

SERVICE MANUAL

COMPACT EXCAVATOR
8026 CTS, JCB 30PLUS

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Foreword

The Operator's Manual


You and others can be killed or seriously injured if you operate or maintain the machine without first studying the Operator's Manual. You must understand and follow the instructions in the Operator's Manual. If you do not understand anything, ask your employer or JCB dealer to explain it.

Do not operate the machine without an Operator's Manual, or if there is anything on the machine you do not understand.

Treat the Operator's Manual as part of the machine. Keep it clean and in good condition. Replace the Operator's Manual immediately if it is lost, damaged or becomes unreadable.

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Introduction

(For: Perkins 400 Series)

This section contains information about the complete engine assembly. For specific engine technical information refer to the technical data section.

Make sure that the correct engine service tools, consumables and torque figures are used when you perform service procedures.

Replacement of oil seals, gaskets, etc., and any component that show signs of wear or damage, is expected as a matter of course.

It is expected that components will be cleaned and lubricated where required, and that any opened hose or pipe connections will be blanked to prevent excessive loss of hydraulic fluid, engine oil and ingress of dirt.

Basic Description

The Perkins 400 series engines are indirect injection engines. The engines are controlled with a mechanically actuated fuel injection pump. The engine cylinders are arranged in-line. The cylinder head assembly has one inlet valve and one exhaust valve for each cylinder. Each cylinder valve has a single valve spring.

The crankshaft for the engine has main bearing journals. End play is controlled by the thrust washers that are located on the rear main bearing.

The timing gears are stamped with timing marks in order to ensure the correct assembly of the gears. When the No. 1 piston is at top centre compression stroke, the teeth that are stamped on the crankshaft gear and the camshaft gear will be in alignment with the idler gear.

The crankshaft gear turns the idler gear which then turns the camshaft gear and the gear for the engine oil pump.

The fuel injection pump is mounted in the crankcase. The fuel injection pump is operated by lobes on the camshaft. The fuel transfer pump is located on the right hand side of the crankcase. The fuel transfer pump is also operated by lobes on the camshaft.

The fuel injection pump conforms to requirements for emissions. If any adjustments to the fuel injection pump timing and high idle are required you must refer to a Perkins distributor or a Perkins dealer. Some fuel injection pumps have mechanical governors that control the engine rpm. Some fuel injection pumps have a governor that is electrically controlled.

A gerotor oil pump is located in the centre of the idler gear. The engine oil pump sends lubricating oil to the main oil gallery through a pressure relief valve and an engine oil filter. The rocker arms receive pressurized oil through an externally located oil line that runs from the main oil gallery to the cylinder head.

Coolant from the bottom of the radiator passes through the belt driven centrifugal cooling pump. The coolant is cooled by the radiator and the temperature is regulated by a water temperature regulator.

Engine efficiency, efficiency of emission controls, and engine performance depend on adherence to correct operation and maintenance recommendations. Engine performance and efficiency also depend on the use of recommended fuels, lubrication oils, and coolants. Refer to the Maintenance Schedules (PIL 78-24).

Health and Safety

Hot Components

Touching hot surfaces can burn skin. The engine and machine components will be hot after the unit has been running. Allow the engine and components to cool before servicing the unit.

Turning the Engine

Do not try to turn the engine by pulling the fan or fan belt. This could cause injury or premature component failure.

Notice: *The engine and other components could be damaged by high pressure washing systems. Special precautions must be taken if the machine is to be washed using a high pressure system. Make sure that the alternator, starter motor and any other electrical components are shielded and not directly cleaned by the high pressure cleaning system. Do not aim the water jet directly at bearings, oil seals or the engine air induction system.*

WARNING! *To bleed the injectors you must turn the engine. When the engine is turning, there are parts rotating in the engine compartment. Before starting this job make sure that you have no loose clothing (cuffs, ties etc) which could get caught in rotating parts. When the engine is turning, keep clear of rotating parts.*

Notice: *Clean the engine before you start engine maintenance. Obey the correct procedures. Contamination of the fuel system will cause damage and possible failure of the engine.*

Notice: *Do not exceed the correct level of engine oil in the sump. If there is too much engine oil, the excess must be drained to the correct level. An excess of engine oil could cause the engine speed to increase rapidly without control.*

WARNING! *The engine has exposed rotating parts. Switch off the engine before working in the engine compartment. Do not use the machine with the engine cover open.*

WARNING! *Hot oil and engine components can burn you. Make sure the engine is cool before doing this job. Used engine crankcase lubricants contain harmful contaminants. In laboratory tests it was shown that used engine oils can cause skin cancer.*

Notice: *A drive belt that is loose can cause damage to itself and/or other engine parts.*

WARNING! *Do not open the high pressure fuel system with the engine running. Engine operation causes high fuel pressure. High pressure fuel spray can cause serious injury or death.*

CAUTION! *It is illegal to pollute drains, sewers or the ground. Clean up all spilt fluids and/or lubricants. Used fluids and/or lubricants, filters and contaminated materials must be disposed of in*

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Technical Data

Table 18.

Description					
Engine model	HL 403C-15 (Tier 2), GL 403D-15 (Tier 3)	GK 403D-15 (Tier 3)	HL 403C-17 (Tier 2), GK 403D-17 (Tier 3),	HL 403C-11 (Tier 2), GJ 403D-11 (Tier 3), EJ 403F-11 (T4F)	GH 403D-07 (Tier 3)
Type	Vertical in-line, 3 cylinder, normally aspirated, 4 stroke, water cooled diesel.	Vertical in-line, 3 cylinder, normally aspirated, 4 stroke, water cooled diesel.	Vertical in-line, 3 cylinder, normally aspirated, 4 stroke, water cooled diesel.	Vertical in-line, 3 cylinder, normally aspirated, 4 stroke, water cooled diesel.	Vertical in-line, 3 cylinder, normally aspirated, 4 stroke, water cooled diesel.
Weight (dry)	154kg	154kg	160kg	87kg	71kg
Number of cylinders	3	3	3	3	3
Nominal bore size	88mm	88mm	88mm	77mm	67mm
Stroke	90mm	90mm	100mm	81mm	72mm
Combustion Cycle	4-stroke	4-stroke	4-stroke	4-stroke	4-stroke
Firing order	1-2-3	1-2-3	1-2-3	1-2-3	1-2-3
Compression ratio	22.5:1	22.5:1	23:1	23:1	23.5:1
Swept volume	1496 cm ³	1496 cm ³	1663 cm ³	1131 cm ³	762 cm ³
Valve clearance (cold)	0.2mm	0.2mm	0.2mm	0.2mm	0.2mm
Idling speed	1050 RPM (Revolutions Per Minute)	1050 RPM	1050 RPM	1325 RPM	
Maximum no-load speed	2420 RPM	2250 RPM	2592 RPM	2450 RPM	
Compression pressure	29.4bar (426.1psi) at 250 RPM	29.4bar (426.1psi) at 250 RPM	29.4bar (426.1psi) at 250 RPM		
Power output	20.9kW at 2200 RPM	18.4kW at 2100 RPM	29.4kW at 2400 RPM	13.7kW at 2200 RPM (Tier 2), 14.6kW at 2200 RPM (Tier 3), 14.4kW at 2200 RPM (T4F)	12.2kW at 2800 RPM

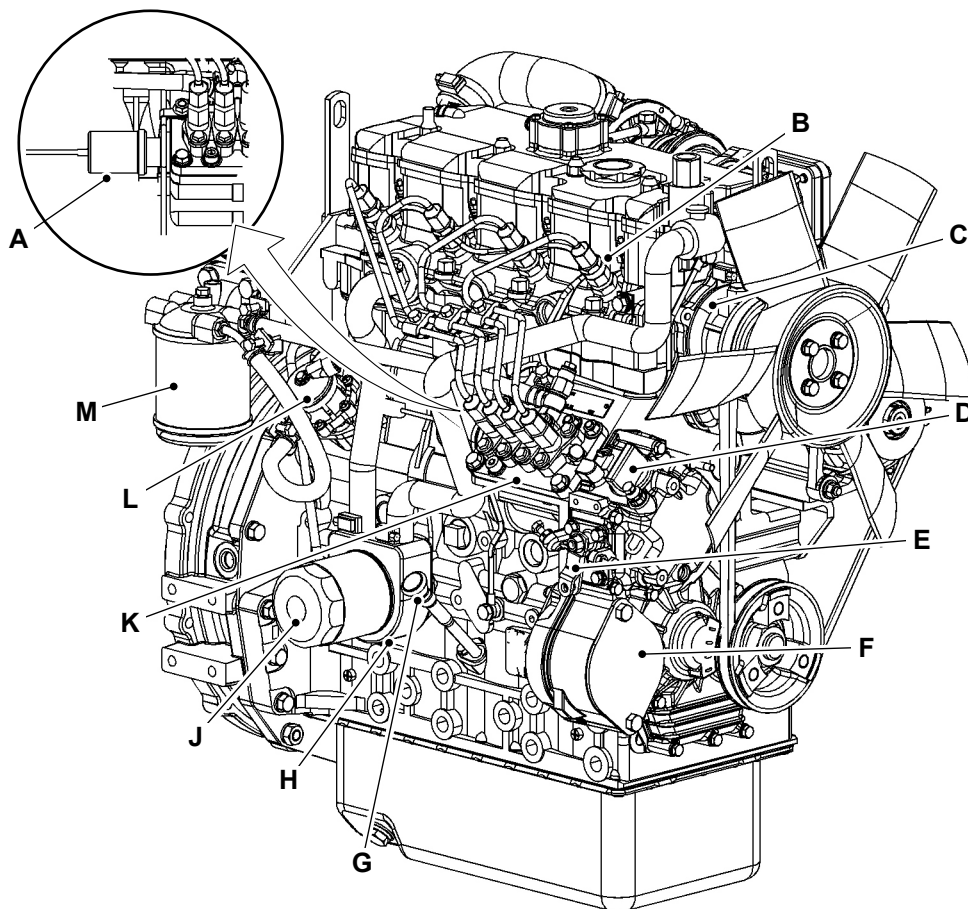
Component Identification

(For: Perkins 400 Series)

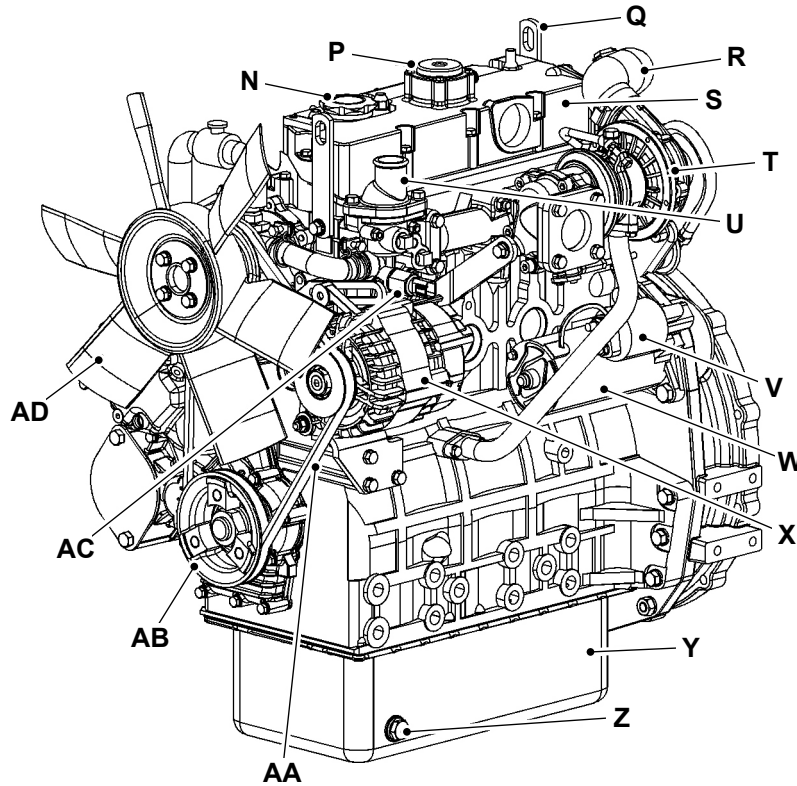
External

The following identifies the main components of a typical engine assembly visible from the exterior. Some variants may differ in detail.

Figure 75. Front and right side view



- | | |
|---------------------------------|--|
| A Fuel shutoff solenoid | B Number one fuel injector |
| C Water pump | D Lower engine oil filler cap |
| E Throttle lever | F Cover plate for the accessory drive |
| G Engine oil level gauge | H Engine oil cooler |
| J Engine oil filter | K Fuel injection pump |
| L Transfer pump | M Fuel filter |

Figure 76. Front and left side view


- | | |
|--|----------------------------------|
| N Top engine oil filler cap | P Crankcase breather |
| Q Rear Lifting eye | R Air inlet elbow |
| S Valve mechanism cover | T Turbocharger |
| U Water temperature regulator housing | V Starting motor solenoid |
| W Electric starting motor | X Alternator |
| Y Engine oil pan | Z Engine oil drain plug |
| AA Fan drive belt | AB Crankshaft pulley |
| AC Coolant temperature switch | AD Cooling fan |

Drain and Fill

(For: Perkins 400 Series)

Oil

Oil is toxic. If you swallow any oil, do not induce vomiting, seek medical advice. Used engine oil contains harmful contaminants which can cause skin cancer. Do not handle used engine oil more than necessary. Always use barrier cream or wear gloves to prevent skin contact. Wash skin contaminated with oil thoroughly in warm soapy water. Do not use petrol, diesel fuel or paraffin to clean your skin.

WARNING! Hot oil and engine components can burn you. Make sure the engine is cool before doing this job. Used engine crankcase lubricants contain harmful contaminants. In laboratory tests it was shown that used engine oils can cause skin cancer.

CAUTION! Keep your face away from the drain hole when removing the drain plug.

CAUTION! The oil filter canister will contain some oil which could spill out when you remove the canister.

CAUTION! Oil will gush from the hole when the drain plug is removed. Keep to one side when you remove the plug.

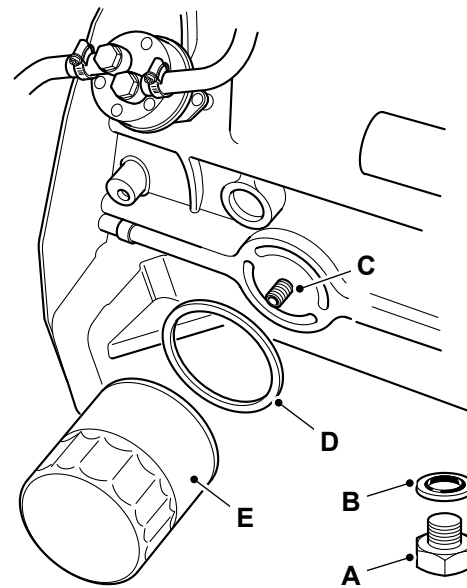
Drain

Engine oil replacement must be completed in accordance with the service schedules. Failure to replace the oil replacement at the recommended interval could cause serious engine failure.

Drain the oil when the engine is warm as contaminants held in suspension will then be drained with the oil.

1. Make the machine safe. Refer to (PIL 01-03).
2. Get access to the engine.
3. Place a container of suitable size beneath the drain plug.
4. Remove the filter cap.
5. Remove the oil filler canister. If necessary use a chain or strap wrench.
6. Remove the oil dipstick.
7. Put a suitable container beneath the drain plug.
8. Remove the oil sump drain plug and O-ring from both sides of the oil sump.
9. Drain the engine oil.

Figure 77.



- A Drain plug
- B O-ring
- C Filter mounting face
- D Seal
- E Filter canister

Fill

1. Clean and install the drain plug with a new O-ring.
2. Tighten the plug to the correct torque value.
3. Through one of the filler points, fill the engine with the recommended oil to the MAX mark on the dipstick. The oil must be added slowly.
4. Wipe off any spilled oil.
5. Apply a thin layer of oil around the seal on the filter canister.
6. Install the filler canister. Tighten the filter canister with hand then an additional one quarter turn.
7. Install the filter cap.
8. Operate the engine, until the oil pressure low warning light has extinguished.
9. Check for oil leakage.
10. When the oil has cooled, check the oil level again, and if necessary top up with clean engine oil.

Table 30. Torque Values

Item	Description	Nm
A	Drain plug	35

Clean

▲ Notice: Clean the engine before you start engine maintenance. Obey the correct procedures. Contamination of the fuel system will cause damage and possible failure of the engine.

Notice: The engine and other components could be damaged by high pressure washing systems. Special precautions must be taken if the machine is to be washed using a high pressure system.

Make sure that the alternator, starter motor and any other electrical components are shielded and not directly cleaned by the high pressure cleaning system. Do not aim the water jet directly at bearings, oil seals or the engine air induction system.

Before carrying out any service procedures that require components to be removed, the engine must be properly cleaned.

Cleaning must be carried out either in the area of components to be removed or, in the case of major work, or work on the fuel system, the whole engine and surrounding machine must be cleaned.

Stop the engine and allow it to cool for at least one hour. DO NOT attempt to clean any part of the engine while it is running.

1. Make sure that the electrical system is isolated.
2. Make sure that all electrical connectors are correctly connected. If connectors are open install the correct caps or seal with water proof tape.
3. Cover the alternator with a plastic bag to prevent water ingress.
4. Seal the engine air intake, exhaust and breather system.
5. Make sure that the oil filler caps and dipstick are correctly installed.
6. Use a low pressure water jet and brush to soak off mud or dirt.
7. Apply an approved cleaning and degreasing agent with a brush. Obey the manufacturers instructions.
8. Use a pressure washer to remove the soft dirt and oil. Important: DO NOT aim the water jet directly at oil seals or electrical and electronic components such as the engine electronic control unit (ECU), alternator or fuel injectors. DO NOT place the jet nozzle closer than 600mm (24in) to any part of the engine.

9. When the pressure washing is complete, move the machine away from the wash area, or alternatively, clean away the material washed from the machine.

10. Before working on specific areas of the engine, use a compressed air jet to dry off any moisture. When the area is dry, use a soft clean brush to remove any sand or grit particles that remain.

11. When removing components, be aware of any dirt or debris that may be exposed. Cover any open ports and clean away the deposits before proceeding.

Additional cleaning must be carried out prior to working on the high pressure fuel system. Refer to Fuel System, General, Clean (PIL 18-00).

Check (Leaks)

(For: Perkins 400 Series)

The walk-around inspections should be performed before starting the machine. It can help to prevent machine damage and ensure your safety. A walk-around inspection should only take a few minutes. When the time is taken to perform these checks, costly repairs and accidents can be avoided.

Inspect the engine for leaks and for loose connections:

1. Do a thorough inspection of the engine compartment before starting the engine.
2. Look for the following items and do the repair as necessary.
 - 2.1. Oil leaks.
 - 2.2. Coolant leaks.
 - 2.3. Loose bolts.
 - 2.4. Worn belts.
 - 2.5. Loose connections.
 - 2.6. Build up of dirt.
3. Make sure that the guards are in the correct place. Repair the damaged guards or replace the missing guards, if any.
4. Wipe all the caps and the plugs before the engine is serviced to reduce the chances of system contamination.
 - 4.1. If any leaks are found, clean up the fluid.
 - 4.2. Find the source and correct the leak.
 - 4.3. If leaking is suspected, check the fluid levels more often than recommended until the leak is found or fixed, or until the suspicion of a leak is proved to be unwarranted.
 - 4.4. Make a note that accumulated grease and/or oil on an engine is a fire hazard. Remove the accumulated grease and oil.
5. Make sure that the cooling system hoses are correctly clamped and the cooling system hoses are tight. Check for leaks. Check the condition of all pipes. Refer to (PIL 21-00).
6. Inspect the cooling pump for coolant leaks. Refer to (PIL 21-09).
7. Inspect the lubrication system for leaks at the front oil seal, the rear oil seal, the oil sump, the oil filters and the rocker cover.
8. Inspect the fuel system for leaks. Look for loose fuel line clamps and/or tie-wraps. Refer to (PIL 18-00).
9. Inspect the piping for the air intake system and the elbows for cracks and for loose clamps. Refer to (PIL 15-24).
10. Make sure that the hoses and the tubes are not contacting other hoses, tubes, wiring harnesses, etc.
11. Inspect the engine drive belt for cracks, breaks or other damage. Refer to (PIL 15-18).
 - 11.1. For applications that require multiple drive belts, replace the belts in matched sets. Replacing only one belt of a matched set will cause the new belt to carry more load because the older belt is stretched. The additional load on the new belt could cause the new belt to break.
12. Drain the water and the sediment from the fuel tank on a daily basis in order to make sure that only clean fuel enters the fuel system.
13. Inspect the wiring and the wiring harnesses for loose connections and for worn wires or frayed wires. Refer to (PIL 33-12).
14. Inspect the ground/earth strap for a good connection and for good condition.
15. Disconnect any battery chargers that are not protected against the current drain of the starter motor. Check the condition and the electrolyte level of the batteries, unless the engine is equipped with a maintenance free battery. Refer to (PIL 33-03).
16. Check the condition of the gauges. Replace any gauges that are cracked. Replace any gauge that cannot be calibrated.

Check (Pressure)

(For: Perkins 400 Series)

Special Tools

Description	Part No.	Qty.
Pressure Gauge (0-40 Bar)	892/00278	1
Digital Hydraulic Pressure Test Kit	998/11051	1

Compression test

Important: Compression tests should only be used to compare pressures between cylinders of an engine. If one or more cylinders vary more than 3.5bar (50.7psi) then those cylinders may be damaged. The cylinder compression test should not be the only test for determining the condition of an engine.

The following conditions can affect the result of the cylinder compression test, make sure you check the following points before starting the test:

- The battery is in good condition.
 - The battery is fully charged.
 - The starter motor operates correctly.
 - The valve lash adjustment is set correctly.
 - The compression gauge is accurate.
1. Remove the fuel injector from the cylinder to measure the compression for that cylinder.
 2. Connect a suitable compression gauge to the cylinder.
 3. Disconnect the ESOS (Engine Shut-Off Solenoid).
 4. Operate the starter motor and record the pressure on the compression gauge.
 5. Repeat step 1 to step 4 for each cylinder.
 6. Repair the engine if the compression is lower than the repair limit. Refer to Table 31.

Important: Make sure that you measure the compression on all of the cylinders. If all of the cylinders are not checked an improper diagnosis may result. The compression pressure will vary with the change in engine RPM (Revolutions Per Minute). It is necessary to keep the engine RPM constant for all cylinders when you are taking a compression reading.

Table 31.

-	Standard at assembly	Repair limit
Compression pressure ⁽¹⁾	29.4bar (426.1psi)	24.5bar (355.1psi)

(1) The compression pressure is taken at 250 RPM.

Oil Pressure Test

Important: You must use a suitable pressure gauge that measures the oil pressure in the engine. An oil pressure gauge that has a defect can indicate low oil pressure.

1. Make sure that the engine is filled to the correct oil level.
2. Connect the pressure gauge to a pressure test point location for engine oil.
 Special Tool: Digital Hydraulic Pressure Test Kit (Qty.: 1)
 Special Tool: Pressure Gauge (0-40 Bar) (Qty.: 1)
3. Start the engine. Allow the engine to obtain normal operating temperature.
4. Keep the oil temperature constant with the engine at the rated RPM. Read the pressure gauge.
5. Check the engine oil pressure is correct. Refer to Table 32.

Table 32.

Oil Pressure ⁽¹⁾	
Oil pressure at high idle	1.96–4.41bar (28.4–63.9psi)
Oil pressure at low idle	0.49bar (7.1psi)

(1) The 011 temperature must be 80–110°C (175.9–229.8°F)

Remove and Install

(For: Perkins 400 Series)

The lifting equipment used must be an approved type and capable of lifting the engine safely. The recommended lifting equipment is shown. Use a spreader bar when lifting the engine. Never attempt to manually lift heavy components on your own. Always use lifting equipment, or obtain the help of an assistant. Inspect the lifting brackets for signs of damage. The brackets must be correctly torqued to the crankcase. Make sure the lifting equipment does not damage any of the engine dressing and the rocker cover.

There will be some component differences depending on the machine variant. Before attempting to remove the engine ensure that all the necessary components have either been removed, or safely disconnected from the engine.

Before Removal

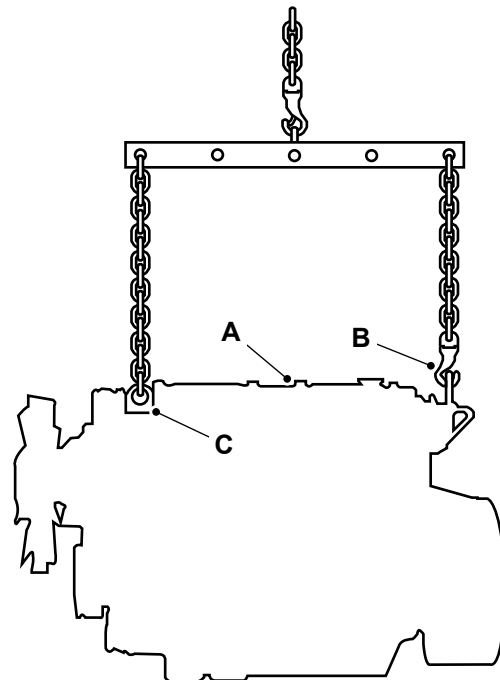
1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
2. Make the machine safe. Refer to (PIL 01-03).
3. Get access to the engine.

Remove

1. Disconnect and remove the battery. Refer to (PIL 33-03).
2. Drain the engine oil. Refer to (PIL 15-21).
3. Drain the engine coolant and remove the cooling pack. Refer to (PIL 21-03).
4. Discharge the hydraulic pressure. Refer to (PIL 30-00).
5. Drain the hydraulic tank. Disconnect and plug the hydraulic pipes. Label the hoses to ensure correct reassembly.
6. Disconnect and plug the hydraulic cooler hoses. Label the hoses to ensure correct reassembly.
7. Disconnect the exhaust system.
8. Label the cab heater hoses at the engine crankcase. Release the hose clips and remove the hoses.
9. Disconnect the wiring connections from the starter motor. Refer to (PIL 15-75).
10. Disconnect the wiring connections from the alternator. Refer to (PIL 15-72).

11. Disconnect the wiring connections from the engine sensors and actuators. Refer to (PIL 15-84).
12. Disconnect the fuel supply line at the fuel lift pump and the spill line at the fuel injection pump. Cap all hoses and ports to prevent ingress of dirt.
13. Disconnect the electrical harness at the engine harness.
14. Uncouple the electrical harness at the ECM (Engine Control Module) machine side connector. Important: DO NOT touch the connector pins on the ECM or harness connectors. Cover the connectors to prevent contamination.
15. Ensure that all relevant harnesses and hoses are unclipped from the engine and tied out of the way.
16. Disconnect and plug the hoses at the hydraulic pump.
17. Disconnect the wiring to the hydraulic pump.
18. Attach slings to the engine lifting eyes.

Figure 78.



- A** Engine
- B** Sling
- C** Lifting eye

19. Take the weight of the engine on the hoist and remove the engine mounting bolts.
20. Withdraw the engine in a level attitude until it is clear of the chassis. Raise the engine to lift it clear of the machine.

21. Lower the engine into a suitable stand that is capable of supporting the weight of the engine.

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Fill the cooling system with the correct mix of coolant fluid. Refer to (PIL 21-00).
3. Fill and Check the hydraulic fluid level. Refer to (PIL 30-00).
4. Fill and Check the engine oil level. Refer to (PIL 15-00).
5. On completion, check hydraulic and cooling system for leakage and levels.
6. Check the function of drive and excavator services.

Table 33. Torque Values

Item	Nm
C	25

Store and Recommission

(For: Perkins 400 Series)

Consumables

Description	Part No.	Size
Cleaner/Degreaser - General purpose solvent based parts cleaner	4104/1557	0.4L

If the engine is not started for several weeks, the lubricating oil will drain from the cylinder walls and from the piston rings. This forms the rust on the cylinder walls. The rust on the cylinder walls will cause increased engine wear and a reduction in engine service life.

If an engine is out of operation and if use of the engine is not planned, special precautions should be made. If the engine is stored for more than one month, a complete protection procedure is recommended.

When you protect the engine in accordance with the following procedure, it makes sure that no corrosion will occur.

1. Before you store the engine make sure that:
 - 1.1. The environment is not humid or exposed to bad weather.
 - 1.2. The storage place is not near an electric panel.
 - 1.3. Prevent storing the engine in direct contact with the ground.

Lubrication System

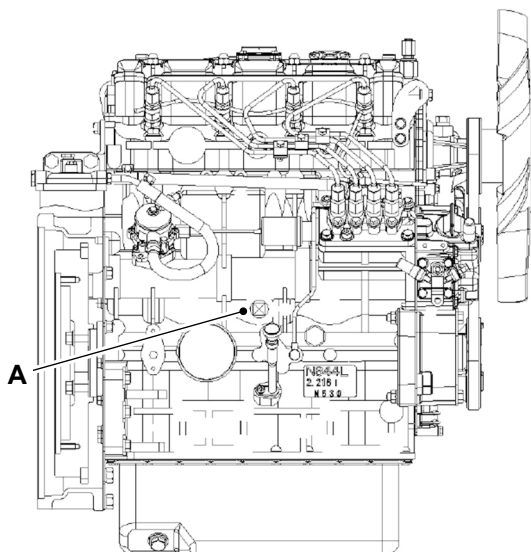
1. Drain the fuel system completely and refill the system with preservative fuel.
 - 1.1. The "1772204 POWERPART Lay-Up 1" can be mixed with the normal fuel in order to change the fuel into preservative fuel.
 - 1.2. If preservative fuel is not available, the fuel system can be filled with normal fuel. This fuel must be discarded at the end of the storage period together with the fuel filter elements.
2. Operate the engine until the engine reaches the normal operating temperature.
3. Stop any leaks from fuel, lubricating oil or air systems.
4. Stop the engine and drain the lubricating oil from the oil sump.

5. Replace the lubricating oil filter.
6. Fill the oil sump to the Full Mark on the engine oil level gauge with new, clean lubricating oil.
 - 6.1. Add "1762811 POWERPART Lay-Up 2" to the oil in order to protect the engine against corrosion.
 - 6.2. If "1762811 POWERPART Lay-Up 2" is not available, use a preservative of the correct specification instead of the lubricating oil.
 - 6.3. If a preservative is used, this must be drained completely at the end of the storage period and the oil sump must be refilled to the correct level with normal lubricating oil.

Cooling System

1. Make the machine safe. Refer to (PIL 01-03).
2. Remove the filler cap of the cooling system.
3. Remove the drain plug from the side of the crankcase.

Figure 79.



A Drain plug

4. Make sure that the drain hole is not restricted.
5. Drain the engine.
6. Open the tap or remove the drain plug at the bottom of the radiator. If the radiator does not have a tap or a drain plug, disconnect the hose at the bottom of the radiator.
7. Drain the radiator.
8. Flush the cooling system with clean water.
9. Fit the drain plugs and the filler cap.

10. Close the tap or connect the radiator hose.
11. Fill the cooling system with an approved antifreeze mixture because this gives protection against corrosion. Certain corrosion inhibitors could cause damage to some engine components. Contact your JCB dealer for details.
12. Operate the engine for a short period to circulate the coolant in the engine.
13. Disconnect the battery. Refer to (PIL 33-03).
14. Apply the "1734115 POWERPART Lay-Up 3" to protect the battery terminal from corrosion.
15. Put the battery into safe storage in a fully charged condition.
16. If installed, clean the crankcase breather and seal the end of the pipe.
17. Remove the fuel injectors and spray "1762811 POWERPART Lay-Up 2" for specified duration into each cylinder bore with the piston at BDC (Bottom Dead Centre).
18. Slowly rotate the crankshaft for one complete revolution and then install the fuel injectors.

Induction System

1. Remove the air filter assembly.
2. If necessary, remove the fuel pipes that are installed between the air filter assembly and the turbocharger.
3. Spray "1762811 POWERPART Lay-Up 2" into the turbocharger. The duration of the spray is printed on the container.
4. Seal the turbocharger with waterproof tape.

Exhaust System

1. Remove the exhaust pipe.
2. Spray "1762811 POWERPART Lay-Up 2" into the turbocharger. The duration of the spray is printed on the container.
3. Seal the turbocharger with waterproof tape.

General Items

1. If the lubricating oil filler is installed on the valve mechanism cover, remove the filler cap.
2. If the lubricating oil filler cap is not installed on the valve mechanism cover, remove the valve mechanism cover.
3. Spray "1762811 POWERPART Lay-Up 2" around the rocker shaft assembly.

4. Install the filler cap or the valve mechanism cover.
5. Seal the vent of the fuel tank or the fuel filler cap with waterproof tape.
6. Remove the alternator drive belts and put the drive belts into storage.
7. In order to prevent corrosion, spray the engine with "1734115 POWERPART Lay-Up 3". Do not spray the area inside the alternator.

Engine Starting After Storage

1. Remove the protective sheet.
2. Use a cloth soaked in degreasing fluid to remove the protective treatment from the external parts.
[Consumable: Cleaner/Degreaser - General purpose solvent based parts cleaner](#)
3. Inject lubricating oil (not more than 2cm³) into the intake ducts.
4. Adjust the alternator belt tension. Refer to (PIL 15-18).
5. Refuel the machine.
6. Make sure that the oil and the coolant are up to the maximum level.
7. Start the engine and run at idle speed for the specified duration.
Duration: 2min
8. Bring the engine to 75% of the maximum rated speed for the specified duration.
Duration: 5–10min
9. Stop the engine.
10. While the oil is still hot, drain the protective oil into a suitable container.
11. Put new oil up to the maximum level.
12. Replace the filters (air, oil and fuel).
13. Drain the cooling system completely and put new coolant up to the maximum level. Refer to (PIL 21-00).

Important: Over an amount of time, lubricants and filters lose their properties, so it is important to consider whether they need replacing, also based on the criteria mentioned in the maintenance schedules.

If the engine is not to be used for an extended period, the protective treatment procedure must be repeated within 730d of the previous one.

00 - General

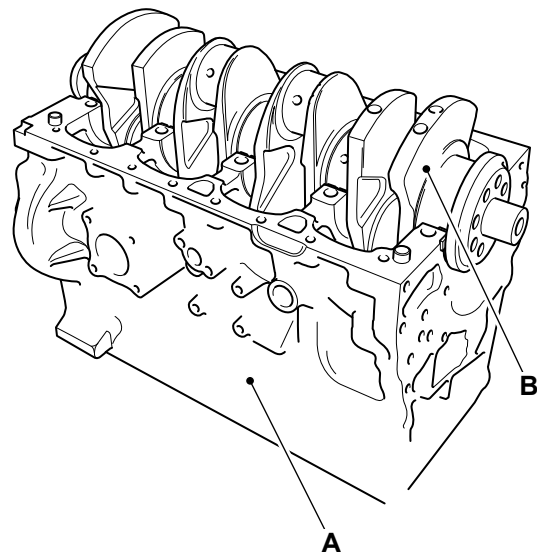
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Introduction

The crankcase is the housing for the crankshaft. The enclosure forms the largest cavity in the engine and is located below the cylinders. It is integral with the cylinder bank and forms an engine block. It has an opening in the bottom to which an oil sump is attached with a gasket and bolted joint.

The crankcase protects the crankshaft and connecting rods from foreign objects it also keeps the engine oil contained and allows the oil to be pressurised and also provide the rigid structure with which to join the engine to the transmission.

Figure 80.



- A** Crankcase
- B** Crankshaft

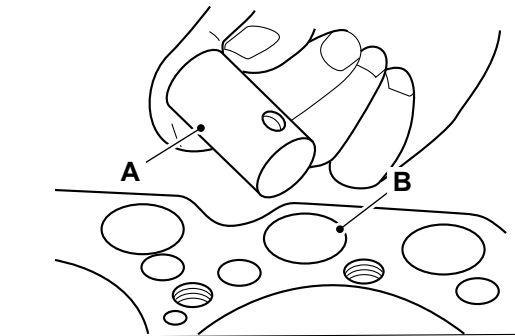
Technical Data

(For: Perkins 400 Series)

Table 34. Cylinder bore data

Description	Data
Diameter of bore	84–84.019mm
Bore service limit	84.2mm
Flatness of the top of the cylinder	Less than 0.05mm
Service limit for the flatness	0.12mm
Clearance between the tappet and the tappet bore (Maximum)	0.058mm
Clearance between the tappet and the tappet bore (Service limit)	0.08mm

Figure 81.



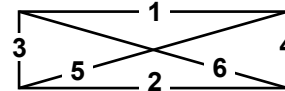
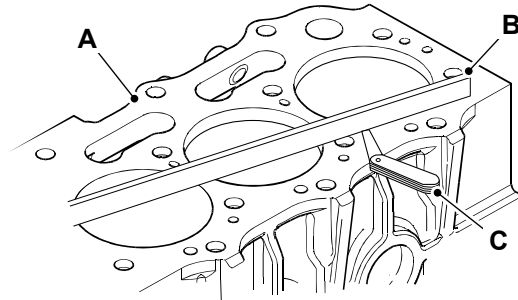
A Tappet
B Tappet bore

Check (Condition)

(For: Perkins 400 Series)

1. Check the six positions for flatness with a straight edge and the feeler gauge. Refer to Figure 82.

Figure 82.



A Crankcase
B Straight edge
C Feeler gauge

2. Inspect the top of the crankcase for cracks, damage and warping.
3. Inspect each cylinder bore.
 - 3.1. Make sure that there are no signs of scoring or corrosion.
 - 3.2. Measure each cylinder bore with a suitable gauge.
 - 3.3. Measure the area of each cylinder bore that is in contact with the top, middle and bottom piston rings.
 - 3.4. Make sure that you measure each cylinder bore at right angles to the crankshaft.
 - 3.5. Do NOT use the flex-hone process on this engine.
4. Make sure that the cylinder bore dimensions do not exceed the specified service limits. Refer to Technical data (PIL 15-03).
5. If the service limit for the crankcase is exceeded, you must replace the crankcase.

Technical Data

(For: Perkins 400 Series)

Table 35. Cylinder head gasket

Piston height below top face of crankcase	Gasket Thickness
+0.35mm to +0.5mm	1.2mm
+0.5mm to +0.6mm	1.3mm

Table 36. Distortion of the cylinder head

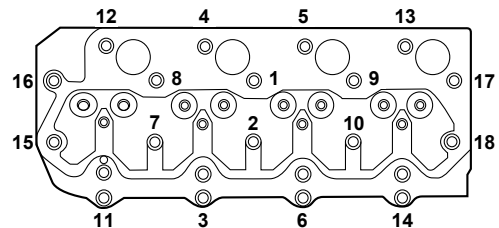
Description	Data
Distortion of the cylinder head	0–0.05mm
Maximum service limit	0.12mm
Maximum limit for re-grinding the cylinder head	0.15mm

Check (Condition)

(For: Perkins 400 Series)

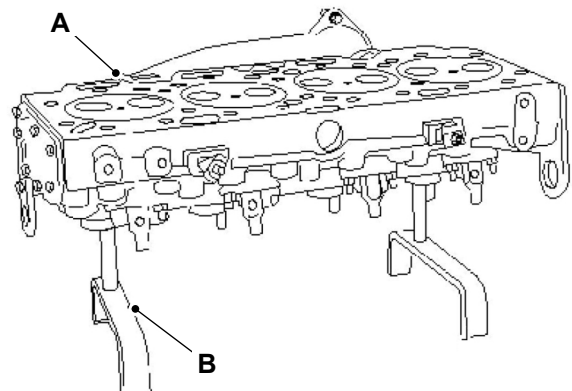
1. Make the machine safe. Refer to (PIL 01-03).
2. Get access to the engine. Refer to (PIL 06-06).
3. Remove the cylinder head bolts in the reverse numerical order. This will prevent distortion of the cylinder head. Refer to Figure 83.

Figure 83.



4. Remove the cylinder head from the engine.
5. Clean the cylinder head thoroughly.
6. Make sure that the contact surface of the cylinder head and the contact surface of the crankcase are clean, smooth and flat.
7. Inspect the bottom surface of the cylinder head for pitting, corrosion and cracks.
8. Inspect the area around the valve seats and the holes for the fuel injectors.
9. Put the cylinder head on a suitable support.

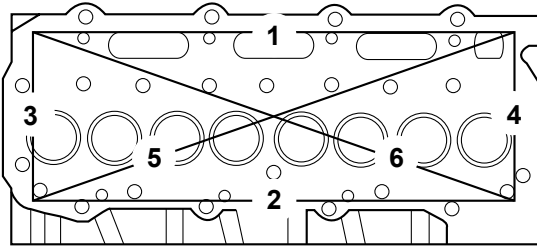
Figure 84.



- A** Cylinder head
B Support

10. Use a straight edge and a feeler gauge to check the six positions for distortion. Refer to Figure 85.

Figure 85.

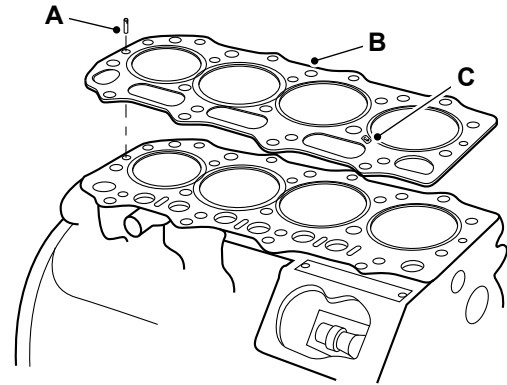


Calibrate

(For: Perkins 400 Series)

- The dowel pins in the crankcase hold the cylinder head gasket in the correct position when the cylinder head is installed. Refer to Figure 86.
- The stamped marking on the cylinder head gasket must face upward. This makes sure that the cylinder head gasket is installed correctly. Refer to Figure 86.

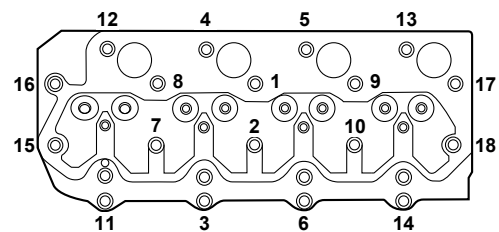
Figure 86.



- A** Dowel pins
- B** Gasket
- C** Stamped marking

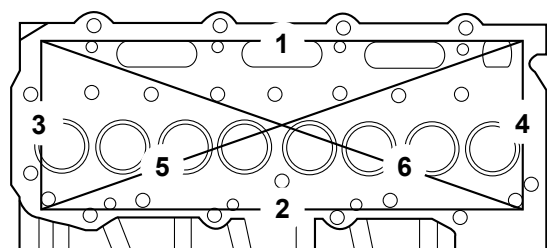
- Before you tighten the bolts, apply clean engine oil on the threads of the bolts. The bolts must be tightened to the torque of 101N·m in the specified numerical sequence only. Refer to Figure 87.

Figure 87.



- Use a straight edge and a feeler gauge to check the six positions for distortion. Refer to Figure 88.

Figure 88.



- If you grind the cylinder head, check the valve depth below the cylinder head face. Refer to (PIL 15-30).

Remove and Install

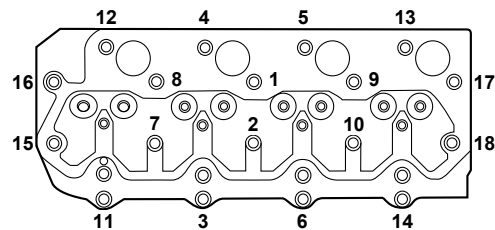
(For: Perkins 400 Series)

- ▲ CAUTION** This component is heavy. It must only be removed or handled using a suitable lifting method and device.

Remove

1. Make the machine safe. Refer to (PIL 01-03).
2. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
3. Remove the exhaust manifold. Refer to (PIL 18-24).
4. Remove the fuel filter. Refer to (PIL 18-09).
5. Remove the fuel injectors. Refer to (PIL 18-18).
6. Remove the glow plugs. Refer to (PIL 15-80).
7. Remove the rocker shaft and the push rods. Refer to (PIL 15-42).
8. Remove the cooling pump. Refer to (PIL 21-09).
9. Drain the cooling system. Refer to (PIL 21-00).
10. Gradually loosen the bolts in reverse numerical order. This will prevent distortion of the cylinder head. Refer to Figure 89.

Figure 89.



11. Remove the bolts from the cylinder head.
12. Carefully lift the cylinder head off the crankcase with a suitable lifting device.
13. Make sure of the following:
 - 13.1. Do not use a lever to separate the cylinder head from the crankcase.
 - 13.2. Take care not to damage the machined surfaces of the cylinder head.
 - 13.3. Avoid contamination of the cylinder bores with coolant or with debris.



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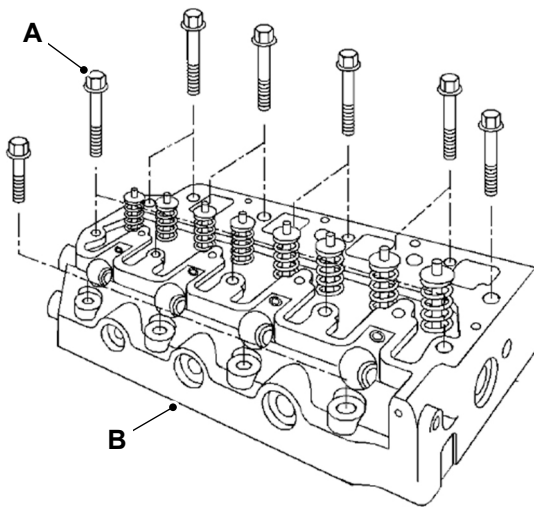
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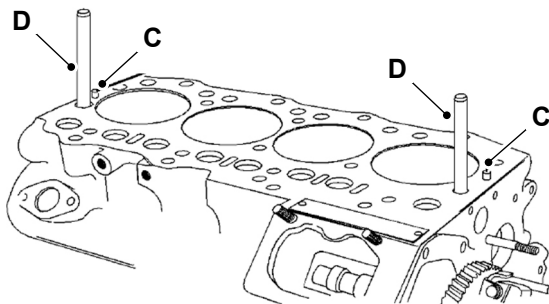
- 13.4. Place the cylinder head on a surface that will not scratch the face of the cylinder head.
14. Remove the cylinder head gasket. Retain the old gasket to help identification.
15. Make a note of the position of the dowels. Do not remove the dowels unless they are damaged.
16. If necessary, remove the thermostat from the cylinder head. Refer to (PIL 21-12).

Figure 90.



- A Bolt
- B Cylinder head

Figure 91.



- C Dowel
- D Guide bolt (M11 by 100mm)

Install

1. Clean the mating surfaces of the cylinder head and the crankcase.
2. Make sure that no debris enters the cylinder bores, the coolant passages, or the lubricant passages.
3. Inspect the mating surface of the cylinder head for distortion. If the mating surface of the cylinder

head is distorted beyond the maximum permitted limits, replace the cylinder head.

4. Inspect dowels for damage. If necessary, replace the dowels in the crankcase.
5. Install the guide bolts to the crankcase.
6. Make sure that the new gasket is of the same thickness as the old gasket.
7. Align the gasket with the guide bolt and the dowels. Install the gasket onto the crankcase.
8. Lift the cylinder head with a suitable lifting device.
9. Align the cylinder head with the guide bolts on the crankcase. Install the cylinder head onto the crankcase.
10. Make sure that the cylinder head is correctly positioned on the dowels.
11. Remove the guide bolts.
12. Install the bolts to the cylinder head.
13. Tighten the bolts to the correct torque value in the specified numerical sequence only. Refer to Figure 89.
14. If removed, install the thermostat to the cylinder head. Refer to (PIL 21-12).
15. Install the cooling pump. Refer to (PIL 21-09).
16. Install the rocker shaft and the push rods. Refer to (PIL 15-42).
17. Install the glow plugs. Refer to (PIL 15-80).
18. Install the fuel injectors. Refer to (PIL 18-18).
19. Install the fuel filter. Refer to (PIL 18-09).
20. Install the exhaust manifold. Refer to (PIL 18-24).

Table 37. Torque Values

Item	Description	Nm
A	Bolt	100

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