Perkins®

THE HEART OF EVERY GREAT MACHINE

M0064276 (en-us)
December 2015

Systems Operation Testing and Adjusting

4008-30 Industrial Engine

SD8 (Engine)

Important Safety Information

Most accidents that involve product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or to other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "DANGER", "WARNING" or "CAUTION". The Safety Alert "WARNING" label is shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

The message that appears under the warning explains the hazard and can be either written or pictorially presented.

Operations that may cause product damage are identified by "NOTICE" labels on the product and in this publication.

Perkins cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are, therefore, not all inclusive. If a tool, procedure, work method or operating technique that is not specifically recommended by Perkins is used, you must satisfy yourself that it is safe for you and for others. You should also ensure that the product will not be damaged or be made unsafe by the operation, lubrication, maintenance or repair procedures that you choose.

The information, specifications, and illustrations in this publication are on the basis of information that was available at the time that the publication was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service that is given to the product. Obtain the complete and most current information before you start any job. Perkins dealers or Perkins distributors have the most current information available.

⚠ WARNING

When replacement parts are required for this product Perkins recommends using Perkins replacement parts.

Failure to heed this warning can lead to premature failures, product damage, personal injury or death.

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Systems Operation Section

Fuel System

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Fuel System Operation

The fuel supply circuit is a conventional design for engines that use fuel injectors. The fuel supply circuit uses a fuel transfer pump to deliver fuel from the fuel tank to the fuel injectors. The transfer pump is a fixed displacement gear pump. The fuel transfer pump is installed to the back of the oil pump.

A fuel priming pump is on the fuel transfer pump to fill the system. The system must be primed after the filter changes. The system must be primed after draining the fuel supply and return manifolds, when the fuel injectors are replaced.

The fuel flows continuously from the fuel supply manifold through the fuel injectors. The fuel flows when either the supply or the fill port in the injector is not closed by the injector body assembly plunger. The fuel that is not injected into the cylinder is returned to the tank through the fuel return manifold.

A pressure regulating valve is installed at the end of the fuel return manifold. The pressure regulating valve controls the entire fuel system pressure. This ensures that the fuel injectors are correctly filled with fuel.

The mechanically actuated fuel injector system provides total control of injection timing. The injection timing is varied to optimize the performance of the engine.

A speed sensor measures engine speed. A digital governor regulates the input of the fuel to the engine so that the actual engine speed matches the desired engine speed. Engine speed is maintained by the governor by a speed sensor. The speed sensor is mounted next to the flywheel gear. The governor actuator that is controlled by the digital governor for the required load is connected to the linkage of the fuel injectors. The fuel is injected into the cylinder at precisely the correct moment for the most efficient combustion.

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Fuel Injector Mechanism

The fuel injector mechanism provides the downward force that is required to pressurize the fuel in the fuel injection pump. The mechanically operated fuel injector allows fuel to be injected into the combustion chamber.

Force is transmitted from the fuel injector lobe on the camshaft through the lifter to the pushrod. The force from the pushrod is transmitted through the rocker assembly and to the top of the fuel injection pump. The adjusting nut allows setting of the injector timing.

Air Inlet and Exhaust System

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Air Inlet and Exhaust System

The components of the air inlet and exhaust system control the quality and the amount of air that is available for combustion. There are two separate turbochargers that are installed on the rear of the engine.

The hot charge air from the turbochargers is directed by large air pipes to the aftercooler. The cooling of the charge air is achieved by inserting this additional radiator in front of the normal radiator that cools water. The single radiator fan pushes air through each matrix in series. The air passes through the matrix for charge air. After the air passes through the radiator for charge air, the air is directed through pipes that have a large bore to the air intake manifolds.

The camshaft controls the movement of the valve system components and injectors.

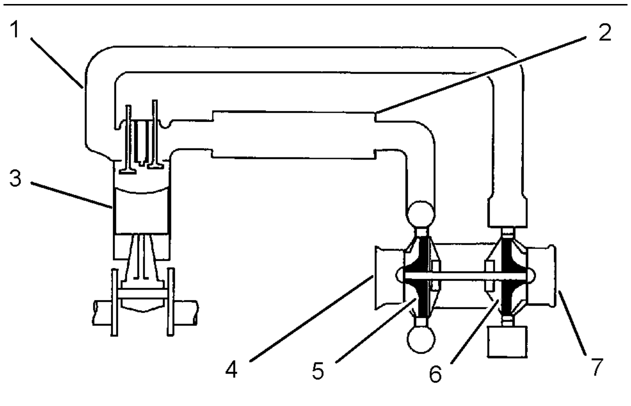

Illustration 1 g01188937

Air Inlet And Exhaust System

(1) Exhaust manifold
(2) Aftercooler
(3) Engine cylinder
(4) Air inlet
(5) Turbocharger compressor wheel
(6) Turbocharger turbine wheel
(7) Exhaust outlet

Clean inlet air from the air cleaners is pulled through air inlet (4) into the turbocharger compressor by compressor wheel (5). The rotation of the compressor wheel compresses the air. The rotation of the turbocharger compressor wheel then forces the air through a tube to aftercooler (2). The aftercooler lowers the temperature of the compressed air before the air enters the inlet chamber in each cylinder head. Air flow from the inlet chamber into the cylinder heads is controlled by the inlet valves.

There are two inlet valves and two exhaust valves for each cylinder. Refer to Systems Operation, “Valve Mechanism”. The inlet valves open when the piston moves down on the inlet stroke. The cooled, compressed air is forced into the cylinder from the inlet chamber.

The inlet valves close and the piston starts to move up on the compression stroke. When the piston is near the top of the compression stroke, fuel is injected into the cylinder. The fuel mixes with the air and combustion starts. The force of the combustion pushes the piston downward on the power stroke. When the piston moves upward again, the piston is on the exhaust stroke. The exhaust valves open and the exhaust gases are pushed through the exhaust port into exhaust manifold (1). After the piston makes the exhaust stroke, the exhaust valves close and the cycle starts again.

Exhaust gases from exhaust manifold (1) go into the turbine side of the turbocharger. The exhaust gases cause turbine wheel (6) to turn. The turbine wheel is connected to the shaft that drives the turbocharger compressor wheel (5). The exhaust gases exit through exhaust outlet (7).

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Valve Mechanism

The valve system components control the flow of the inlet air and the exhaust gases into the cylinders and out of the cylinders during engine operation.

The crankshaft gear drives the camshaft gears through idlers. The camshaft must be timed to the crankshaft in order to get the correct relation between the piston and the valve movement.

The camshaft has three lobes for each cylinder. Two lobes operate the valves and one operates the fuel injector.

As the camshaft turns, the lobes on the camshaft cause lifters to move up and down. This movement causes pushrods to move rocker arms. The movement of the rocker arms cause bridge pieces to move downward. The bridge pieces open two valves simultaneously. The valves can be either inlet valves or exhaust valves. There are two inlet valves and two exhaust valves for each cylinder.

Valve springs cause the valves to close when the lifters move downward.

Lubrication System

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Lubrication System

Lubrication System Components

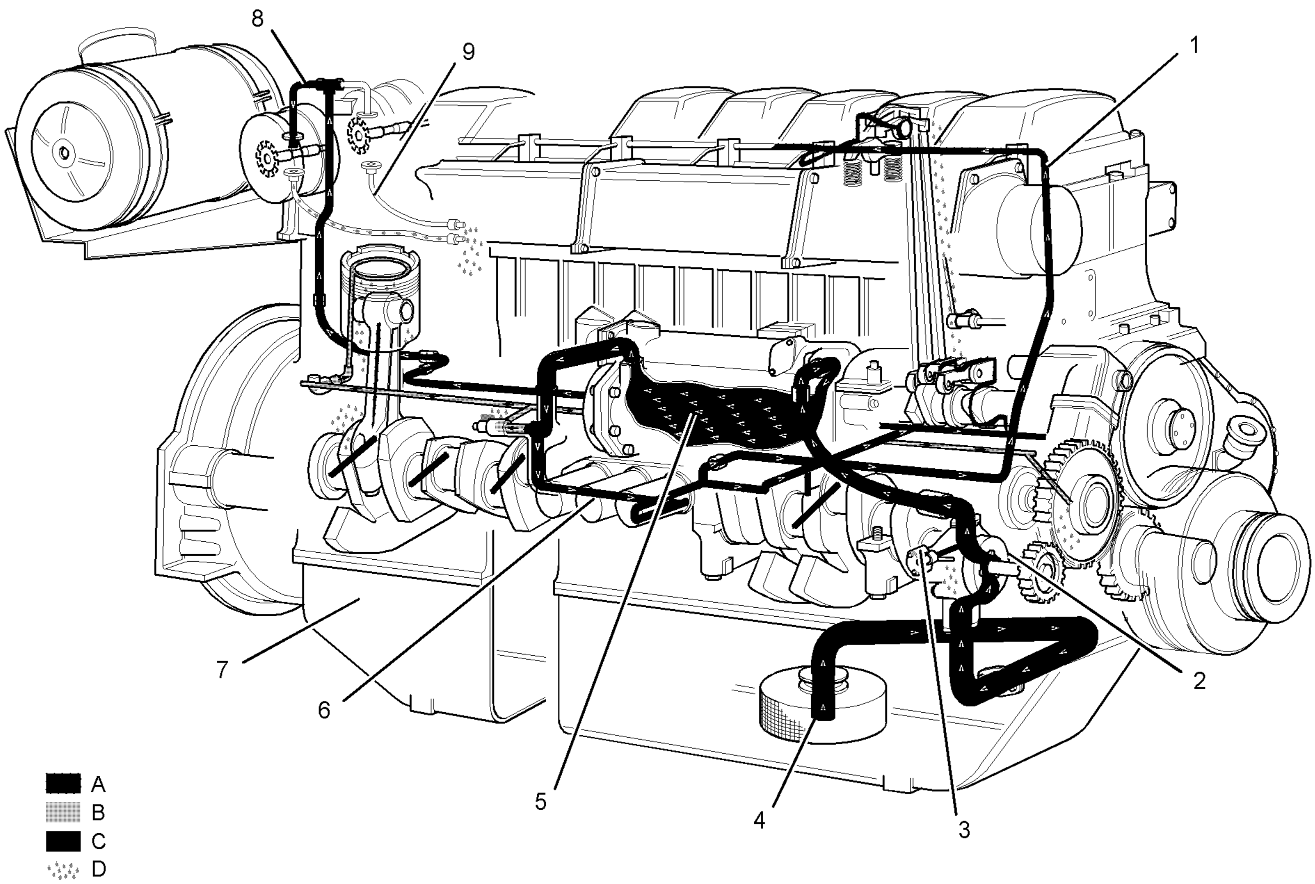

Illustration 2 g01372216

Typical example of the lubrication system components

(A) Oil pressure circuit
(B) Oil circuit for piston cooling
(C) Oil pressure relief
(D) Oil return to sump
(1) Oil supply line for rocker shafts
(2) Engine oil pump
(3) Engine oil relief valve
(4) Strainer
(5) Oil cooler
(6) Oil filters
(7) Engine oil pan
(8) Oil supply line for turbocharger
(9) Oil return line for turbocharger

Engine Oil Flow Through the Engine Oil Filter and Engine Oil Cooler

When the engine is at normal operating temperature, the engine oil pump (2) pumps engine oil from the engine oil pan (7) through the strainer (4). The engine oil is pumped to the engine oil cooler (5). The engine oil flows through the engine oil filters (6) to the oil gallery in the cylinder block and to the supply line (1) for the rocker shafts. Engine oil from the turbocharger goes back through the return line (9) to the engine oil pan (7).

The three engine oil filters are full flow oil filters.

Engine Oil Flow in the Engine

The engine oil pump has a pressure relief valve that is designed to open if the engine oil pressure becomes excessive. This prevents high-pressure engine oil from damaging the O-ring seals for the engine oil cooler and for the engine oil filter. The remainder of the engine oil is pumped normally to the engine oil gallery in the cylinder block.

The engine oil gallery is the source of pressurized engine oil for the engine and for the attachments.

The flow of engine oil which goes to the main bearings is divided. Some of the engine oil provides lubrication between the main bearings and the bearing surfaces (journals) of the crankshaft. Some of the engine oil goes through the drilled passages into the crankshaft. This engine oil provides lubrication between the connecting rod bearings and the bearing surfaces (journals) of the crankshaft. The engine oil provides cooling and lubrication for the following components:

- Pistons
- Piston pins
- Cylinder walls
- Camshaft bearings
- Pushrods
- Valve lifters

Some of the engine oil lubricates the valve stems. The remainder of the engine oil drains from the cylinder head to lubricate the pushrods.

The bearings for the timing gear receive pressurized engine oil from the oil gallery.

For components on the outside of the engine such as the turbocharger, engine oil goes through supply lines from the engine oil gallery.

Cooling System

i06512674

Cooling System

The coolant is circulated through the engine by a centrifugal water pump. The water pump is on the front of the engine. The water pump has a gear that is driven by the idler gear. Coolant from the inlet line goes into the water pump. The rotation of the impeller in the water pump then pumps the coolant through the system.

The coolant from the water pump goes through the engine oil cooler to the coolant jackets in the cylinder block. From the cooling jackets around the cylinders, the coolant flows upwards into the cylinder heads. The coolant returns via a water rail to the housing for the water temperature regulator. The thermostat housing has three water temperature regulator elements. The water temperature regulator elements determine the direction of the coolant flow depending on the temperature. When cold, the coolant flow is directed back via a by-pass pipe to the coolant pump suction to be recirculated.

With the thermostat open, the coolant is allowed to enter the radiator. The coolant is cooled by air blowing over the single core cooling matrix. The hot air from the turbocharger is directed via a large diameter air pipe to the aftercooler. The hot air flows through a single core radiator and is directed through large bore pipes to the engine air inlet manifold. The cooling of the charge air is achieved by installing an extra radiator at the side of the normal coolant cooling radiator and in the airflow of the cooling fan. The radiator fan forces air through each matrix in parallel.

The oil cooler comprises of a tubestack enclosed within a cast body and sealed by O-rings and joints to the port covers. The covers are secured by bolts, setscrews, and spring washers to the body. Oil is delivered from the lubricating oil pump via a flexible pipe into the inlet port and into cooler body circulating around the outside of the tubes. Coolant is delivered from the water pump and passes from the outlet pipe to the end cover inlet port. Then passes through the tubes, and makes one pass in both directions. The coolant then exits from the outlet port to the water transfer pipe and into the water jacket.

Basic Engine

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Cylinder Block, Liners and Heads

The cylinders in the cylinder block are arranged in-line. The main bearing caps that locate the crankcase are fastened to the cylinder block with four bolts, two through the face and two side bolts.

The cylinder liners can be removed for replacement. The top surface of the cylinder block is the seat for the cylinder liner flange. Engine coolant flows around the cylinder liners to keep the cylinder liners cool. Two O-ring seals around the bottom of the cylinder liner make a seal between the cylinder liner and the cylinder block. A sealing compound is applied under the cylinder liner flange. This makes a seal between the top of the cylinder liner and the cylinder block.

The engine has a separate cylinder head for each cylinder. Two inlet valves and two exhaust valves, which are controlled by a pushrod valve system, are used for each cylinder. Valve guides without shoulders are pressed into the cylinder heads. The opening for the unit injector is located between the four valves. A lobe on the camshaft moves the pushrod that operates the unit injector. Fuel is injected directly into the cylinder.

Coolant goes out of the cylinder block and into the cylinder head through four openings in each cylinder head face. Water seals are used in each opening to prevent coolant leakage. O-rings seal the engine oil drain line between the cylinder head and the cylinder block.

Camshaft covers allow access to the camshaft and to the valve lifters. Crankcase covers allow access to the crankshaft connecting rods, the main bearings, and the piston cooling jets. When the covers are removed, all the openings can be used for inspection and for service.

i06512669

Pistons, Rings and Connecting Rods

The piston is a one-piece piston that is a casting of aluminum alloy. The piston crown carries all three piston rings. Oil from the piston cooling jets flows through a chamber which is located directly behind the rings. The oil cools the pistons. This maintains the correct operating temperature of the piston. The pistons have three rings which include two compression rings and one oil control ring. All the rings are located above the piston pin bore. Oil is removed from the wall of the cylinder and returns to the crankcase through holes in the oil control ring groove.

The pistons should be checked regularly for wear or damage. Check that the piston rings are free to move in the grooves and that the rings are not broken. The clearance of the piston ring should be inspected regularly. Remove the piston rings and clean the grooves. Discard the piston rings. Install new piston rings in the piston grooves. Check the clearance for the piston ring by inserting a suitable feeler gauge between the piston groove and the top of piston ring. Refer to Specifications, “Piston and Rings” for the dimensions. Use a suitable feeler gauge to measure the piston ring gap. Refer to Specifications, “Piston and Rings” for the dimensions.

The connecting rod has a taper on the pin bore end. This taper gives the rod and the piston more strength in the areas with the most load. Two bolts hold the rod cap to the rod. The connecting rod bearing caps are matched to the connecting rod and must not be interchanged. There are different weight bands for the connecting rods. Ensure that the different weight bands are taken into account when installing replacement parts.

Measure the bores in the connecting rod and ensure that the bores meet the diameters according to the correct specifications. When the connecting rod is installed, follow the instructions for tightening the bolts. Refer to Specifications, “Connecting Rod”.

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Crankshaft

The crankshaft changes the combustion forces in the cylinder into usable rotating torque. A vibration damper is used at the front of the crankshaft to reduce torsional vibrations (twist) that can damage the engine.

The crankshaft drives a group of gears that are on the front of the engine. The gear group drives the oil pump, the camshaft, the fuel transfer pump via the oil pump, the water pump, and the auxiliary drives.

Seals are used at both ends of the crankshaft. The seals are replaceable. Pressurized oil is supplied to all main bearings through drilled holes in the webs of the cylinder block. The oil then flows through drilled holes in the crankshaft to provide oil to the connecting rod bearings. The crankshaft is held in place by nine main bearings. A thrust washer is installed on either side of the rear main bearing. This controls the end play of the crankshaft.

Note: The balance weights that are on the crankshaft must not be removed. If a balance weight needs to be replaced, the crankshaft must be returned to Perkins.

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Camshaft

There is one camshaft that runs through the cylinder block. The camshaft is supported by nine bearings. Oil is fed to the camshaft bearings from the main gallery through the cylinder block. The camshaft is driven by the gear group in a clockwise direction viewed from the flywheel end.

As the camshaft turns, each lobe moves a lifter. There are three lifters for each cylinder. Each outside lifter moves a pushrod and two inlet valves or two exhaust valves. The center lifter moves a pushrod that operates the fuel injector.

The camshaft must be in time with the crankshaft. The relation of the camshaft lobes to the crankshaft position causes the valves and fuel injectors in each cylinder to operate at the correct time relative to the piston stroke.

Electrical System

i02692982

Electrical System

The electrical system may have a charging circuit. The electrical system will have a starting circuit, and a low amperage circuit. Some of the electrical system components are used in more than one circuit.

The charging circuit is in operation when the engine is running. The alternator for charging the battery (if equipped) makes electricity for the charging circuit. An internal voltage regulator in the alternator controls the electrical output in order to keep the battery at a full charge.

The starting circuit is in operation only when the start switch is activated.

Charging System Components

Alternator

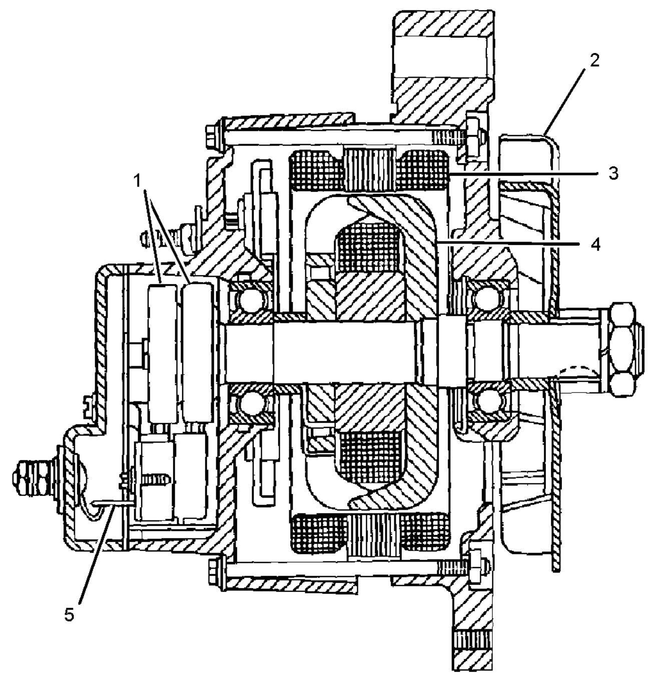

Illustration 3 g01357159

Alternator

(1) Slip rings
(2) Fan
(3) Stator
(4) Rotor
(5) Brush assembly

The alternator is a three-phase charging unit that contains an integral voltage regulator. The alternator is driven from a notched auxiliary drive belt.

Starting System Components

Starting Motor

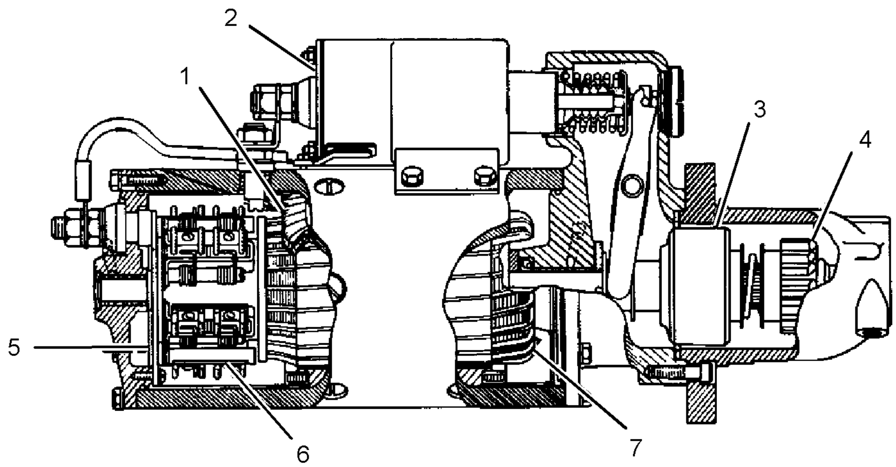

Illustration 4 g01357162

(1) Field
(2) Solenoid
(3) Clutch
(4) Pinion
(5) Commutator
(6) Brush assembly
(7) Armature

The starting solenoid (2) is an electromagnetic switch that performs the following basic operations:

- The starting solenoid (2) closes the high current starting motor circuit with a low current start switch circuit.
- The starting solenoid (2) engages the pinion of the starting motor (4) with the ring gear.

Solenoid (2) has windings (one or two sets) around a hollow cylinder. A plunger that is spring loaded is inside the cylinder. The plunger can move forward and backward. When the start switch is closed and electricity is sent through the windings, a magnetic field (1) is made. The magnetic field (1) pulls the plunger forward in the cylinder. This moves the shift lever in order to engage the pinion drive gear with the ring gear. The front end of the plunger then makes contact across the battery and motor terminals of solenoid (2). Next, the starting motor begins to turn the flywheel of the engine.

When the start switch is opened, current no longer flows through the windings. The spring now pushes the plunger back to the original position. At the same time, the spring moves the pinion gear away from the flywheel.

When two sets of solenoid windings are used, the windings are called the hold-in winding and the pull-in winding. Both sets of windings have the same number of turns around the cylinder, but the pull-in winding uses a wire with a larger diameter. The wire with a larger diameter produces a greater magnetic field (1). When the start switch is closed, part of the current flows from the battery through the hold-in windings. The rest of the current flows through the pull-in windings to the motor terminal. The current then flows through the motor to ground. Solenoid (2) is fully activated when the connection across the battery and the motor terminal is complete. When solenoid (2) is fully activated, the current is shut off through the pull-in windings. At this point, only the smaller hold-in windings are in operation. The hold-in windings operate for the duration of time that is required in order to start the engine. Solenoid (2) will now draw less current from the battery, and the heat that is generated by solenoid (2) will be kept at an acceptable level.

Testing And Adjusting Section

Electronic Control System

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Engine Governing - Adjust

The engine is governed by the Pandaros Digital Governor. In order to make adjustments to the Pandaros Digital Governor, refer to Special Instruction, REHS2806, “Pandoras Digital Governor” for more information.

Fuel System

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General Information (Fuel System)
(Diesel)

Either too much fuel or not enough fuel for combustion can be the result of a problem in the fuel system. Work is often done on the fuel system when the problem is really with some other part of the engine. Finding the cause of the problem can be difficult, especially when smoke comes from the exhaust. Smoke that comes from the exhaust can be caused by a faulty fuel injector. Smoke can also be caused by one or more of the reasons that follow:

- Not enough air for good combustion
- An overload at high altitudes (if applicable)
- Oil leakage into combustion chamber
- Air inlet and exhaust leaks
- Not enough compression

i02953018

Fuel System Inspection

A problem with the components that supply fuel to the engine can cause low fuel pressure. This can decrease engine performance.

1. Check the fuel level in the fuel tank. Look at the cap for the fuel tank. Make sure that the vent is not filled with debris.

2. Check the fuel lines for fuel leakage. Be sure that none of the fuel lines have a restriction or a faulty bend.

3. Install new main fuel filters.

4. Inspect the pressure valve on the fuel return rail.

i02990052

Checking Engine Cylinders

When the engine is under load, the temperature of an exhaust manifold port can indicate the condition of a fuel injector. Low temperature at an exhaust manifold port is an indication of no fuel to the cylinder. This can possibly indicate an injector with a defect or a problem with the control system. An extra high temperature at an exhaust manifold port can indicate too much fuel to the cylinder. High temperatures may also be caused by an injector with a defect.

Air Inlet and Exhaust System

i06512664

Valve Lash - Adjust

Table 1

Required Tools			
Tool	**Part Number**	**Part Name**	**Qty**
A	SE253	Crankshaft Turning Tool	1
B	-	Feeler gauge	1

NOTICE

Only qualified service personel should perform this maintenance. Refer to the Service Manual or your authorized Perkins dealer or your Perkins distributor for the complete valve lash adjustment procedure.

Operation of Perkins engines with incorrect valve lash can reduce engine efficiency, and also reduce engine component life.

WARNING

Ensure that the engine cannot be started while this maintenance is being performed. To help prevent possible injury, do not use the starting motor to turn the flywheel.

Hot engine components can cause burns. Allow additional time for the engine to cool before measuring/adjusting valve lash clearance.

Note: The valve bridges must be set before the valve lash is adjusted.

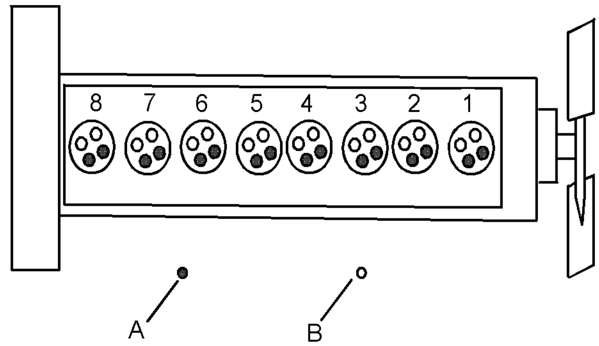

Illustration 5 g01359594

Eight cylinder engine

(A) Inlet valve
(B) Exhaust valve

Ensure that all power is disconnected to the engine.

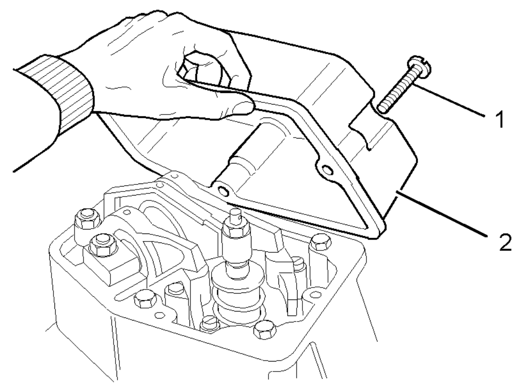

Illustration 6 g01241573

Typical example

1. Remove the capscrews (1).

2. Remove the rocker cover (2).

3. Remove the joint (not shown).

4. Repeat steps 1 through 3 for the remaining rocker covers.

For 4008-30 engine, set the valve lash in the sequence that is shown in the table 2 .

Table 2

Eight cylinder engine		
Top Center Position	**Engine cylinder with valves on the rock**	**Set the bridge adjustment and set valve lash.**
1-8	8	1
4-5	5	4

(continued)

(Table 2, contd)

2-7	2	7
3-6	3	6
1-8	1	8
4-5	4	5
2-7	7	2
3-6	6	3

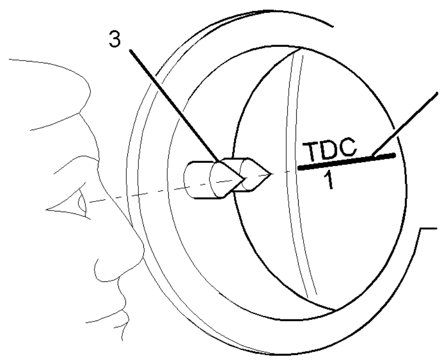

Illustration 7 g06006364

Typical example

5. Remove the blanking plug in the flywheel housing. Use Tooling (A) to rotate the crankshaft until the appropriate mark (4) on the flywheel is in alignment with the pointers (3). Ensure that there is clearance between the rocker arm and the bridgepiece.

Note: The timing window is located in the flywheel housing.

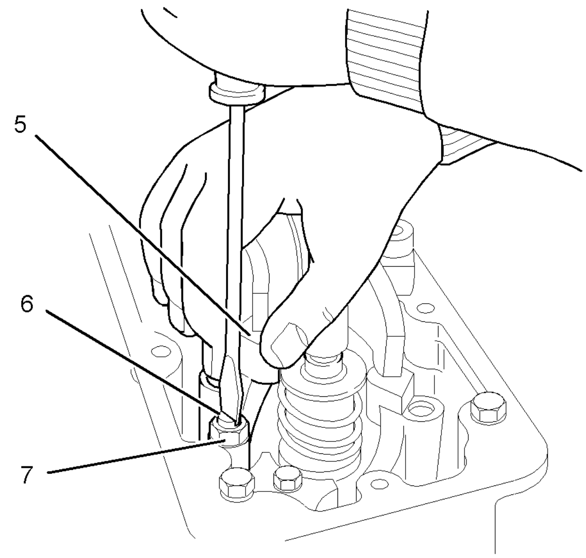

Illustration 8 g01241584

Typical example

6. Loosen the locknut (7) on the inlet valve bridge.

7. Hold the top edge of the bridge piece (5). Turn the adjuster screw (6) down until it contacts the valve.

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

8. Tighten the locknut (7) to a torque of 50 N·m (37 lb ft).

9. Repeat steps 6 through 8 for the exhaust valve bridge.

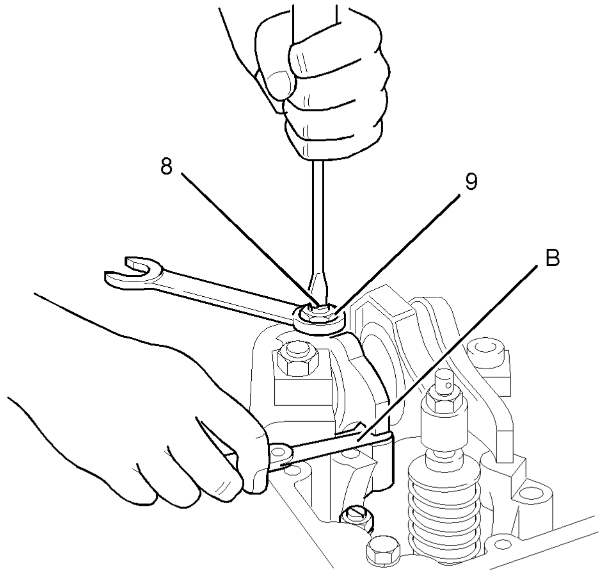

Illustration 9 g01241598

Typical example

10. Use Tooling (B) to check the valve lash. If necessary, follow steps 10.a through 10.f to adjust the valve lash. Set the valve lash to 0.4 mm (0.016 inch).

a. Loosen the locknut (9) on the rocker arm of the inlet valve.

b. Use Tooling (B) to set the valve lash.

c. Turn the adjuster (8) until the pad on the rocker arm is in contact with Tooling (B).

d. Tighten the locknut (7) to a torque of 50 N·m (37 lb ft).

e. Ensure that the valve lash is correct.

f. Repeat step 10 for the rocker arm of the exhaust valve.

11. Repeat steps 5 through 10 for the remaining rockers.

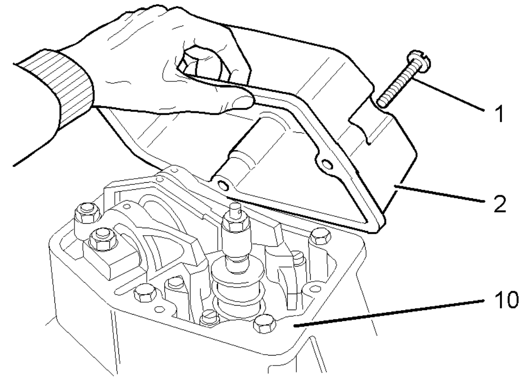

Illustration 10 g01241917

Typical example

12. Ensure the rocker cover (2) is clean and free from damage. Ensure the joint face of the rocker base (10) is clean and free from damage.

13. Install a new joint (not shown).

14. Install the rocker cover (2).

15. Install the capscrews (1). Tighten the capscrews to a torque of 4 N·m (35 lb in).

16. Repeat steps 12 through 15 for the remaining rocker covers.

i02863396

Turbocharger

WARNING

Hot engine components can cause injury from burns. Before performing maintenance on the engine, allow the engine and the components to cool.

WARNING

Personal injury can result from rotating and moving parts.

Stay clear of all rotating and moving parts.

Never attempt adjustments while the machine is moving or the engine is running unless otherwise specified.

The machine must be parked on a level surface and the engine stopped.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

Before you begin inspection of the turbocharger, be sure that the inlet air restriction is within the specifications for your engine. Be sure that the exhaust system restriction is within the specifications for your engine. Refer to Systems Operation, Testing and Adjusting, “Air Inlet and Exhaust System - Inspect”.

The condition of the turbocharger will have definite effects on engine performance. Use the following inspections and procedures to determine the condition of the turbocharger.

- Inspection of the Compressor and the Compressor Housing
- Inspection of the Turbine Wheel and the Turbine Housing

Inspection of the Compressor and the Compressor Housing

Remove air piping from the compressor inlet.

1. Inspect the compressor wheel for damage from a foreign object. If there is damage, determine the source of the foreign object. As required, clean the inlet system and repair the intake system. Replace the turbocharger. If there is no damage, go to Step 3.

2. Clean the compressor wheel and clean the compressor housing if you find buildup of foreign material. If there is no buildup of foreign material, go to Step 3.

3. Turn the rotating assembly by hand. While you turn the assembly, push the assembly sideways . The assembly should turn freely. The compressor wheel should not rub the compressor housing. Replace the turbocharger if the compressor wheel rubs the compressor wheel housing. If there is no rubbing or scraping, go to Step 4.

4. Inspect the compressor and the compressor wheel housing for oil leakage. An oil leak from the compressor may deposit oil in the aftercooler. Drain and clean the aftercooler if you find oil in the aftercooler.

a. Check the oil level in the crankcase. If the oil level is too high, adjust the oil level.

b. Inspect the air cleaner element for restriction. If restriction is found, correct the problem.

c. Inspect the engine crankcase breather. Clean the engine crankcase breather or replace the engine crankcase breather if the engine crankcase breather is plugged.

d. Remove the oil drain line for the turbocharger. Inspect the drain opening. Inspect the oil drain line. Inspect the area between the bearings of the rotating assembly shaft. Look for oil sludge. Inspect the oil drain hole for oil sludge. Inspect the oil drain line for oil sludge in the drain line. If necessary, clean the rotating assembly shaft. If necessary, clean the oil drain hole. If necessary, clean the oil drain line.

e. If Steps 4.a through 4.d did not reveal the source of the oil leakage, the turbocharger has internal damage. Replace the turbocharger.

Inspection of the Turbine Wheel and the Turbine Housing

Remove the air piping from the turbine housing.

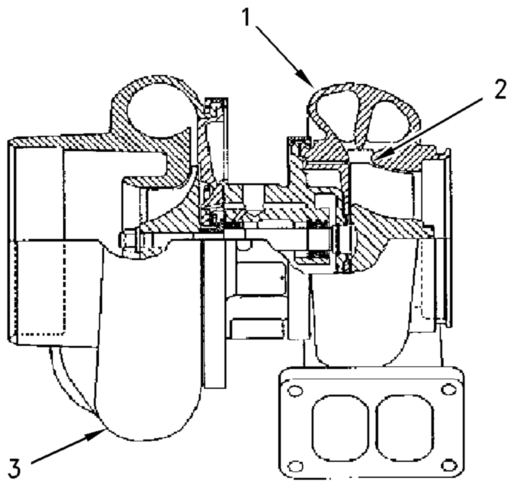

Illustration 11 g00763164

Typical example

(1) Turbine Housing
(2) Turbine Wheel
(3) Turbocharger

1. Inspect the turbine for damage by a foreign object. If there is damage, determine the source of the foreign object. Replace turbocharger (3). If there is no damage, go to Step 2.

2. Inspect turbine wheel (2) for buildup of carbon and other foreign material. Inspect turbine housing (1) for buildup of carbon and foreign material. Clean turbine wheel (2) and clean turbine housing (1) if you find buildup of carbon or foreign material. If there is no buildup of carbon or foreign material, go to Step 3.

3. Turn the rotating assembly by hand. While you turn the assembly, push the assembly sideways. The assembly should turn freely. Turbine wheel (2) should not rub turbine wheel housing (1). Replace turbocharger (3) if turbine wheel (2) rubs turbine housing (1). If there is no rubbing or scraping, go to Step 4.

4. Inspect the turbine and turbine housing (1) for oil leakage. Inspect the turbine and turbine housing (1) for oil coking. Some oil coking may be cleaned. Heavy oil coking may require replacement of the turbocharger. If the oil is coming from the turbocharger center housing go to Step 4.a.

a. Remove the oil drain line for the turbocharger. Inspect the drain opening. Inspect the area between the bearings of the rotating assembly shaft. Look for oil sludge. Inspect the oil drain hole for oil sludge. Inspect the oil drain line for oil sludge. If necessary, clean the rotating assembly shaft. If necessary, clean the drain opening. If necessary, clean the drain line.

b. If crankcase pressure is high, or if the oil drain is restricted, pressure in the center housing may be greater than the pressure of turbine housing (1). Oil flow may be forced in the wrong direction and the oil may not drain. Check the crankcase pressure and correct any problems.

c. If the oil drain line is damaged, replace the oil drain line.

d. Check the routing of the oil drain line. Eliminate any sharp restrictive bends. Make sure that the oil drain line is not too close to the engine exhaust manifold.

e. If Steps 4.a through 4.d did not reveal the source of the oil leakage, turbocharger (3) has internal damage. Replace turbocharger (3).

Lubrication System

i06515918

General Information (Lubrication System)

The following problems generally indicate a problem in the lubrication system of the engine.

- Excessive consumption of engine oil
- Low engine oil pressure
- High engine oil pressure
- Excessive bearing wear

i02693002

Engine Oil Pressure - Test

Table 3

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Pressure Gauge	1
	-	Connector 1/4 inch BSP	1

Tooling (A) measures the engine oil pressure in the system.

1. Ensure that the engine is filled to the correct level with the correct engine oil. Refer to Operation and Maintenance Manual, “Refill Capacities” for further information and refer to Operation and Maintenance Manual, “Fluid Recomendations” for further information. If any other viscosity of oil is used, the information in Table 4 cannot be used.

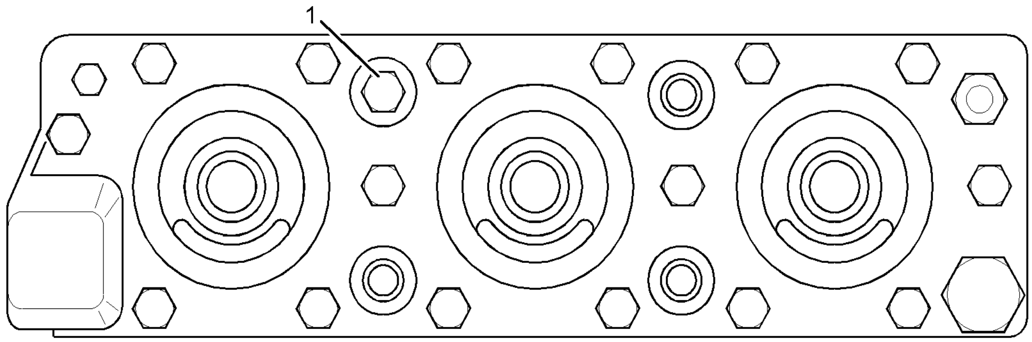

Illustration 12 g01371843

Pressure test location

(1) Location for the pressure test

2. Connect the Tooling (A) to location (1) on the engine oil filter housing.

3. Operate the engine. When the engine oil has achieved a temperature of 99 °C (210 °F), read the pressure gauge and record the pressure.

4. Refer to Table 4 in order to determine if the engine oil pressure is acceptable.

Table 4

Engine Oil Pressure	
Test RPM	**Minimum Permissible Pressure**
1500	250 kPa (36 psi)

If the engine oil pressure is low, determine the cause and correct the condition. Otherwise, engine failure or a reduction in engine service life can result.

5. Compare the recorded engine oil pressure with the engine oil pressure indicator on the instrument panel.

A faulty engine oil pressure indicator or a faulty sensor can provide false indications of low engine oil pressure or high engine oil pressure. If there is a notable difference between the engine oil pressure readings, determine the cause.

Note: A record of engine oil pressure can be used as an indication of possible engine problems or damage. A sudden change of 70 kPa (10 psi) in the engine oil pressure may indicate a problem. Inspect the engine and correct the problem.

i02693004

Excessive Bearing Wear - Inspect

When some components of the engine show bearing wear in a short time, the cause can be a restriction in a passage for engine oil.

An engine oil pressure indicator may show that there is enough engine oil pressure, but a component is worn due to a lack of lubrication. In such a case, look at the passage for the engine oil supply to the component. A restriction in an engine oil supply passage will not allow enough lubrication to reach a component. This will result in early wear.

i02693005

Excessive Engine Oil Consumption - Inspect

Engine Oil Leaks on the Outside of the Engine

Check for leakage at the seals at each end of the crankshaft. Look for leakage at the gasket for the engine oil pan and all lubrication system connections. Look for any engine oil that may be leaking from the crankcase breather. This can be caused by combustion gas leakage around the pistons. A dirty crankcase breather will cause high pressure in the crankcase. A dirty crankcase breather will cause the gaskets and the seals to leak.

Engine Oil Leaks into the Combustion Area of the Cylinders

Engine oil that is leaking into the combustion area of the cylinders can be the cause of blue smoke. There are several possible ways for engine oil to leak into the combustion area of the cylinders:

- Leaks between worn valve guides and valve stems
- Worn components or damaged components (pistons, piston rings, or dirty return holes for the engine oil)
- Incorrect installation of the compression ring and/ or the intermediate ring
- Leaks past the seal rings in the turbocharger shaft
- Overfilling of the crankcase
- Wrong dipstick or guide tube
- Sustained operation at light loads

Excessive consumption of engine oil can also result if engine oil with the wrong viscosity is used.

i02693006

Increased Engine Oil Temperature - Inspect

If the engine oil temperature is higher than normal, the engine oil cooler may have a restriction. Look for a restriction in the passages for engine oil in the engine oil cooler. The engine oil pressure will not necessarily decrease due to a restriction in the engine oil cooler.

Make sure that the cooling system is operating properly. A high coolant temperature in the engine oil cooler will cause high engine oil temperature.

i02693007

Engine Oil Pressure is Low

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

The following conditions can cause an indication of low engine oil pressure:

- Low engine oil level
- Problem with the engine oil pressure gauge
- Contaminated engine oil
- Improper circulation of the engine oil
- Worn components

Low Engine Oil Level

Check the engine oil level. If the engine oil level is too far below the suction tube, the engine oil pump cannot supply enough lubrication for the engine components. If the engine oil level is low, add engine oil in order to obtain the correct level. For the correct engine oil to use, refer to Operation and Maintenance Manual, “Refill Capacities” and Operation and Maintenance Manual, “Fluid Recommendations”.

Engine Oil Pressure Gauge

Refer to Testing and Adjusting, “Engine Oil Pressure - Test”. If the engine oil pressure gauge is incorrect, install a new gauge.

Contaminated Engine Oil

Engine oil that is contaminated with another liquid will cause low engine oil pressure. High engine oil level can be an indication of contamination. Determine the reason for contamination of the engine oil and make the necessary repairs. Change the engine oil and the engine oil filters. For the correct engine oil to use, refer to Operation and Maintenance Manual, “Fluid Recommendations”.

Improper Circulation of the Engine Oil

Several factors could cause improper circulation of the engine oil:

- The engine oil filters are clogged. Replace the engine oil filters.
- A line or a passage for the engine oil is disconnected or broken. Replace the line or clear the passage.
- The engine oil cooler is clogged. Thoroughly clean the engine oil cooler.
- There is a problem with a piston cooling jet. The piston cooling jets direct engine oil toward the bottom of the pistons in order to cool the pistons. This also provides lubrication for the piston pin. Breakage, a restriction, or incorrect installation of a piston cooling jet will cause seizure of the piston.
- The inlet screen of the suction tube for the engine oil pump can have a restriction. This restriction can cause cavitation and a loss of engine oil pressure. Check the inlet screen on the suction tube and remove any material that may be restricting engine oil flow.
- The suction tube is drawing in air. Check the joints of the suction tube for cracks or a damaged O-ring seal.
- There is a problem with the engine oil pump. Check the gears of the engine oil pump for excessive wear. Engine oil pressure is reduced when gears in the engine oil pump have too much wear.

NOTICE

Perkins oil filters are manufactured to Perkins specifications. Use of an oil filter that is not recommended by Perkins could result in severe damage to the engine bearings, crankshaft, etc., as a result of the larger waste particles from unfiltered oil entering the engine lubricating system. Only use oil filters recommended by Perkins.

Worn Components

Excessive clearance at the crankshaft or camshaft bearings will cause low engine oil pressure. Also, inspect the clearance between the rocker arm shafts and the rocker arms. Check the engine components for excessive clearance.

i02693008

Engine Oil Pressure is High

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

Engine oil pressure will be high if the engine oil bypass valves become stuck in the closed position and the engine oil flow is restricted. Foreign matter in the engine oil system could be the cause for the restriction of the oil flow and the movement of the engine oil bypass valves. If the engine oil bypass valves are stuck in the closed position, remove each bypass valve and clean each bypass valve in order to correct this problem. You must also clean each bypass valve bore. Install new engine oil filters. New engine oil filters will prevent more debris from causing this problem. For information on the repair of the engine oil filter bypass valve, refer to Disassembly and Assembly, “Engine Oil Filter Base - Disassemble”.

NOTICE

Perkins oil filters are manufactured to Perkins specifications. Use of an oil filter that is not recommended by Perkins could result in severe damage to the engine bearings, crankshaft, etc., as a result of the larger waste particles from unfiltered oil entering the engine lubricating system. Only use oil filters recommended by Perkins.

Cooling System

i02857803

General Information (Cooling System)

This engine has a type of cooling system that is pressurized. The cooling system has two advantages.

- The pressure helps prevent cavitation.
- The risk of boiling is reduced.

The boiling point is affected by three factors: pressure, altitude and concentration of glycol in the coolant. The boiling point of a liquid is increased by pressure. The boiling point of a liquid is decreased by a higher altitude. Illustration 13 shows the effects of pressure and altitude on the boiling point of water.

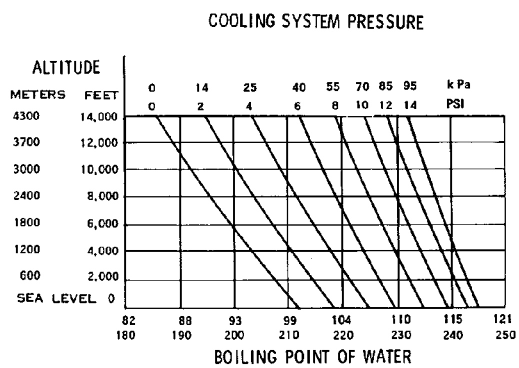

Illustration 13 g00286266

The boiling point of the coolant also depends on the type of coolant and the concentration of glycol. A greater concentration of glycol has a higher boiling temperature. However, glycol transfers heat less effectively than water. Because of the boiling point and the efficiency of heat transfer, the concentration of glycol is important.

Three basic problems can be associated with the cooling system:

- Overheating
- Coolant loss
- Overcooling

If the cooling system is not properly maintained, solids such as scale and deposits reduce the ability of the cooling system to transfer heat. The engine operating temperature will increase.

When the engine is overloaded, the engine will run in the lug condition. When the engine is running in the lug condition, the engine is operating at a lower engine rpm that reduces the coolant flow. Decreased coolant flow during high load will cause overheating.

Coolant can be lost by leaks. Overheated coolant can be lost through the cooling system's pressure relief valve. Lower coolant levels contribute to additional overheating. Overheating can result in conditions such as cracking of the cylinder head and piston seizure.

A cracked cylinder head or cylinder liner will force exhaust gas into the cooling system. The additional pressure causes coolant loss, cavitation of the water pump, less circulation of coolant, and further overheating.

Overcooling is the result of coolant that bypasses the water temperature regulators and flows directly to the radiator or to the heat exchanger. Low load operation in low ambient temperatures can cause overcooling. Overcooling is caused by water temperature regulators that remain open. Overcooling reduces the efficiency of operation. Overcooling enables more rapid contamination of the engine oil. This results in the formation of sludge in the crankcase and carbon deposits on the valves.

Cycles of rapid heating and cooling can result in cracked cylinder heads, gasket failure, accelerated wear, and excessive fuel consumption.

If a problem with the cooling system is suspected, perform a visual inspection before you perform any tests on the system.

Pressure Test on the Oil Cooler

Table 5

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Pressure Gauge	1

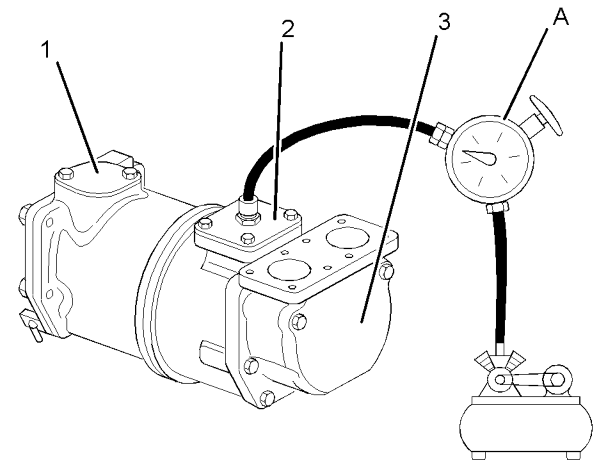

Illustration 14 g01426580

Typical example

1. Make a blanking plate (1). Make a blanking plate with a connection for an air pipe.
2. Fill the oil cooler with clean hot water until the water is level within the outlet flange.
3. Install new joints to blanking plates (1) and (3). Install blanking plates (1) and (3) to the oil cooler.
4. Connect compressed air to the oil cooler. Use Tooling (A). Set the pressure at 345 kPa (50 psi). The pressure should stay constant for three minutes.

i02858317

Visual Inspection

Cooling systems that are not regularly inspected are a cause for increased engine temperatures. Make a visual inspection of the cooling system before a test is made with test equipment.

WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

1. Check the coolant level in the cooling system. Read the two indicators for the coolant level in the top of the radiator (if equipped).
2. Look for leaks in the system.
3. Look for bent core fins or debris between the fins of the radiator (if equipped). Be sure that air flow through the radiator is not restricted.
4. Check for damage to the fan blades (if equipped).
5. After the engine is cool, remove the filler cap slowly. This will allow any pressure out of the cooling system. Inspect the filler cap and the surface that seals the cap. This surface must be clean and the seal must not be damaged.
6. Check the pressure relief valve. Contact your OEM for further information.

i06551650

Water Temperature Regulator - Test

WARNING

Personal injury can result from hot coolant, steam and alkali.

At operating temperature, engine coolant is hot and under pressure. The radiator and all lines to heaters or the engine contain hot coolant or steam. Any contact can cause severe burns.

Remove filler cap slowly to relieve pressure only when engine is stopped and radiator cap is cool enough to touch with your bare hand.

Cooling System Conditioner contains alkali. Avoid contact with skin and eyes.

Note: This information only applies to engine-mounted fresh water temperature regulators.

1. Remove the water temperature regulator from the engine.
2. Heat the coolant gradually in a suitable container.
3. Hang the water temperature regulator in the container of coolant. The water temperature regulator must be below the surface of the coolant and away from the sides and the bottom of the container.
4. Keep the coolant at the correct temperature for 10 minutes. The opening temperature of the water temperature regulator is 84° C (183° F).
5. After 10 minutes, remove the water temperature regulator. Ensure that the valve on the water temperature regulator is fully open.

Replace the water temperature regulator if the valve on the water temperature regulator is not open at the specified temperature. Refer to Operation and Maintenance Manual, “Water Temperature Regulator - Replace” for further information.

Basic Engine

i02857720

Connecting Rod Bearings

Before you install the piston and piston pin, measure the bore in the piston pin bearing. Before you install the connecting rod, measure the bore in the bearing for the crankshaft. The bores must be within specifications or the bearings will not fit properly. This will cause wear and damage to the connecting rod, the bearing for the piston pin, the bearing for the crankshaft, the piston pin, and the crankshaft.

After the bearings are installed, measure the bores in the bearings. Refer to Specifications, “Connecting Rod” for the correct measurements.

The length of a connecting rod can be altered by use. After the bearings are installed, measure the distance from the center of the piston pin bearing to the center of the crankshaft bearing. Refer to Specifications, “Connecting Rod” for the correct measurements.

Connecting rod bearings are available with 0.25 mm (0.0010 inch) and 0.51 mm (0.020 inch) smaller inside diameter than the original size bearing. These bearings are for crankshafts that have been ground.

i02859895

Main Bearings

Main bearings are available with an inside diameter that is 0.25 mm (0.010 inch) or 0.51 mm (0.020 inch) smaller than the inside diameter of the original bearings. These bearings are for crankshafts that have been ground. Refer to Specifications, “Connecting Rod” for further information.

If necessary, replace the main bearings. Refer to Disassembly and Assembly, “Crankshaft Main Bearings - Remove and Install” for the correct procedure.

i02862425

Cylinder Block

1. Clean all of the coolant passages and the oil passages.

2. Check the cylinder block for cracks and damage.

3. The top deck of the cylinder block must not be machined. This will affect the depth of the cylinder liner flange and the piston height above the cylinder block.

4. Check the front camshaft bearing for wear. Refer to Specifications, “Camshaft Bearings” for the correct specification of the camshaft bearing. If a new bearing is needed, use a suitable adapter to press the bearing out of the bore. Ensure that the oil hole in the new bearing faces the front of the block. The oil hole in the bearing must be aligned with the oil hole in the cylinder block. The bearing must be aligned with the face of the recess.

i06516674

Cylinder Head

1. Visually examine the valve face for damage (1). Examine the valve stem for score marks, wear, or damage near the groove for the valve keepers (3).

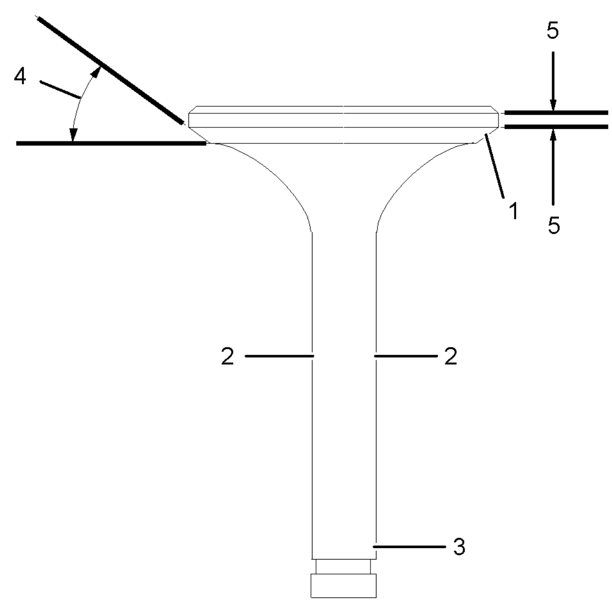

Illustration 15 g01425719

Typical example

2. Check the dimension of the valve stem (2). Refer to Specifications, “Cylinder Head Valves”.

3. If the valve is within the service limit but with slight damage to the valve face (1), the valve can be refaced at an angle of 20 degrees (4).

Note: If the dimension (5) is less than 1 mm (0.04 inch) after refacing, the valve must be discarded.

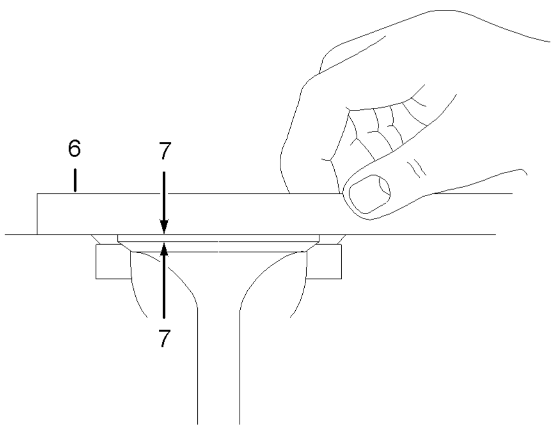

Illustration 16 g01425718

Typical example

1. Install a valve into the cylinder head. Use a straight edge (6) to check the valve depth. If the depth exceeds 1 mm (0.040 inch) (7) the valve must be replaced.

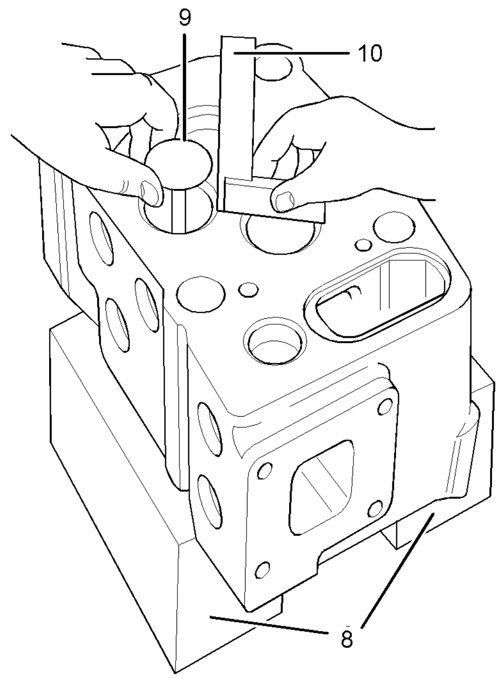

Illustration 17 g01425720

Typical example

2. Support the cylinder head on two blocks of wood (8). Install the valve into the cylinder head. Hold the valve seat so the valve seat protrudes 10 mm (0.40 inch) from the surface of the cylinder head (9). Use a straight edge (10) and check the clearance between the valve and valve guide. If the clearance exceeds 0.5 mm (0.02 inch) the valve guide must be replaced.

3. Check the free length of the valve spring. If the valve spring is less than 55.6 mm (2.2 inch), the valve spring must be replaced.

Inspection and Pressure Test

1. Remove the valves and springs.

Note: Do not scratch any machined surface on the cylinder head.

2. Clean the carbon deposits from the cylinder head and the ports of the cylinder head.

3. Wash the cylinder head with a solvent. The solvent must be used in accordance with the instructions of the manufacturer. Use compressed air to dry the cylinder head.

4. Test the cylinder head for leaks.

5. When the cylinder head is thoroughly clean, check the cylinder head for cracks. Inspect the area around the valve seats. Check around the hole for the fuel injector.

i02693029

Flywheel - Inspect

Face Runout (Axial Eccentricity) of the Flywheel

Table 6

Required Tools			
Tool	Part Number	Part Description	QTY
A	21825617	Dial Indicator Group	1

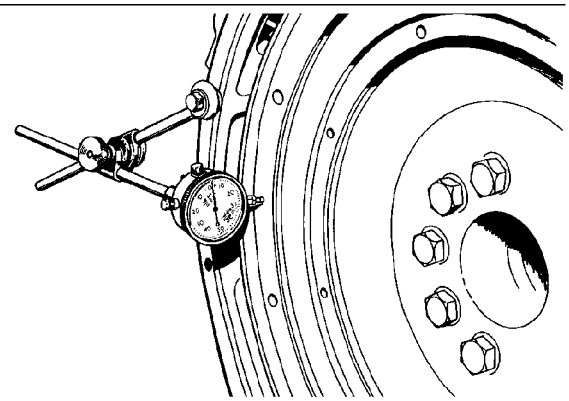

Illustration 18 g00812156

Typical example for checking face runout of the flywheel

(1) Dial indicator group

1. Refer to Illustration 18 and install Tooling (A). Always put a force on the crankshaft in the same direction before the dial indicator is read. This will remove any crankshaft end clearance.
2. Set the dial on Tooling (A) to read zero.
3. Turn the flywheel at intervals of 90 degrees and read the dial.
4. Take the measurements at all four points. The difference between the lower measurements and the higher measurements that are performed at all four points must not be more than 0.13 mm (0.005 inch), which is the maximum permissible face runout (axial eccentricity) of the flywheel.

Bore Runout (Radial Eccentricity) of the Flywheel

Table 7

Required Tools			
Tool	Part Number	Part Description	QTY
A	21825617	Dial Indicator Group	1

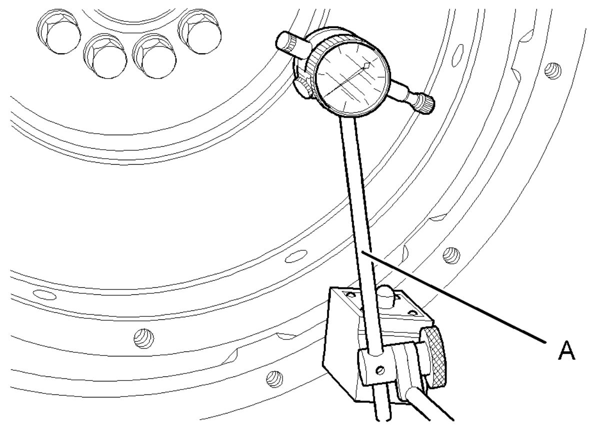

Illustration 19 g01377841

Typical example for checking the bore runout of the flywheel

(1) Dial indicator group

1. Install Tooling (A). Make an adjustment of Tooling (A) so the dial indicator makes contact on the flywheel.
2. Set the dial on Tooling (A) to read zero.
3. Turn the flywheel at intervals of 90 degrees and read the dial.
4. Take the measurements at all four points. The difference between the lower measurements and the higher measurements that are performed at all four points must not be more than the following values for the maximum permissible bore runout (radial eccentricity) of the flywheel.

Maximum flywheel bore runout
. . . . 0.13 mm ((0.005 inch))

i02858320

Flywheel Housing - Inspect

Table 8

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825617	Dial Indicator Group	1

Face Runout (Axial Eccentricity) Of The Flywheel Housing

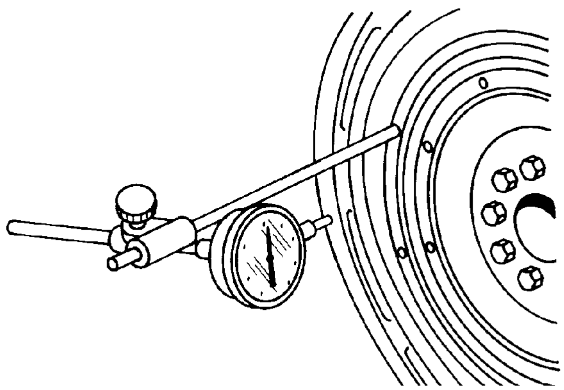

Illustration 20 g00285931

Checking face runout of the flywheel housing

If you use any other method except the method that is given here, always remember that the bearing clearance must be removed in order to receive the correct measurements.

1. Fasten a dial indicator to the flywheel so the anvil of the dial indicator will contact the face of the flywheel housing.
2. Put a force on the crankshaft toward the rear before the dial indicator is read at each point.

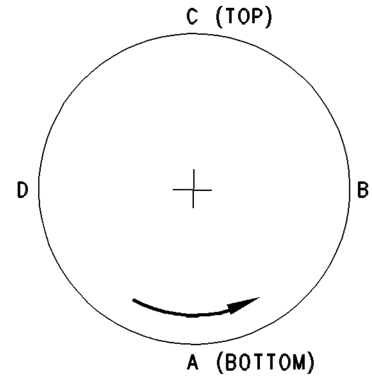

Illustration 21 g00285932

Checking face runout of the flywheel housing

3. Turn the flywheel while the dial indicator is set at 0.0 mm (0.00 inch) at location (A). Read the dial indicator at locations (B), (C) and (D).
4. The difference between the lower measurements and the higher measurements that are performed at all four points must not be more than 0.38 mm (0.015 inch), which is the maximum permissible face runout (axial eccentricity) of the flywheel housing.

Bore Runout (Radial Eccentricity) Of The Flywheel Housing

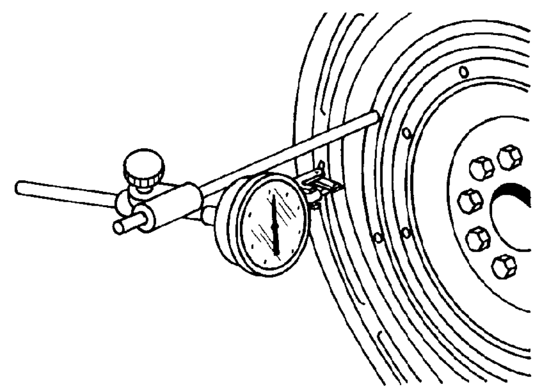

Illustration 22 g00285934

Checking bore runout of the flywheel housing

1. Fasten a dial indicator to the flywheel so the anvil of the dial indicator will contact the bore of the flywheel housing.

CHART FOR DIAL INDICATOR MEASUREMENTS					
	Position of dial indicator				
	Line No.	A	B	C	D
Correction for bearing clearance	I	0			
Dial Indicator Reading	II	0			
Total of Line 1 & 2	III	0	**	*	**

*Total Vertical eccentricity (out of round).
**Subtract the smaller No. from the larger No. The difference is the total horizontal eccentricity.

Illustration 23 g00285936

2. While the dial indicator is in the position at location (C) adjust the dial indicator to 0.0 mm (0.00 inch). Push the crankshaft upward against the top of the bearing. Refer to the illustration 23 . Write the measurement for bearing clearance on line 1 in column (C).

Note: Write the measurements for the dial indicator with the correct notations. This notation is necessary for making the calculations in the chart correctly.

3. Divide the measurement from Step 2 by two. Write this number on line 1 in columns (B) and (D).

4. Turn the flywheel in order to put the dial indicator at position (A). Adjust the dial indicator to 0.0 mm (0.00 inch).

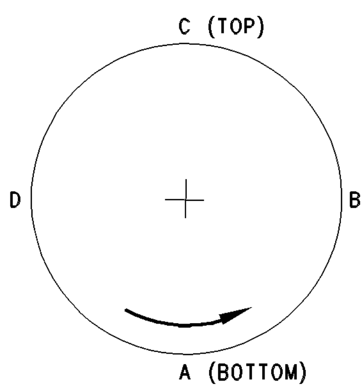

Illustration 24 g00285932

Checking bore runout of the flywheel housing

5. Turn the flywheel counterclockwise in order to put the dial indicator at position (B). Write the measurements in the chart.

6. Turn the flywheel counterclockwise in order to put the dial indicator at position (C). Write the measurement in the chart.

7. Turn the flywheel counterclockwise in order to put the dial indicator at position (D). Write the measurement in the chart.

8. Add the lines together in each column.

9. Subtract the smaller number from the larger number in column B and column D. Place this number on line III. The result is the horizontal eccentricity (out of round). Line III in column C is the vertical eccentricity.

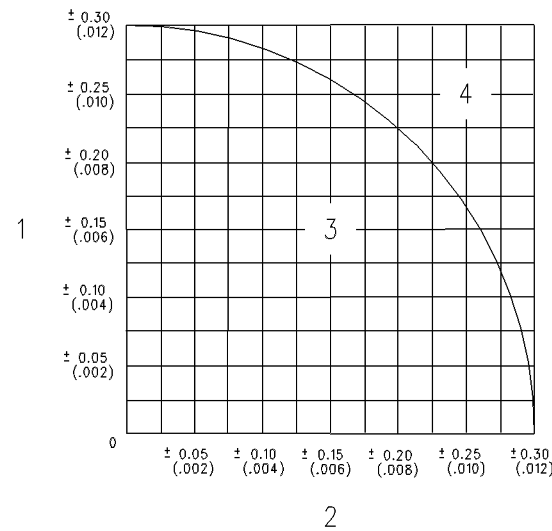

Illustration 25 g00286046

Graph for total eccentricity

(1) Total vertical eccentricity
(2) Total horizontal eccentricity
(3) Acceptable value
(4) Unacceptable value

10. On the graph for total eccentricity, find the point of intersection of the lines for vertical eccentricity and horizontal eccentricity.

11. The bore is in alignment, if the point of intersection is in the range that is marked “Acceptable”. If the point of intersection is in the range that is marked “Not acceptable”, the flywheel housing must be changed.

i02995981

Crankshaft Thrust - Measure

Table 9

Required Tools			
Tool	Part Number	Part Description	QTY
A	21825617	Dial Indicator Group	1

A thrust washer is installed on either side of the rear main bearing. This controls the end play of the crankshaft.

Force the crankshaft toward the front of the engine and back to the rear of the engine.

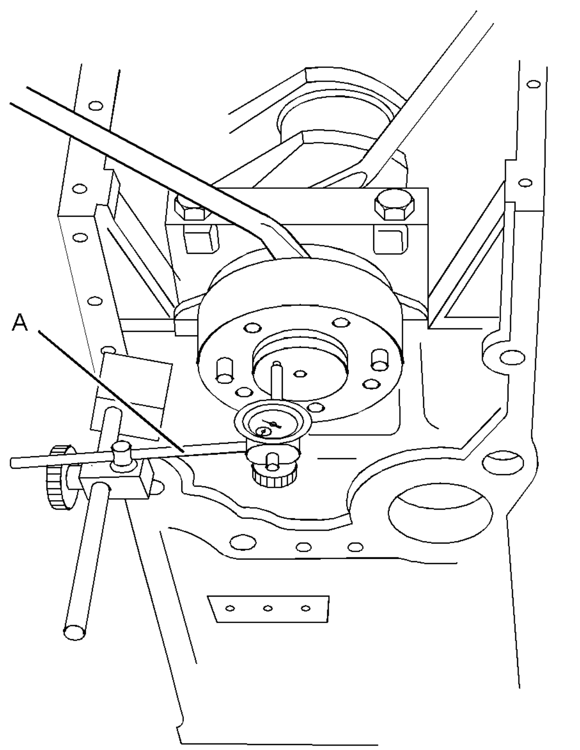

Illustration 26 g01519076

Typical example

1. Check the end play of the crankshaft with Tooling (A).

2. To check the tolerance of the crankshaft end play, refer to Specifications, “Crankshaft”.

i06554414

Vibration Damper

The damper is mounted to the crankshaft on the front of the engine. Damage to the damper will increase torsional vibration. The increase in vibration may result in damage to the crankshaft and to other engine components.

Viscous Damper

Inspect the damper for evidence of fluid leaks. If a fluid leak is found, determine the type of fluid. The fluid in the damper is silicone. Silicone is transparent, smooth, and viscous. It is difficult to remove silicone from most surfaces.

If the fluid leak is engine oil, inspect the crankshaft seals for leaks. If a leak is observed, replace the crankshaft seals.

Inspect the damper. Replace the damper for any of the following reasons:

- The damper has been dropped.
- The damper has been subject to an impact.
- The damper is dented, cracked, or leaking.
- The paint on the damper is discolored from heat.
- The engine has had a failure because of a broken crankshaft.
- Analysis of the engine oil has revealed that the front main bearing is badly worn.
- There is a large amount of gear train wear that is not caused by a lack of engine oil.

i06515929

Gear Group (Front)

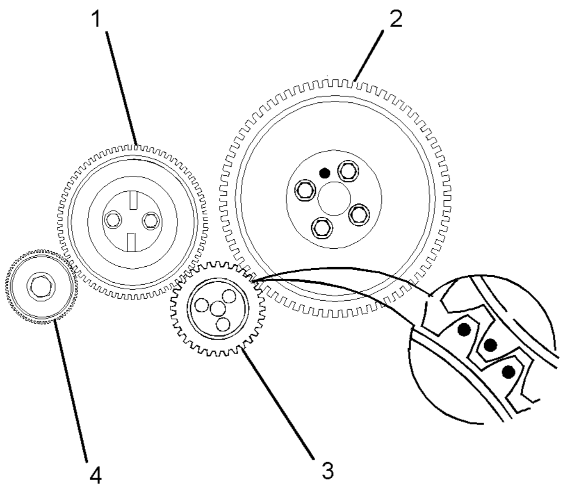

Illustration 27 g06005826

Typical example

(1) Idler gear
(2) Camshaft gear
(3) Crankshaft gear
(4) Oil Pump Gear

1. Inspect the gears for wear or for damage. If the gears are worn or damaged, use new parts for replacement.

2. Make sure that the timing marks on the gears (1), (2), (3) and (4) are in alignment.

3. Measure the backlash between idler gear (1) and oil pump gear (4). Refer to Specifications, "Gear Group (Front)" for the backlash measurement.

4. Measure the backlash between oil pump gear (4) and crankshaft gear (3). Refer to Specifications, "Gear Group (Front)" for the backlash measurement.

5. Measure the backlash between idler gear (1) and crankshaft gear (3). Refer to Specifications, "Gear Group (Front)" for the backlash measurement.

6. Measure the backlash between camshaft gear (2) and idler gear (1). Refer to Specifications, "Gear Group (Front)" for the backlash measurement.

Electrical System

i02693049

Battery

⚠ WARNING

Never disconnect any charging unit circuit or battery circuit cable from the battery when the charging unit is operated. A spark can cause an explosion from the flammable vapor mixture of hydrogen and oxygen that is released from the electrolyte through the battery outlets. Injury to personnel can be the result.

The battery circuit is an electrical load on the charging unit. The load is variable because of the condition of the charge in the battery.

NOTICE

The charging unit will be damaged if the connections between the battery and the charging unit are broken while in operation. Damage occurs because the load from the battery is lost and because there is an increase in charging voltage. High voltage will damage the charging unit, the regulator, and other electrical components.

Use a suitable battery load tester in order to test the battery that does not maintain a charge when the battery is active.

i02995102

Charging System

Note: This procedure is only applicable if a charging system is installed. The charging system must be driven by the engine.

The condition of charge in the battery at each regular inspection will indicate whether the charging system operates correctly. An adjustment is necessary when the battery is constantly in a low condition of charge or a large amount of water is needed.

Test the charging unit and the voltage regulator on the engine. Use wiring and components that are a permanent part of the system. This testing will give an indication of needed repair. After repairs are made, perform a test in order to prove that the units have been repaired to the original condition of operation.

To check for correct output of the alternator, refer to Specifications.

Before the start of on-engine testing, the charging system and the battery must be checked according to the following steps.

1. The battery must be at least 75 percent (1.225 Sp Gr) of the full charge. The battery must be held tightly in place. The battery holder must not put too much stress on the battery.
2. Cables between the battery, the starter, and the engine ground must be the correct size. Wires and cables must be free of corrosion. Wires and cables must have cable support clamps in order to prevent stress on battery connections (terminals).
3. Inspect the drive components for the charging unit in order to be sure that the components are free of grease and oil. Be sure that the drive components have the ability to operate the charging unit.

i06551613

Electric Starting System

One starting motor is installed to the engine.

Use a suitable multimeter in the DCV range to find the starting system components which do not function.

Move the start control switch to activate the starting solenoids. The operation of the starting solenoids can be heard as the pinions of the starting motors are engaged with the ring gear on the engine flywheel.

If a solenoid for a starting motor will not operate, it is possible that the current from the battery did not reach the solenoid. Fasten one lead of the multimeter to the connection terminal for the battery cable on the solenoid. Put the other lead to the battery negative. A zero reading indicates that there is a broken circuit from the battery. More testing is necessary when there is a voltage reading on the multimeter.

The solenoid operation also closes the electric circuit to the motor. Connect one lead of the multimeter to the connection terminal of the solenoid that is fastened to the motor. Fasten the other lead to the battery negative. Activate the starting solenoid and look at the multimeter. A reading of the battery voltage shows that the problem is in the motor. The motor must be removed for further testing. A zero reading on the multimeter shows that the solenoid contacts do not close. Repair the solenoid if the contacts do not close. The clearance on the pinion gear for the starting motor may also need adjusting.

Fasten one multimeter lead to the connecting terminal for the small wire to the solenoid and fasten the other lead to the battery negative. Look at the multimeter and activate the starting solenoid. A voltage reading shows that the problem is in the solenoid. A zero reading indicates that the problem is in the start switch or in the wires for the start switch.

Fasten one multimeter lead to the start switch at the connection terminal for the wire from the battery. Fasten the other lead to the battery negative. A zero reading indicates a broken circuit from the battery. Check the circuit breaker and wiring. If there is a voltage reading, the problem is in the start switch or in the wires for the start switch.

Starting motors that operate too slowly can overload because of too much friction in the engine that is being started. Slow operation of the starting motors can also be caused by the following conditions:

- A short circuit
- Loose connections
- Dirt in the motors

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