
| ● | | Start and run the engine until normal operating temperature is attained |
| ● | | Check the lubricating oil pressure at the gauge **(2)** |
| ● | | Check the restriction indicator for the air filter. Renew the filter element if the indicator shows red |
| | ● | Check the condition and tension of all drive belts **(2)** |
| | ● | Check the specific gravity and the pH value of the coolant |
| | ● | Renew the lubricating oil **(3)** |
| | ● | Renew the canisters of the lubricating oil filter and the rotor of the by-pass filter **(2)** |
| | ● | Check that the radiator is clean and free from debris |
| | ● | Check and reset or change the spark plugs |
| | ● | Ensure that the tappet setting clearances are checked and adjusted if it is necessary **(1)(4)** |

**(1)** By a person who has had the correct training.
**(2)** If fitted.
**(3)** The selection of suitable lubricants should be made in co-operation with a reputable oil company, who can offer the necessary oil sample analysis support to ensure successful lubrication of spark ignited engines. Analysis results will determine the service period which could be less than the 500 hour service period. Refer to Chapter 5, Engine systems for details.
**(4)** After the first 500 hours on a new and overhauled engine.

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

- Drain and flush the coolant system and renew the coolant mixture.
- Check the distributor cap for cracks or ‘tracking’ and the condition of the high tension leads.
- Change the air filter element.
- Ensure that the alternator, starter motor etc and protection switches are checked or serviced as necessary **(1)**.
- Renew crankcase ventilator filter and clean crankcase breather **(1)(2)**.

## Schedule for turbocharged engines in normal use

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

**A** - Every 10 hours or daily

**B** - Every 750 hours or 12 months

**C** - Every 1500 hours

| A | B | C | Operation |
|---|---|---|---|
| ● | | | Check the amount of coolant in the radiator |
| ● | | | Check the level of the lubricating oil in the sump |
| ● | | | Check the gas supply pressure |
| ● | | | Check the lubricating oil pressure at the gauge **(2)** |
| ● | | | Check the restriction indicator for the air filter. Renew the filter element if the indicator shows red |
| | ● | | Check the condition of the high tension leads |
| | ● | | Check the condition and tension of all drive belts **(2)** |
| | ● | | Check the specific gravity and the pH value of the coolant |
| | ● | | Renew the lubricating oil **(3)** |
| | ● | | Renew the canisters of the lubricating oil filter and the rotor of the by-pass filter **(2)** |
| | ● | | Check that the radiator is clean and free from debris |
| | ● | | Check and reset or change the spark plugs |
| | ● | | Renew the crankcase ventilator filter and clean crankcase breather **(1)** |
| | ● | | Ensure that the mounting nuts for the turbocharger are tightened securely |
| | | ● | Ensure that the tappet setting clearances are checked and adjusted if it is necessary **(1)(4)** |

**(1)** By a person who has had the correct training.
**(2)** If fitted.
**(3)** The selection of suitable lubricants should be made in co-operation with a reputable oil company, who can offer the necessary oil sample analysis support to ensure successful lubrication of spark ignited engines. Analysis results will determine the service period which could be less than the 750 hour service period. Refer to Chapter 5, Engine systems for details.
**(4)** After the first 750 hours on a new and overhauled engine.

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

- Drain and flush the coolant system and renew the coolant mixture.
- Ensure the control linkages for the carburettor are free to move and are lubricated.
- Change the air filter element.
- Ensure that the alternator, starter motor, turbocharger and protection switches are checked or serviced as necessary **(1)**.

## Schedule for turbocharged engines in intermittent use

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

**A** - Monthly

**B** - Every 200 hours or 12 months

| A | B | Operation |
|---|---|---|
| ● | | Check the amount of coolant in the radiator |
| ● | | Check the level of the lubricating oil in the sump |
| ● | | Check the gas supply pressure |
| ● | | Start and run the engine until normal operating temperature is attained |
| ● | | Check the lubricating oil pressure at the gauge **(2)** |
| ● | | Check the restriction indicator for the air filter. Renew the filter element if the indicator shows red |
| | ● | Check the condition of the high tension leads |
| | ● | Check the condition and tension of all drive belts **(2)** |
| | ● | Check the specific gravity and the pH value of the coolant |
| | ● | Renew the lubricating oil **(3)** |
| | ● | Renew the canisters of the lubricating oil filter and the rotor of the by-pass filter **(2)** |
| | ● | Check that the radiator is clean and free from debris **(2)** |
| | ● | Check and reset or change the spark plugs |
| | ● | Renew crankcase ventilator filter and clean crankcase breather |
| | ● | Ensure the mounting nuts for the turbocharger are tightened securely **(1)** |
| | ● | Ensure that the tappet setting clearances are checked and adjusted if it is necessary **(1)(4)** |

**(1)** By a person who has had the correct training.
**(2)** If fitted.
**(3)** The selection of suitable lubricants should be made in co-operation with a reputable oil company, who can offer the necessary oil sample analysis support to ensure successful lubrication of spark ignited engines. Analysis results will determine the service period which could be less than the 500 hour service period. Refer to Chapter 5, Engine systems for details.
**(4)** After the first 500 hours on a new and overhauled engine.

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

- Drain and flush the coolant system and renew the coolant mixture.
- Ensure the control linkages for the carburettor are free to move and are lubricated.
- Change the air filter element.
- Ensure that the alternator, starter motor, turbocharger and protection switches are checked or serviced as necessary **(1)**.

## Air filter

The air filter (A) is a dry type unit fitted with a restriction indicator and rain hood.

**Servicing**

To obtain the best performance from the air filter, it should be serviced when indicated, as determined by the restriction indicator. Over servicing does not take full advantage of the features of the air filter and may cause damage.

**How to service the air filter**

**1** Slacken the clamp ring and remove the dust bowl and baffle assembly. Remove the wing nut and separate the bowl and baffle.

**2** Empty the bowl, clean both components and reassemble.

**3** Unscrew the element securing nut and carefully withdraw the element.

**4** Direct a jet of compressed air, maximum pressure of 700 kN/$m^2$ (100 lbf/$in^2$), up and down the inside of the element pleats.

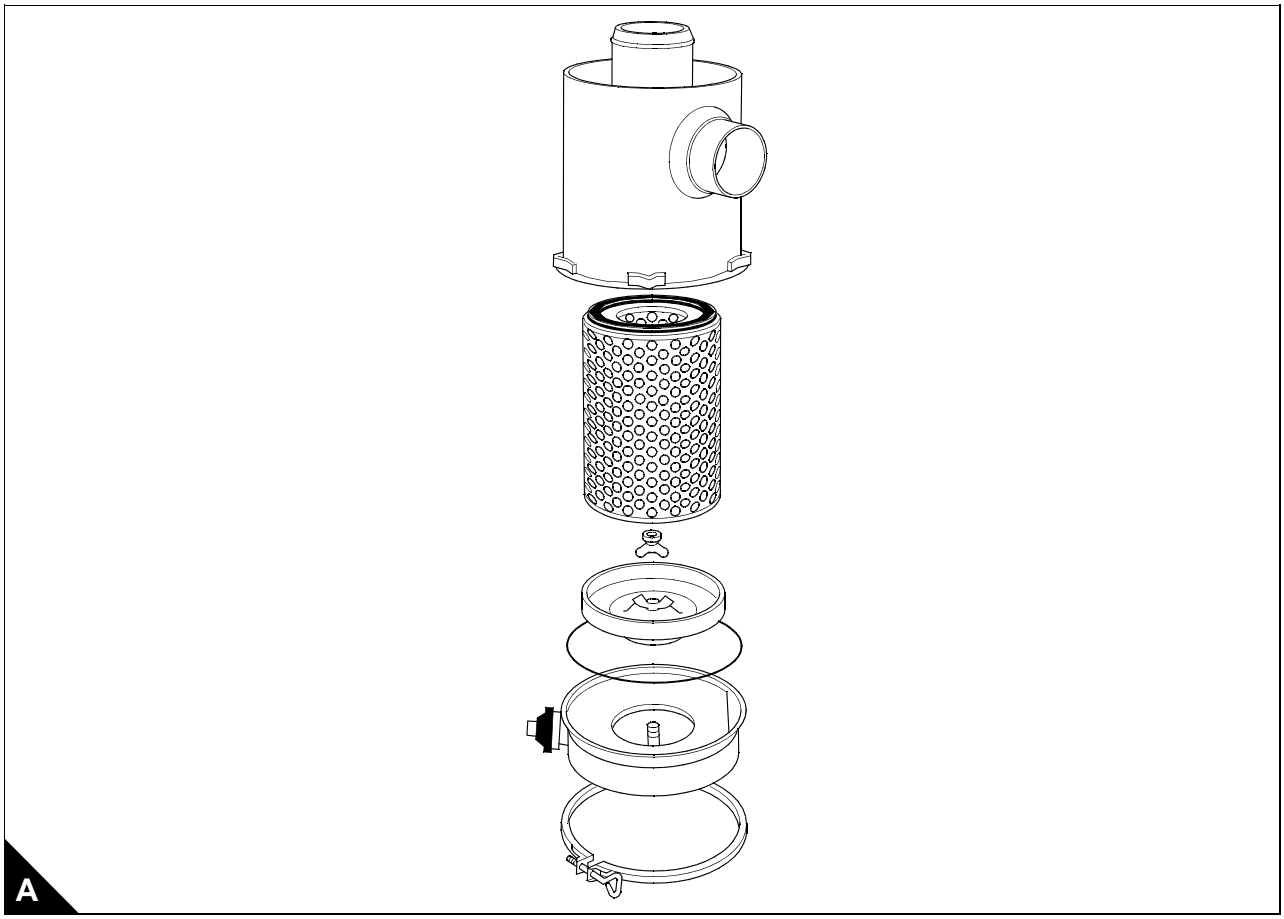
***Caution:*** *Do not hold the jet nozzle close to the element.*

**5** Inspect the element for damage by placing a lighted bulb inside. Thin areas or perforations indicate that the element must be renewed immediately.

**6** Clean the air filter body, refit the element and dust bowl assembly and tighten the clamp ring.

**7** Reset the restriction indicator.

**Note:** An alternative method of cleaning the element is to soak it in a solution of detergent, following the instructions on the packet. For recommended detergent contact Perkins Engines Company Limited.



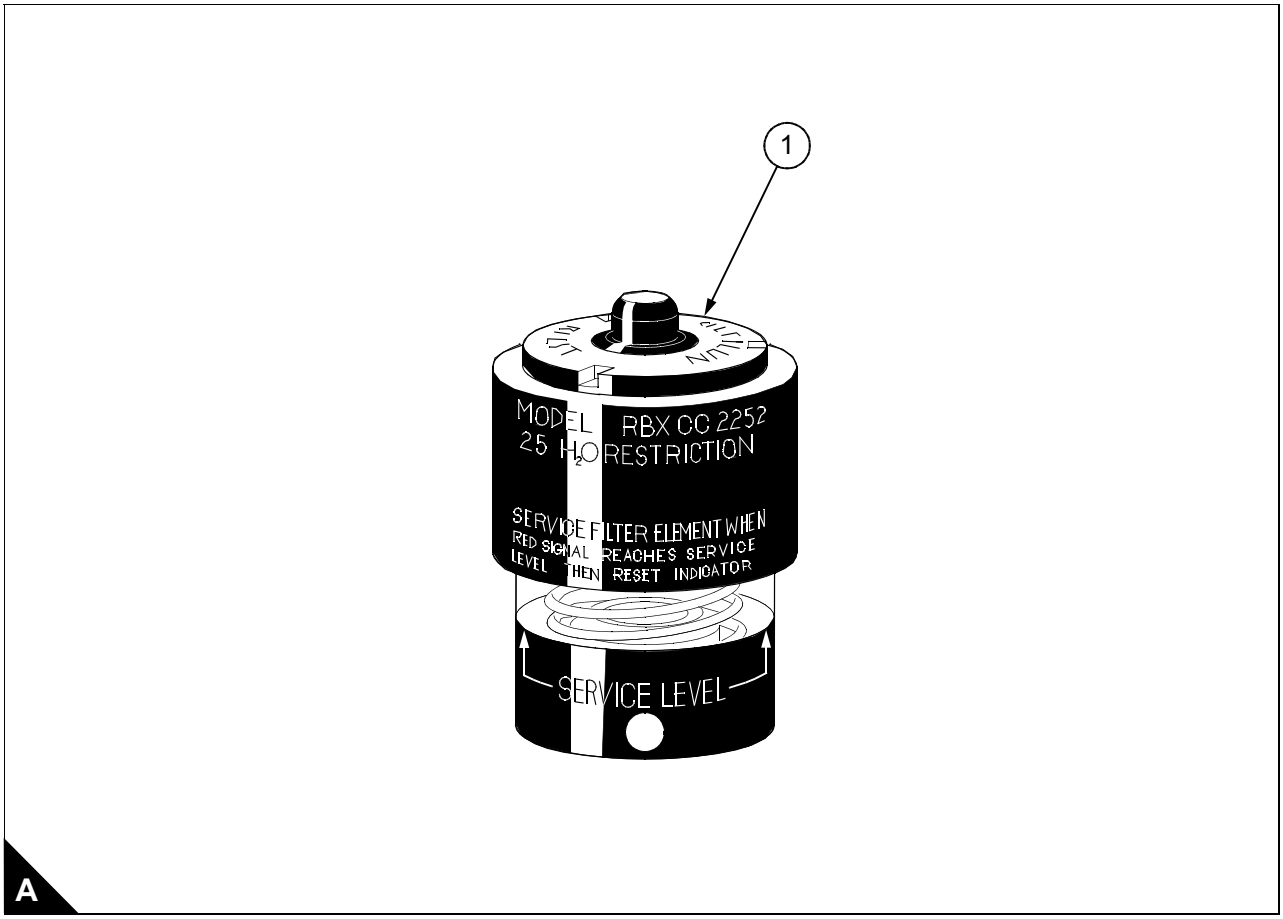
## Restriction indicator

An indicator (A1) is fitted to the air cleaner to give visual warning of the fouling of the element.

As fouling increases, a red sleeve gradually moves into view in the indicator sight glass. At the limit of the fouling the sleeve will reach the service level and remain there when the engine is shut down. This indicates that the air filter must be serviced immediately.

If during engine operation the sleeve shows partial restriction there is no immediate necessity to service the air filter. It is however advisable to service the air filter at normal shutdown.

Press the button in the end of the indicator to reset.



## How to check the drive belts

Check all drive belts and renew a belt if it is worn or damaged. Where more than one belt is used between two pulleys, all of the belts must be renewed together. Do **not** fit an individual belt except where only one belt is fitted as standard.

It is recommended that a bolt tensioner gauge, fitted at the centre of the longest free length (A1) is used to check the belt tension.

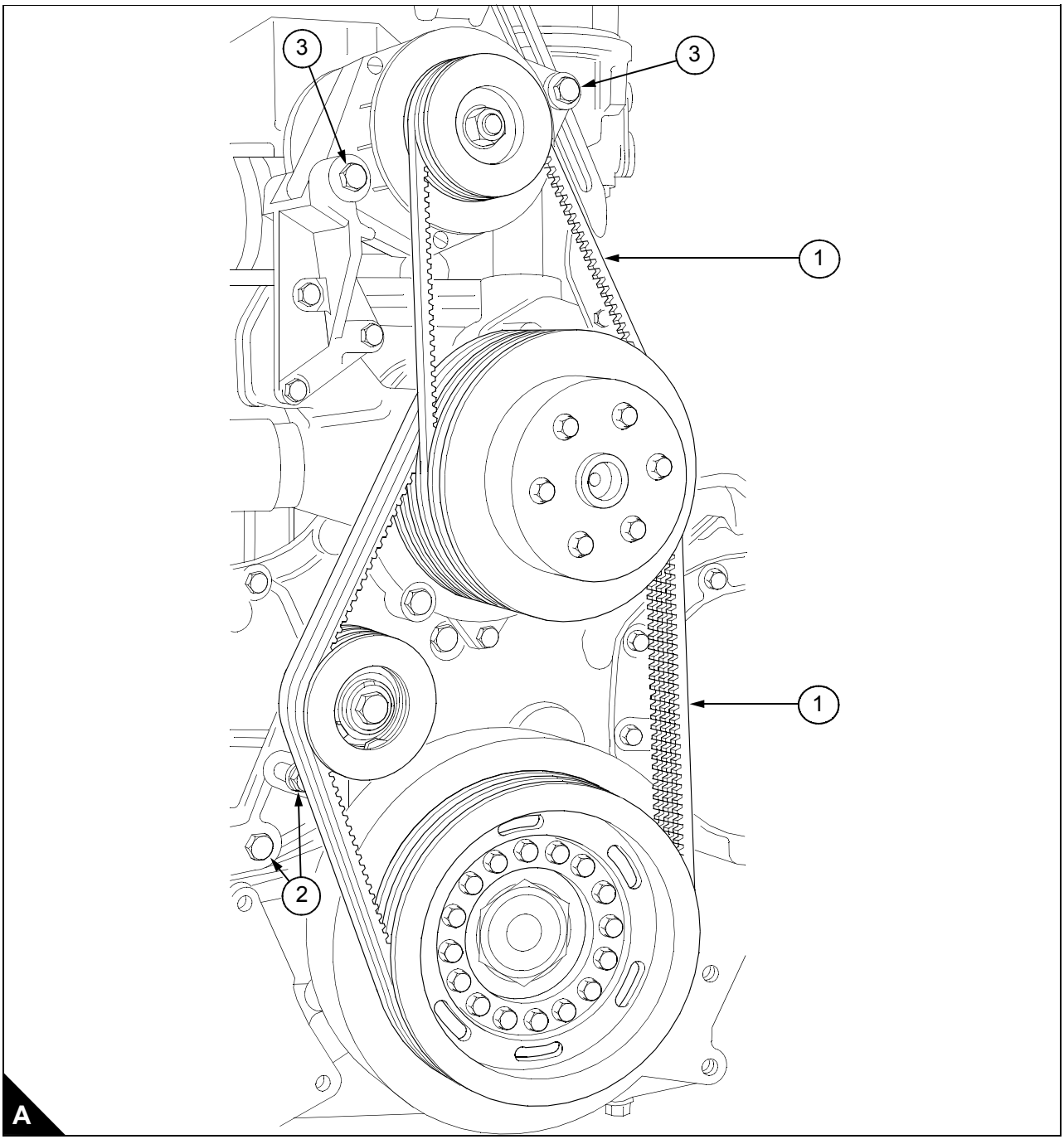
The correct belt deflection at this point should be 12 mm ($^1/_2$ in) under the following pressures:

**Fan belts**

- 254 mm (10 in) pulley centres: 6,3 to 7,25 kgf (14 to 16 lbf).
- 321 mm (12.625 in) pulley centres: 5 to 6 kgf (11 to 13 lbf).

**Alternator belt**

- All engines: 6,5 to 7,5 kgf (14.5 to 16.5 lbf).



## How to adjust the drive belts

**Coolant pump drive belts (where fitted)**

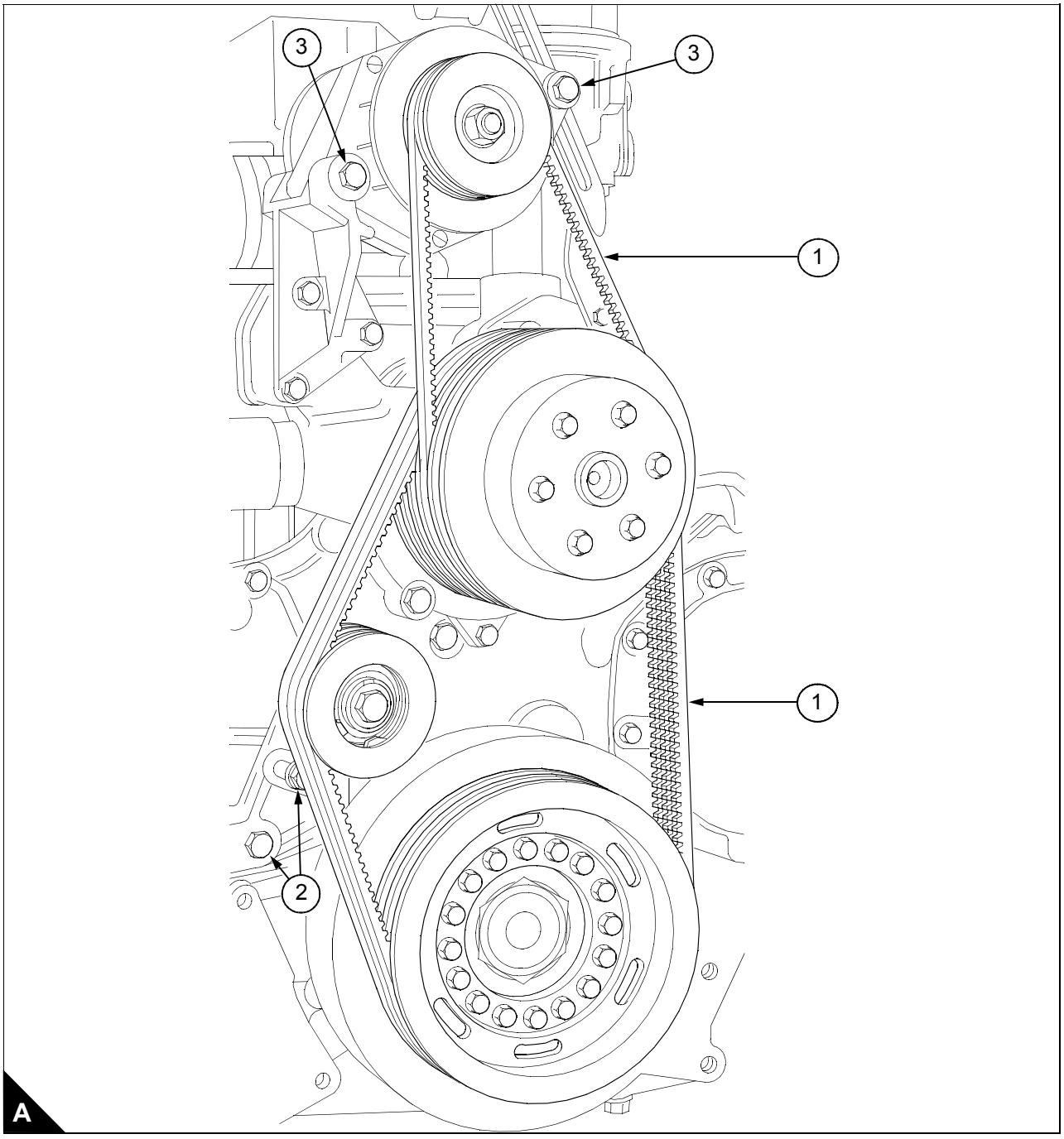
Slacken the belt tensioner securing and clamping bolts (A2); slide the tensioner until the correct belt tension is obtained (see "How to check the drive belts" on page 22) and tighten the two bolts.

**Alternator belt (where fitted)**

Slacken the fixing and adjusting bolts (A3) and position the alternator to obtain the correct belt tension (see "How to check the drive belts" on page 22). Tighten the two bolts.

Re-check the belts to ensure that the tension is still correct.

**Note:** Maximum life and efficiency of the belt will only be obtained if they are maintained at the correct tension.



## How to check the specific gravity of the coolant

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

**For mixtures which contain inhibited ethylene glycol:**

**1** Put a hydrometer, and a reliable thermometer, into the antifreeze mixture and check the readings on both instruments.

**2** Compare the readings obtained with the chart and adjust the strength of the mixture as necessary.

**For mixtures which contain inhibited propylene glycol:**

**1** Open the cover of the refractometer, check that the clear panel is clean and use a small syringe to apply a few drops of the coolant mixture to the clear panel.

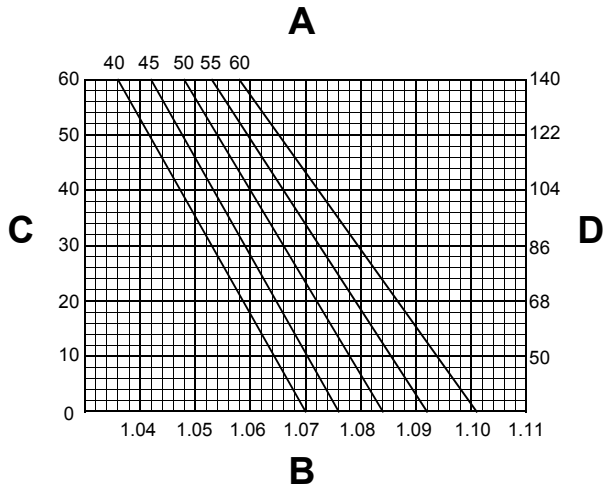
**2** Spread the coolant over the full area of the clear panel and close the cover. Hold the refractometer horizontal with the clear panel up and inspect the sample through the viewer.

**3** Compare the reading with the chart in the instructions; adjust the strength of the mixture as necessary.

***Caution:*** *The clear panel must be cleaned thoroughly before use. If some of the fluid which was tested earlier remains on the clear panel, the reading of the sample will be affected.*

Protection against frost is as follows:

| Antifreeze/water (% by volume) | Protection down to (°C) |
|---|---|
| 50/50 | -35 |
| 06/40 | -40 |




**Specific gravity chart**

**A** = Percentage anti-freeze by volume
**B** = Specific gravity
**C** = Mixture temperature in Centigrade
**D** = Mixture temperature in Fahrenheit

A

## How to check the pH value of the coolant

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

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

## How to renew the engine lubricating oil

Ensure that the engine is on level ground.

**1** Whilst the engine is warm remove the drain plug (A1, B1, C1, C2 or D1) and drain into a suitable container.

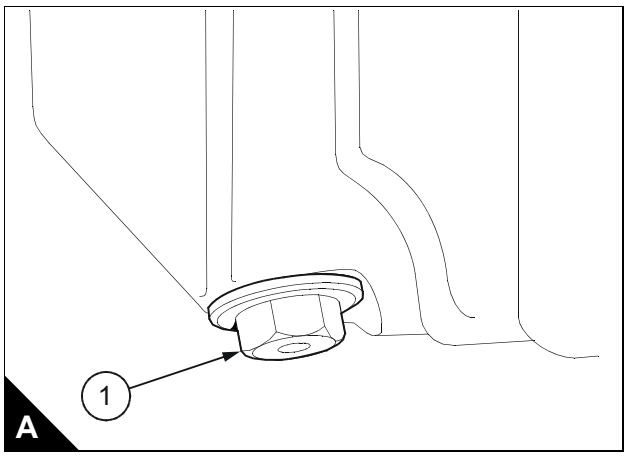
***Caution:*** *A thread insert is fitted to certain sumps. Inspect the thread to find which type is fitted to your engine.*

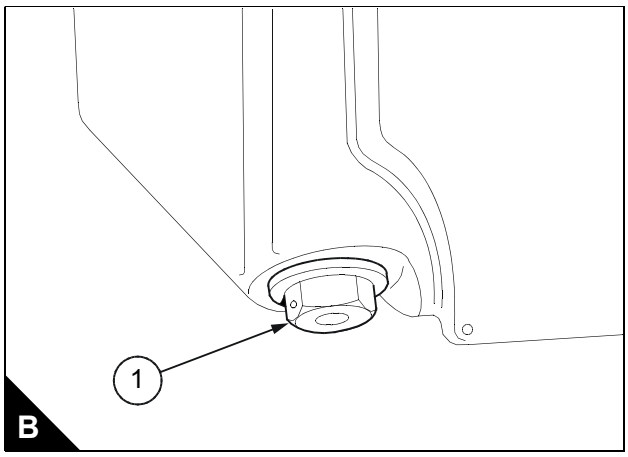
**2** Fit the drain plug and a new sealing washer and, according to the type of thread, proceed as follows:

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

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

**Note:** The drain plugs of engines manufactured from build line number 95200 have a $^{3}/_{4}$ BSP thread.

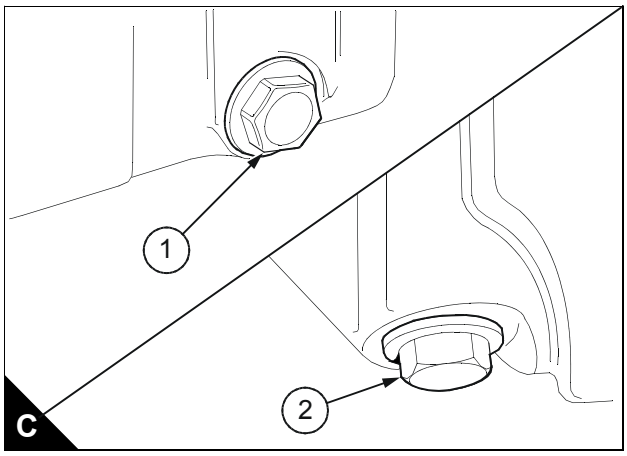


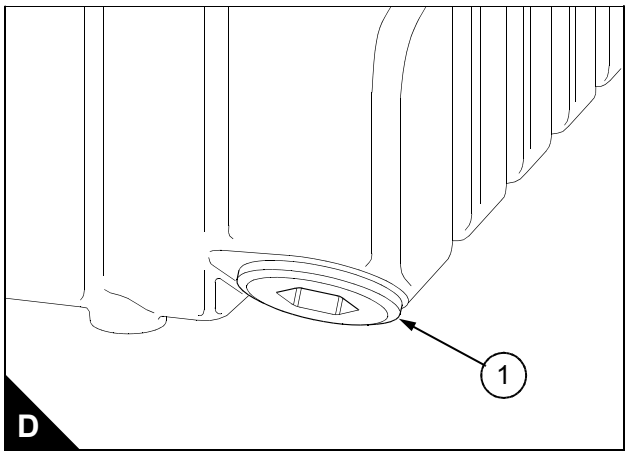




**Sump without a thread insert (C):** These plugs have a $^{3}/_{4}$ BSP thread. Use a spanner - size $^{15}/_{16}$ AF - to tighten the drain plug (C1 or C2) to a torque of 61 Nm (45 lbf ft).

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

***Caution:*** *Overtightening of the drain plug may result in damage to the threads in the sump. It is permissible to repair the thread in sump (B) by use of a $^{5}/_{8}$ inch BSP Helicoil insert.*




*Continued*

Ensure that the engine is on level ground.

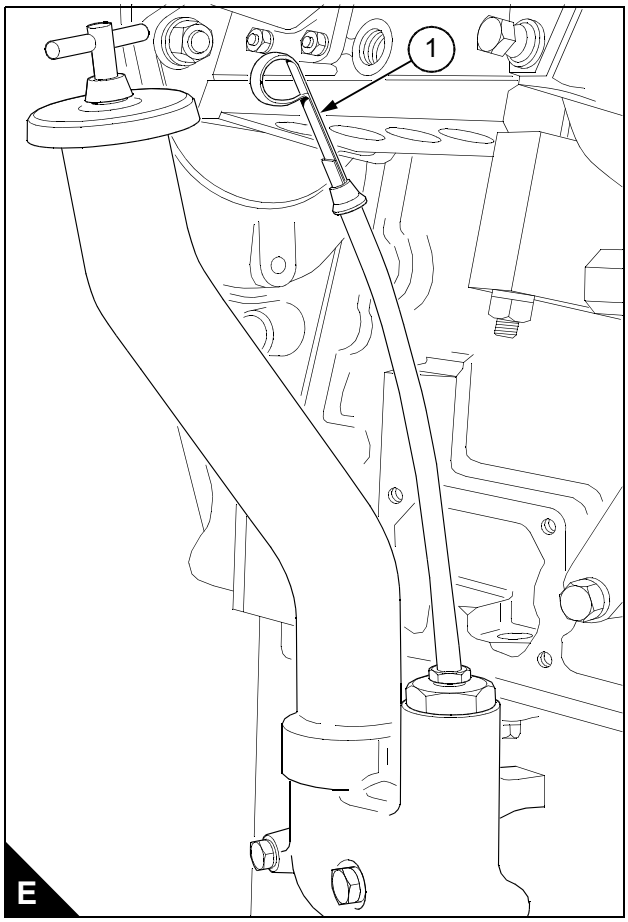
**3** Renew both of the oil filter canisters, see "How to renew the canisters of the oil filter" on page 28.

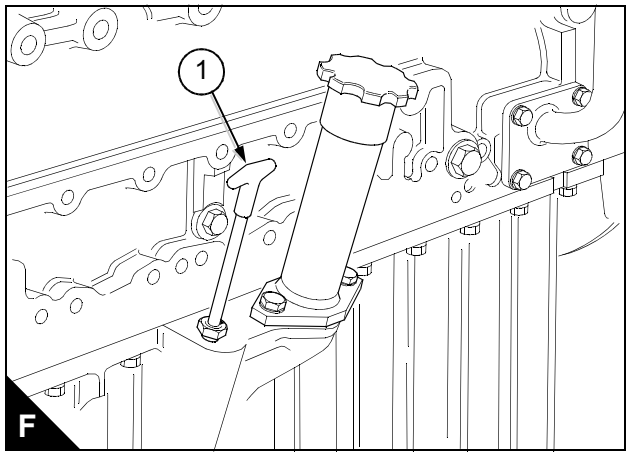
**4** Clean the area around the oil filler cap and remove the cap.

**5** Use a clean container and funnel and fill the engine to the H mark on the dipstick (E1 or F1) with a recommended grade of oil, see "Lubricating oil specification" on page 40.

***Caution:*** *Do not overfill.*

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



## How to renew the canisters of the oil filter

Twin expendable oil filter canisters are fitted to the filter header bracket which is an integral part of the heat exchanger casing, mounted at the front right side of the engine.

**1** Place a tray under the filters and unscrew each canister in turn using strap wrench 21825 825.

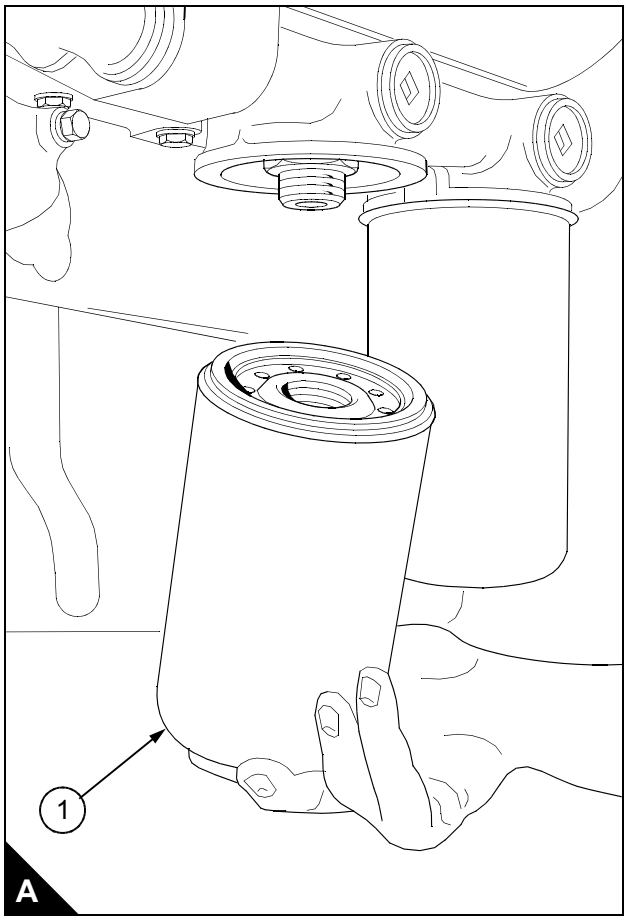
**2** Check that the seal rings are correctly fitted (A1) on the new canisters and clean the filter header bracket contact faces.

**3** Fill two new canisters with a clean approved grade of lubricating oil and apply a light smear to the sealing ring.

**4** Screw each canister into position until the sealing rings contact the face of the header and then a further $1^{1}/_{4}$ turns by hand.

***Caution:*** *Do not overtighten.*

**Note:** A non-adjustable valve fitted in the base of each canister allows unfiltered oil to circulate through the engine if a canister becomes choked and the pressure drop across it exceeds 102,96 kN/m$^2$ (15 lbf/in$^2$).



## Lubricating oil by-pass filter

### Description

Some engines are fitted with a by-pass filter. It is **not** an alternative. The filter must be serviced at the intervals specified for engine oils and main filter changes.

### To dismantle

**1** Clean off any dirt or debris from the area surrounding the filter.

**2** Unscrew the filter bowl (A2), remove and discard the rotor (A3).

**3** Remove the square section rubber ring (A4) from the filter bowl or housing.

### To assemble

**1** Clean all components.

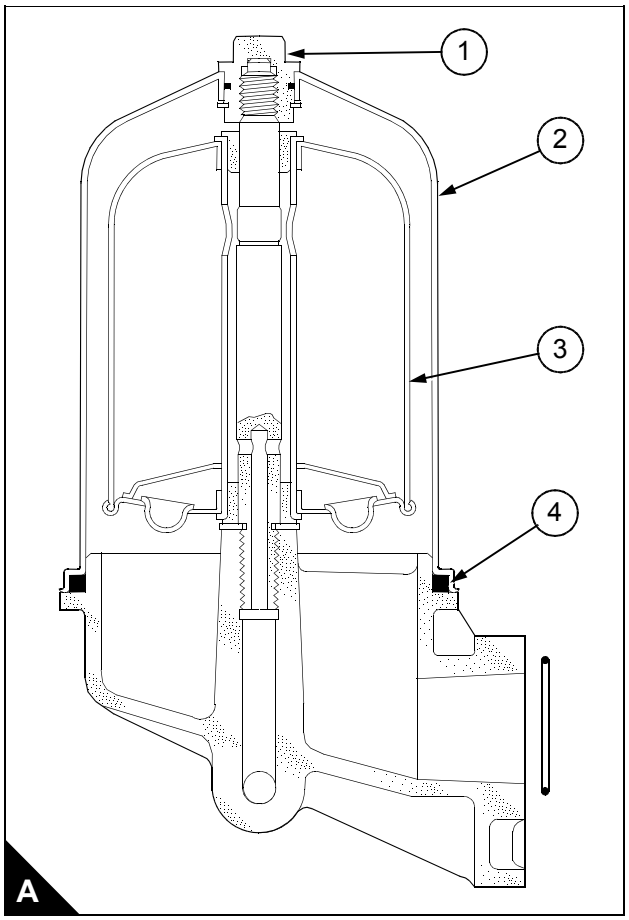
**2** Clean the seal recess in the bowl and wipe clean the seal face on the housing.

**3** Fit a new rubber seal over the seal face of the housing and apply a light smear of oil to the face of the seal.

**4** Assemble a new rotor to the spindle and check that it spins freely.

**5** Fit the bowl and tighten the securing nut (A1) to a torque loading of 20 Nm (15 lbf ft).

**6** When the engine is started, check the filter for leaks and rectify if necessary



## How to change the spark plugs

**1** Disconnect the spark plug leads and note the position of each to ensure that they are refitted to the correct location.

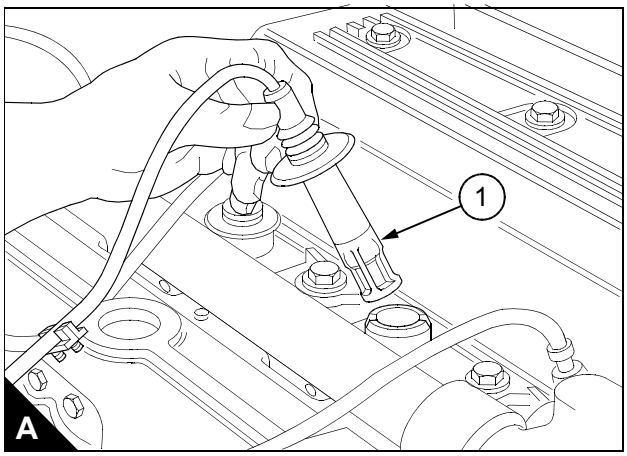
**2** Remove the spark plug extension (A1), unscrew the spark plug using the spanner provided or a 14 mm spark plug socket spanner of no more than 26 mm outside diameter. Clean or renew the spark plugs and set the spark plug gap to 0,30 mm (0.012 in).

**3** Fit the spark plugs and tighten to a torque of 30 Nm (22 lbf ft) or finger-tight and turn a further 90°.

**4** Insert the spark plug extension (A1) and ensure that it is attached firmly to the spark plug terminal. The spark plug extension forms part of the spark plug lead.

**5** Check that the spark plug leads are fitted in the correct sequence.

**Note:** The spark plug leads have a core of copper and are not suppressed. Suppression is accomplished by fitting a resistive spark plug and a resistor in the spark plug extension (A1). The spark plug extension and spark plug leads must be renewed as a set.



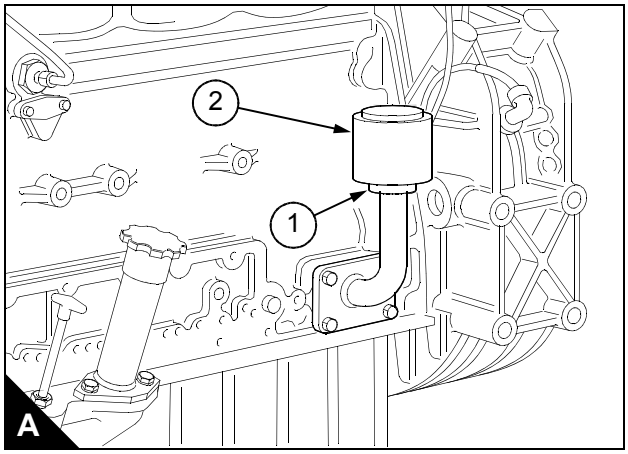
## How to renew the filter of the crankcase breather

**1** Ensure that the area around the breather filter (A2) is clean.

**2** Loosen the hose clip (A1), remove the air inlet filter (A2) and discard.

**3** Ensure that the pipe is clean and is free from restrictions.

**4** Fit carefully a new filter to the inlet pipe and tighten securely the hose clip (A1).



## How to clean the crankcase breather control valve

The crankcase breather control valve (A2) is generally maintenance free. If the lubricating oil consumption is high and also after an engine overhaul, the operation of the breather control valve must be checked and the assembly cleaned or renewed if necessary. Use the procedure which follows:

**1** Loosen the hose clips (A3) and slide the hose fully onto the manifold pipe. This will allow the control valve to be moved vertically.

**2** Push the rubber hose, on the valve-to-inlet manifold pipe, one way as far as it will go to allow the valve to be removed vertically.

**3** Loosen the clamp (A1).

**4** Remove carefully the breather control valve from the pipe. Ensure that it is removed vertically and not tilted in any direction.

**5** Ensure that inlet and outlet pipes (B1 and B3) are clean and free from debris.

**6** To clean a dirty breather control valve, wash thoroughly with diesel oil. Invert the ventilator valve and add diesel oil to the opening (B3) until clean diesel oil flows from the opening (B1). Drain thoroughly the control valve and leave for several hours to dry.

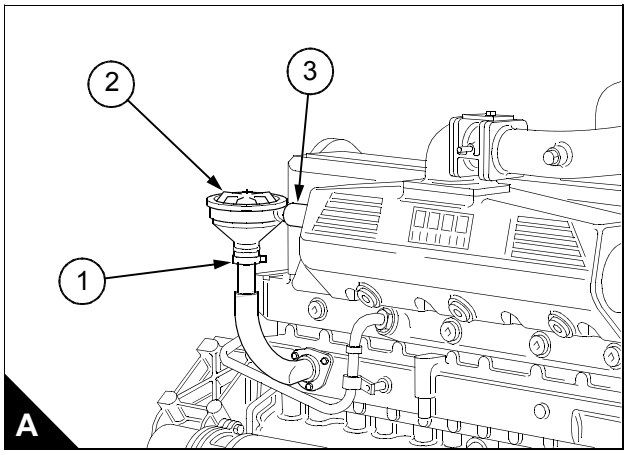
**7** Examine visually the rubber ‘O’ ring (B2) for damage and renew if necessary.

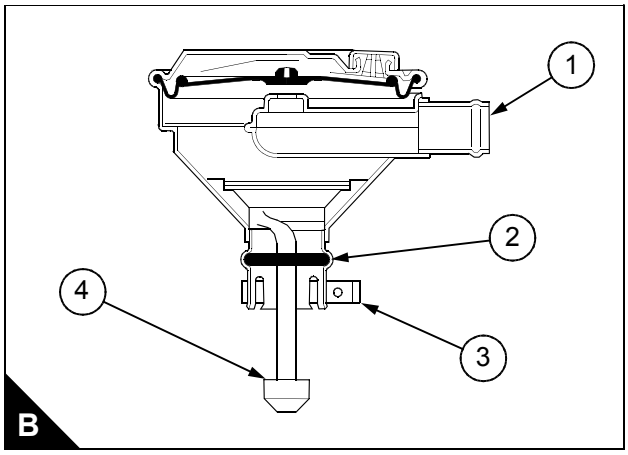
**8** Fill the oil pot (B4) with clean engine oil. Ensure that the control valve is kept upright and fit it carefully to its pipe.

**Note:** Breather control valves on naturally aspirated engines do not have the oil pot (B4).

**9** Align the outlet pipe (B1) with the pipe on the inlet manifold and tighten the clamp (A1).

**10** Return the rubber hose to its original position to connect the control valve to the inlet manifold. Tighten the hose clips (A3).



## How to check the tappet clearances

The tappet clearance is measured between the rocker lever and the top of the valve stem.

The tappet clearances are measured between the rocker levers and the tips of the valves (A). Check and adjust the tappet clearances in the sequence which follows, while the spark plugs are removed for service.

| Valves rocking on cylinder No | Check tappets on cylinder No |
|---|---|
| 6 | 1 |
| 3 | 4 |
| 5 | 2 |
| 1 | 6 |
| 4 | 3 |
| 2 | 5 |

Valves rocking means ‘inlet valve just opening’ and ‘exhaust valve just closing’.

**1** Remove the engine rocker covers.

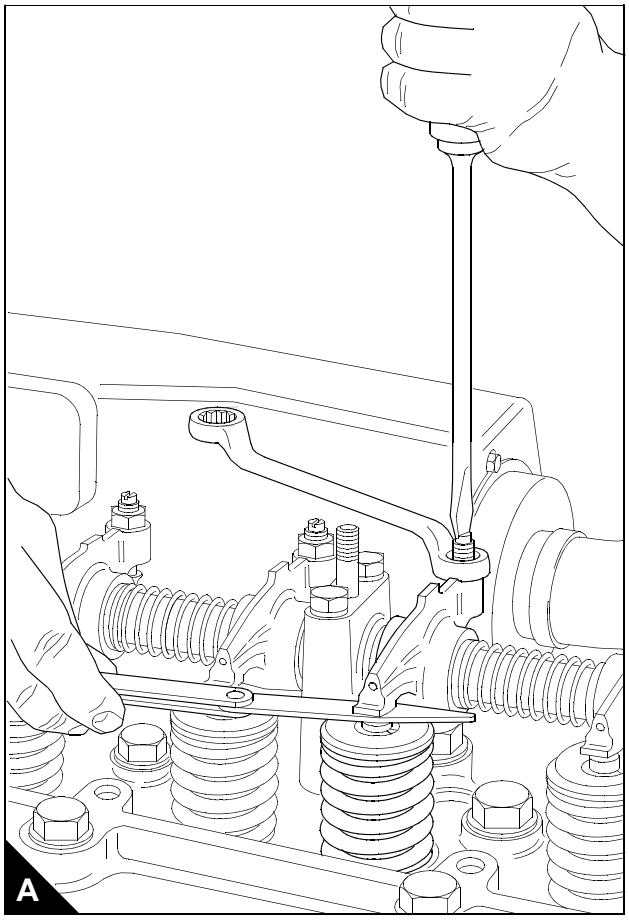
**2** Turn the engine in the normal direction of rotation until the valves on number 6 cylinder are ‘rocking'. Check and adjust the tappet clearances on number 1 cylinder to the correct clearance.

**3** Continue to rotate the engine and adjust the remaining tappets in the sequence given above.

**4** Refit the rocker covers.

**Tappet clearances:**

- Exhaust: 0,508 mm (0.020 in)
- Inlet: 0,254 mm (0.010



## How to drain the cooling system

It is recommended that the system is drained as soon as possible after the engine is stopped and before any deposits in the coolant have settled.

**1** Ensure that the engine is on level ground.

**2** Remove carefully the radiator filler cap, especially when the engine is hot.

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

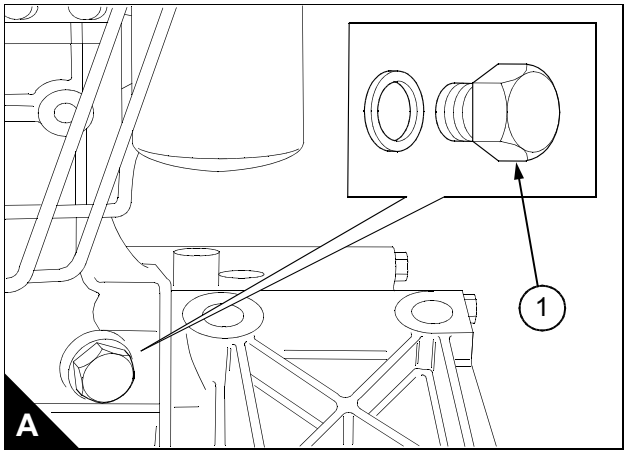
**3** Remove the coolant drain plug (A1) from the rear of the left side of the engine. Ensure that the drain hole is not restricted. Note that on some specifications there is an additional drain plug in the coolant pipe of the oil-to-coolant heat exchanger.

**4** To drain the radiator refer to the Equipment Manufacturer's Instruction Manual.

**5** Flush the system with clean water.

**6** Fit a new sealing washer onto the drain plug. Replace the engine drain plug (in both the engine and the heat exchanger pipe if fitted) and any items removed in accordance with the Instruction Manual as in step 4.

**7** Affix a 'coolant drained' label in a prominent position if the engine is not to be refilled immediately.



# 5

## Engine systems

### Ignition system - distributor type

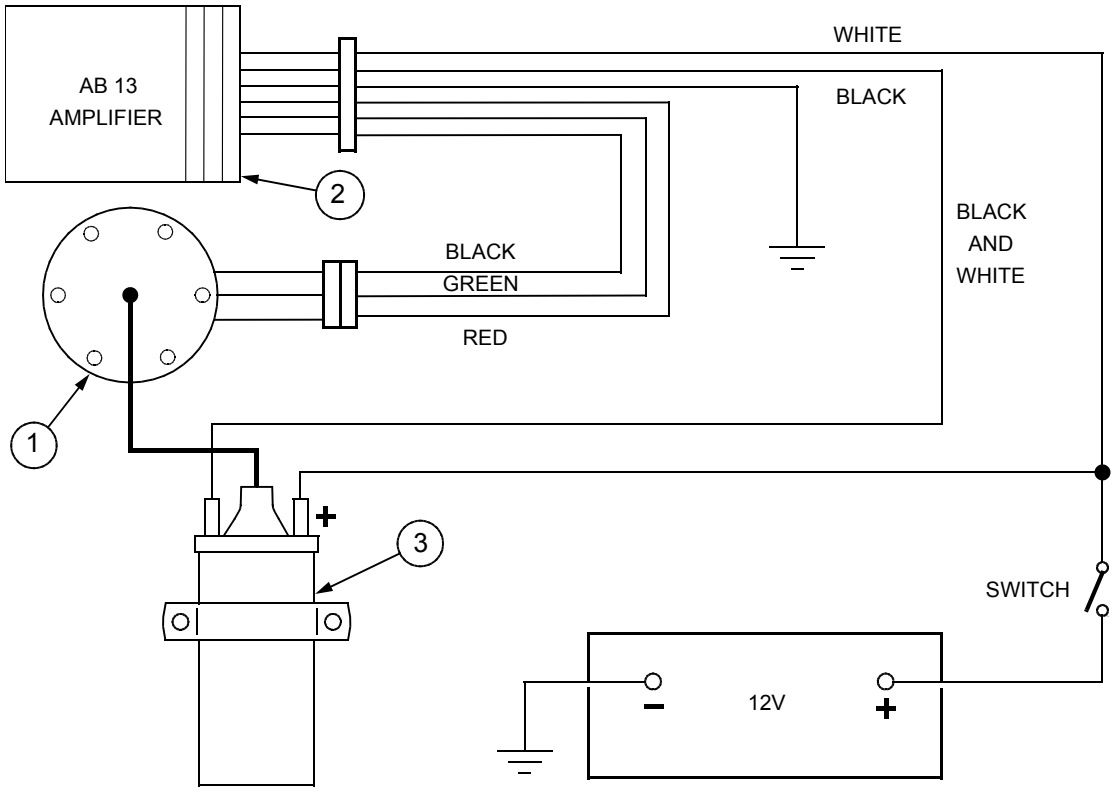
The Perkins 2006SI naturally aspirated spark ignited engine utilises a 12 volt, contactless, electronic distributor system. A Fairbanks Morse system is offered on later engines

The function of the distributor is to provide signals which are accurately timed relative to the position of the engine crankshaft.

The signals are produced by a ‘Hall effect' vane switch through which passes a slotted rotor vane. The distributor is driven at half engine speed and the number of slots on the rotor corresponds to the number of engine cylinders.

When a slot in the rotor vane passes through the vane switch, a signal is produced. These signals are fed to the amplifier/switching unit (A2) which by transistor action switches the supply to the low tension side of the ignition coil (A3).

Distribution of the high tension output produced from the coil is through a conventional rotor arm which forms the upper segment of the rotor vane.




A

**WIRING DIAGRAM FOR CONTACTLESS ELECTRONIC IGNITION**

## Ignition system - Fairbanks Morse type

The Perkins 2006TSI turbocharged, and later 2006SI naturally aspirated, spark ignited engine utilise a 24 volt Fairbanks Morse ignition system.

**Description**

The 24 volt battery is the source of the electrical power; the system is controlled by the Ignition Control Module (ICM)(A2).

Information is placed in the memory of the ICM by the engine manufacturer eg. the number of teeth on the starter ring, the number of cylinders, the firing interval, the start of the engine cycle.

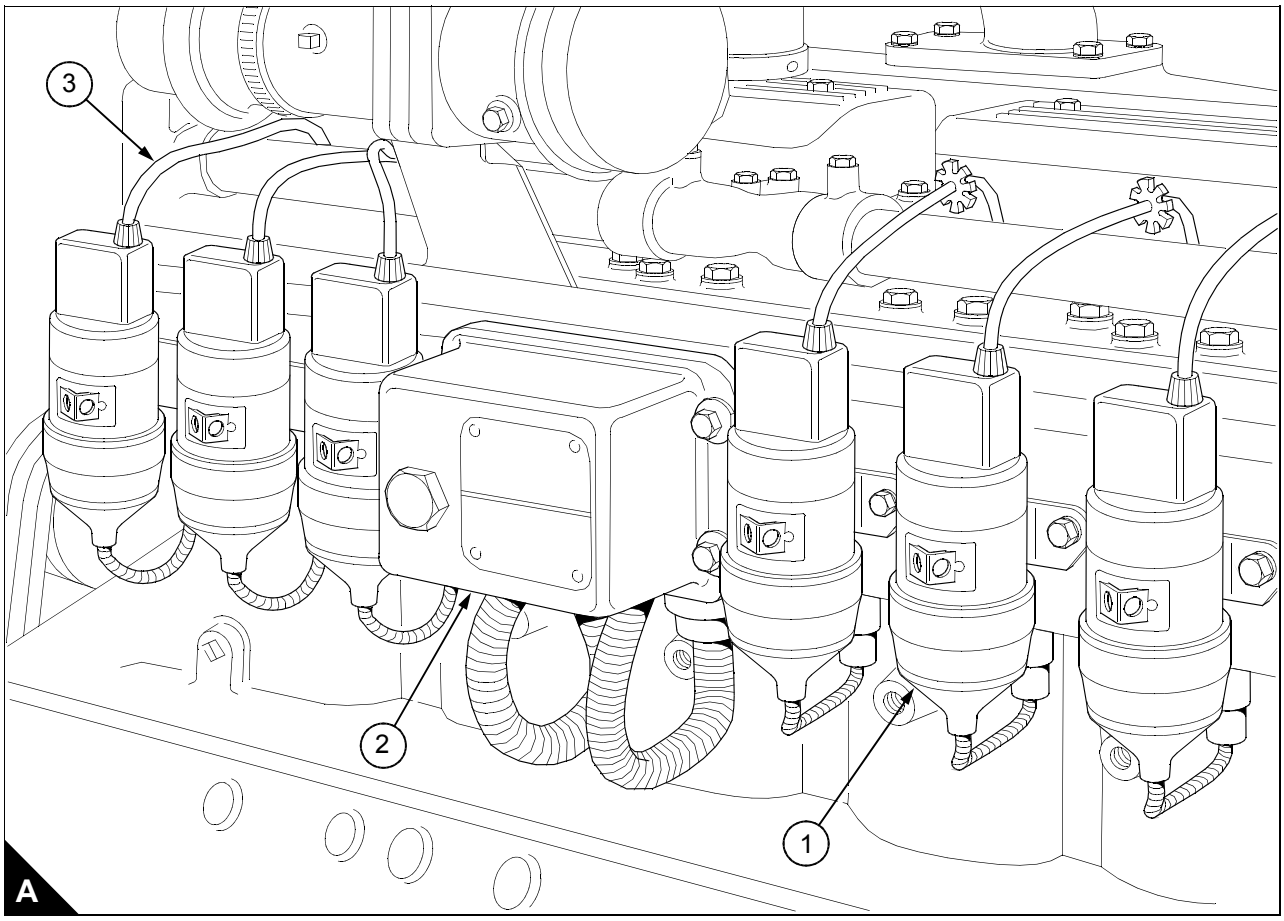
The teeth on the engine flywheel generate alternating current as they pass the sensor in the flywheel housing; this current is transmitted to the ICM.

A sensor, sited at the timing case, senses the reluctor pin attached to the camshaft; the sensor is supplied with 24 volt DC and the reluctor pin completes the circuit as it passes the sensor and

the 24 volt current is returned to the ICM thus indicating the start of a new cycle.

The ICM processes the information and transmits precision timed voltage in correct sequence to each coil (A1).

The coil increases the electrical voltage and transmits it along the high tension leads (A3) to the appropriate spark plug.



## Fuel system

### Introduction

To ensure safe and consistent operation of a gas powered spark ignited engine it is important to pay particular attention to the fuel supply system. In some locations gas engine installations are subject to mandatory requirements. Please discuss proposed installations with the appropriate authorities.

This chapter is intended as a guide to successful installation and cannot cover every possible hazard. It is the responsibility of the installers to consider and avoid possible hazardous conditions at any given installation.

In general these recommendations are based on the 'British Gas Code of Practice for Natural Gas Fuelled Spark Ignition Engines' - Publication IM/17. They will also apply to operation on other types of hydrocarbon gaseous fuels, ie. landfill, biogas and well-head gases. With these latter gases there may be additional requirements in terms of gas treatment, dual starting etc. which must be considered at the installation stage.

### Standard equipment

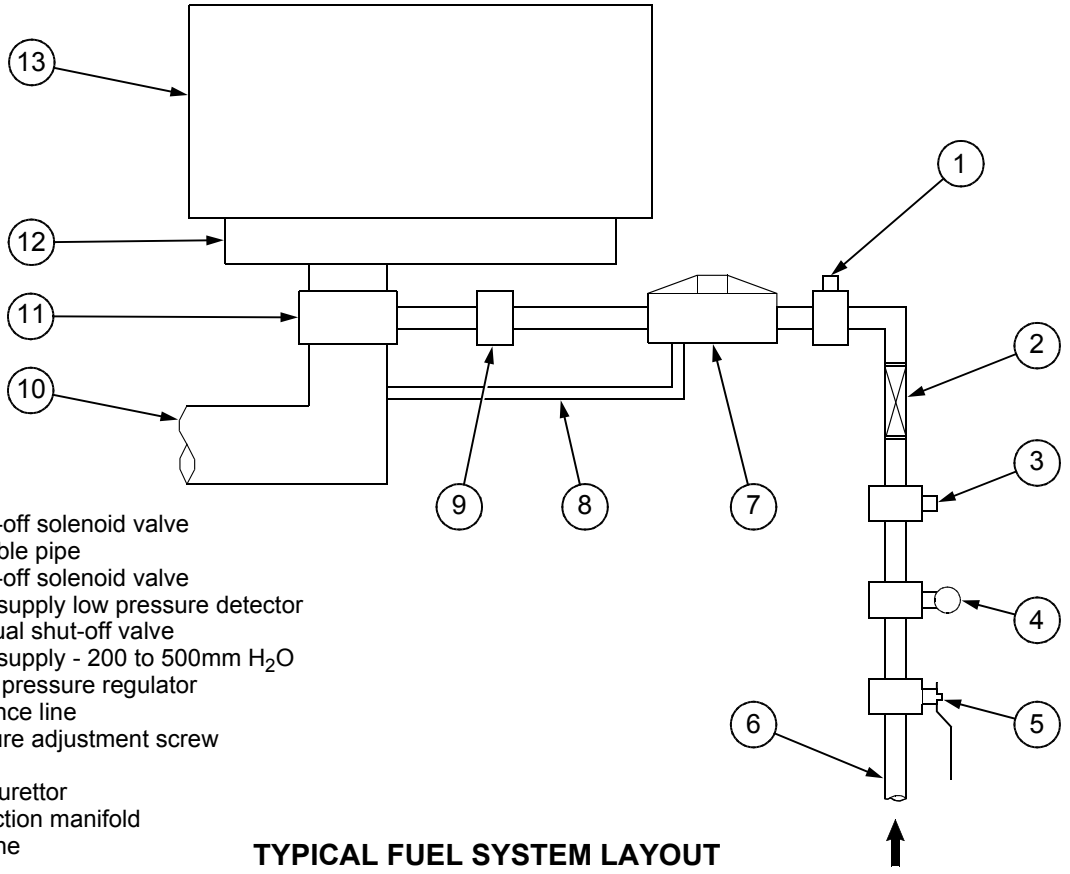
In their basic form Perkins spark ignited engines will be supplied fitted with a carburettor, the zero pressure regulator will be supplied but not fitted.

The purpose of the carburettor is to mix the fuel gas and air in the correct ratio and, in conjunction with the governor, control the flow of the air/fuel mixture to the engine cylinders.

The ratio of air to gas mixed by the carburettor is determined by the difference in pressure of air and gas supplied to the carburettor.

The air to gas pressure differential is maintained by the gas pressure regulator (A).

The function of the balance line on naturally aspirated engines is to allow the regulator to sense actual air inlet pressure. This prevents variations in air to fuel ratio due to air filter restriction in service.




**1** Shut-off solenoid valve
**2** Flexible pipe
**3** Shut-off solenoid valve
**4** Gas supply low pressure detector
**5** Manual shut-off valve
**6** Gas supply - 200 to 500mm $H_2O$
**7** Zero pressure regulator
**8** Balance line
**9** Mixture adjustment screw
**10** Air in
**11** Carburettor
**12** Induction manifold
**13** Engine

**A** **TYPICAL FUEL SYSTEM LAYOUT**

## Coolant

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

Mixtures containing methanol are not approved.

Anti-freeze mixtures supplied by most major chemical and oil companies are suitable, but the operator is responsible for obtaining

the manufacturer's assurance that the ethylene glycol or propylene glycol products they supply have an inhibitor performance level suitable for a multi-metal cooling system.

**2** If anti-freeze is not available, and there is no likelihood of ambient temperatures below 10 °C, then clean fresh ‘soft’ water may be used, treated with 1% by volume of PE(S)L inhibitor, in the cooling system. This proportion is the equivalent of 0,5 litre of inhibitor to 50 litres or 11 UK gallons of water. The inhibitor is available in bottles under Part No. OE 45350 (1,0 litre).

***Caution:*** *The use of any other product may cause serious problems in the cooling system, and the use of insufficiently inhibited coolant mixtures may lead to erosion and/or corrosion of aluminium or cast iron components in the system.*

## Condemnation levels for oil sample analysis

The following levels are intended as a guide for both operator and oil companies. In case of doubt, it should always be remembered that a change of oil is a very cheap alternative to an engine failure.

**Viscosity increase**

| SAE grade | Viscosity CSt at 100 °C | |
|---|---|---|
| | New oil | Used oil |
| 30 | 9.3 - 12.5 | 14.4 max |
| 40 | 12.5 - 16.3 | 19.0 max |

**Insolubles** % wt 0.3 micron filter - 1% max

**TBN and TAN** - For used oil analysis the ASTM D664 gives the most meaningful results. When the TBN has dropped to one third of the new oil value, the oil should be changed. When the TAN reading has increased to the same level as the used oil TBN reading, the oil should be changed.

**Oxidation and Nitration** - assessed by infra-red analysis. Limits to be advised by the individual oil company.

| Element | Limit max ppm | Comment |
|---|---|---|
| **Water** | 5000 | Above these limits indicates coolant leak into the engine. Source of leak needs to be rectified and the oil changed |
| **Glycol, sodium and boron** | 30 | |
| **Silicon** | 30 | Values in excess of 20 ppm usually indicate contamination of air intake system |
| **Iron** | 100 | |
| **Aluminium** | 20 | |
| **Chromium** | 10 | |
| **Molybdenum** | 10 | |
| **Copper** | 40 | On new engines, high levels of Cu, without high Pb, may indicate oil cooler washing and is not a potential problem |
| **Lead** | 20 | |
| **Tin** | 10 | |

## Lubricating oil specification

The following is a list of the products of oil companies who can offer the necessary oil sample analysis support, to ensure the successful lubrication of gas engines.

| Company | 2006SI Natural gas | 2006TSI Natural gas |
|---|---|---|
| Agip | Geum 30<br>Geum 40 | |
| BP | Energol ICDG 30<br>Energol ICDG 40 | |
| Caltex | RPM Gas Engine Oil<br>HDAX 30 and 40 | |
| Castrol | Castrol NG 30 | |
| Century | Centlube Supreme G30<br>Centlube Supreme G40 | |
| Chevron | Gas Engine Oil HDAX<br>SAE30 and SAE40 | |
| Esso | Essolube G30<br>Estor Super 15W/40<br>EHL SHPC40<br>Essolube PX 40 | EHL SHPC40 |
| Kuwait | Q8 EL-3396 SAE40 | |
| Millers | Millgas 30<br>Millgas 40 | |
| Mobil | Pegasus 480 SAE40<br>Pegasus 1 | Pegasus 480 SAE40<br>Pegasus 1 |
| Morris | Ring-Free NG30 | |
| Shell | Mysella T 30<br>PAD 5547 | |
| Texaco | Geotex HD 30<br>Geotex HD 40 | |

**Note:** It is explicit in the Perkins Engines Company Limited, Shrewsbury, guarantee that an engine must be operated with approved fuel, lubricant and coolant, and maintained in accordance with the engine service schedule.

# 6

# Fault diagnosis

## Problems and possible causes

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

## Code list of possible causes

**1** Battery capacity low
**2** Bad electrical connections
**3** Fault in the starter motor
**4** Wrong grade of lubricating oil
**5** The starter motor turns the engine too slowly
**6** Gas tap off
**7** Gas solenoid inoperative
**8** Zero Pressure Regulator needs adjustment
**9** Throttle is closed
**10** Insufficient gas pressure (see 8)
**11** Restriction in the air filter
**12** Insufficient gas flow (see 8)
**13** Faulty spark plugs
**14** Distributor cap faulty (if fitted)
**15** Coil(s) faulty
**16** Damaged or "tracking" across high tension leads
**17** Faulty rotor vane (if fitted)
**18** Restricted movement of the engine speed control
**19** Restriction in the exhaust pipe
**20** The engine temperature is too high
**21** The engine temperature is too low
**22** Wrong tappet clearances
**23** Oil has entered air filter from the breather system of the crankcase
**24** Not enough lubricating oil in the sump
**25** Fault in gauge
**26** Dirty lubricating oil filter element
**27** Damage to fan or raw water pump (if fitted)
**28** Fault in engine mounting or flywheel housing
**29** Too much lubricating oil in the sump
**30** Damage to fan or restriction in passages of heat exchanger if fitted
**31** Restriction in breather pipe
**32** Not enough coolant in system
**33** Mixture too rich
**34** Mixture too lean
**35** Incorrect quality of gas
**36** Regulator diaphragm faulty
**37** Incorrect valve timing
**38** Bad compression
**39** Leakage past the cylinder head gasket
**40** Valves are not free
**41** Air locks in cooling system
**42** Worn cylinder bores
**43** Leakage past the valves and seats
**44** Piston rings are not free or are worn or broken
**45** Valve stems and/or guides are worn
**46** Crankshaft bearings are worn or damaged

**47** Lubricating oil pump is worn
**48** Relief valve is not free to close
**49** Relief valve is not free to open
**50** Relief valve spring is broken
**51** Fault in suction pipe of lubricating oil pump
**52** Piston damage
**53** Wrong piston fitted
**54** Flywheel housing or flywheel is not aligned correctly
**55** Fault in thermostat or the engine thermostat is of wrong type
**56** Restriction in engine coolant passages
**57** Fault in coolant pump
**58** Damage to valve stem oil seals
**59** Restriction in sump strainer
**60** Valve spring is broken

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