INTRODUCTION

GENERAL

This section has the description and the repair procedures for the engine and the fuel system Removal, disassembly, cleaning, assembly, installation, specifications and troubleshooting procedures are included.

⚠ DANGER

Some gaskets used in this engine can contain asbestos or other fibers. Breathing asbestos dust is a cancer or lung disease hazard. Do not create dust! Use vacuum equipment for asbestos or follow the cleaning procedure described below.

- **Use a hand scraper to remove old gasket material. Do not use a power tool or compressed air.**
- **Make sure the gasket material is wet with water or oil to prevent particles in the air.**
- **Discard all asbestos material in a closed container while it is still wet. Put an "ASBESTOS" warning label on the container. Discard asbestos material safely.**

⚠ CAUTION

Disconnect the battery cables before doing any disassembly and repair to the engine or parts of the electrical system.

The diodes and resistors in the electrical system can be damaged if the following cautions are not followed:

- **Do not disconnect the battery when the engine is running. The voltage surge can damage the diodes and resistors.**
- **Do not disconnect an electric wire before the engine is stopped and the switches are "OFF".**
- **Do not cause a short circuit by connection of the electric wires to the wrong terminals. Make sure a correct identification is made of the wire before it is connected.**
- **Make sure a battery is the correct voltage and polarity before it is connected.**
- **Do not check for current flow by making a spark because the transistors can be damaged.**

DESCRIPTION

The Isuzu C240 diesel engine is a four–cylinder engine that has a displacement of 2369 cm^3 (144.5 in^3). The firing order is 1–3–4–2. The No. 1 cylinder is toward the end of the engine with the fan. The serial number of the engine is found on the right–hand side of the crankcase at the No. 1 cylinder location.

The cylinder head has a small ignition chamber above each cylinder. The diesel fuel is injected into this ignition chamber at the beginning of each power stroke of the piston. This design of the combustion chambers gives better fuel efficiency and less engine noise at the engine speeds used in a lift truck. A glow plug is also installed in each ignition chamber. These glow plugs are cold start aids to make the diesel engine easier to start when the engine is cold.

The valve seats and valve guides can be replaced during an engine overhaul.

The crankshaft has five main bearings. The main bearing in the center of the crankshaft is also the thrust bearing and has thrust washers (thrust bearings) on each side of the main bearing.

The pistons are aluminum alloy and have four piston rings. Each of the three compression rings have a special shape designed for its position on the piston. The fourth piston ring is the oil control ring.

The engines used in the S/H1.25–3.00XL (S/H25–60XL) units have an auxiliary gear drive on the timing cover for the hydraulic pump. On the H2.00–3.20XM (H40–65XM) units the hydraulic pump is driven by the transmission.

Isuzu C240 diesel engines installed in lift trucks before April 1990 all have a fuel injection pump, Model PE4A, made by Diesel Kiki under license from Robert Bosch. This fuel injection pump has four plunger assemblies that supply fuel to the four fuel injectors.

Engines with a fuel injection pump, Model PE4A, have a pneumatic governor to control the maximum engine speed. The operation of this governor is described in the **Fuel System** later in this section.

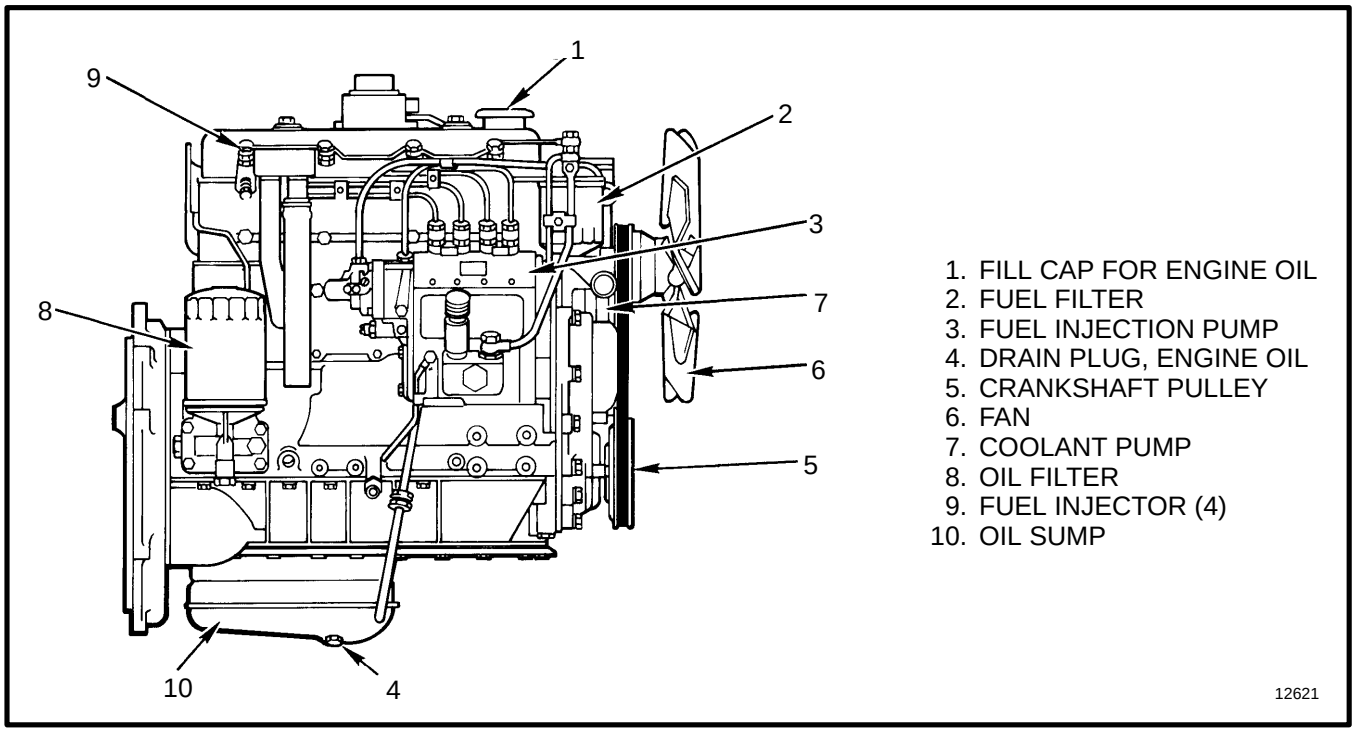


FIGURE 1. ISUZU C240 DIESEL ENGINE

Some Isuzu C240 diesel engines installed in lift trucks after April 1990 have a fuel injection pump, Model VE, made by Diesel Kiki. This fuel injection pump has one plunger assembly that supplies fuel to the four fuel injectors.

Engines with a fuel injection pump, Model VE, have a mechanical governor to control the maximum engine speed. The operation of this governor is described in the Fuel System later in this section.

Engines with a fuel injection pump, Model PE4A, must have a shut–off valve in the air intake manifold. This shut–off valve prevents the engine from starting and running in the reverse direction.

The design of the fuel injection pump, Model VE, prevents the engine from starting and running in the reverse direction. The fuel will not be sent to a cylinder during a compression stroke.

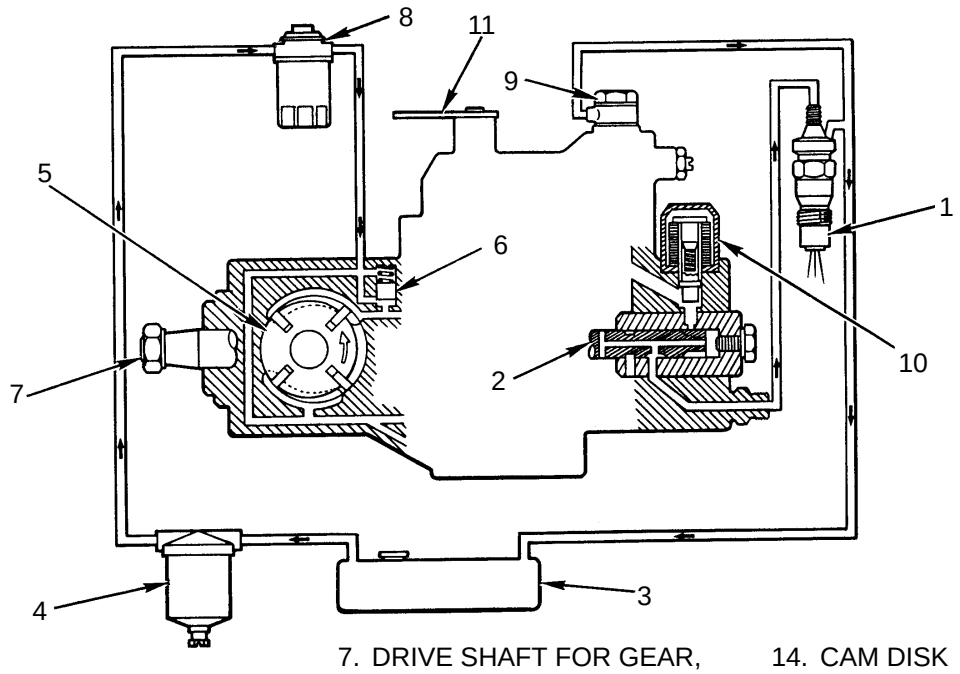
FUEL SYSTEM

Description

NOTE: Special tools and training are needed to repair the fuel injection pump. A fuel injection pump is normally sent to an authorized Diesel Kiki repair station if repairs are necessary. Fuel injectors also require special equipment and training for repair. Most users have a special repair service do this work. **The repair of the fuel injection pump and the fuel injectors are not described in this section.**

A description of the fuel systems for the fuel injection pump, Model VE and fuel injection pump, Model PE4A are included in the following paragraphs.

Check the timing of the fuel injection pump as described in Checks and Adjustments. During installation of the fuel injection pump, remove the air from the fuel system as described in CHECKS AND ADJUSTMENTS.



1. FUEL INJECTOR
2. PLUNGER
3. FUEL TANK
4. WATER SEPARATOR
5. FUEL PUMP (VIEW ROTATED FOR CLARITY)
6. REGULATOR VALVE
7. DRIVE SHAFT FOR GEAR, FUEL INJECTION PUMP
8. FINAL FUEL FILTER
9. OVERFLOW VALVE
10. MAGNET VALVE
11. CONTROL LEVER
12. FLY WEIGHT (4)
13. ROLLER HOLDER
14. CAM DISK
15. TIMER
16. PLUNGER SPRING
17. DELIVERY VALVE
18. DISTRIBUTOR HEAD
19. GOVERNOR LEVER
20. ADJUSTMENT SCREW, FULL LOAD

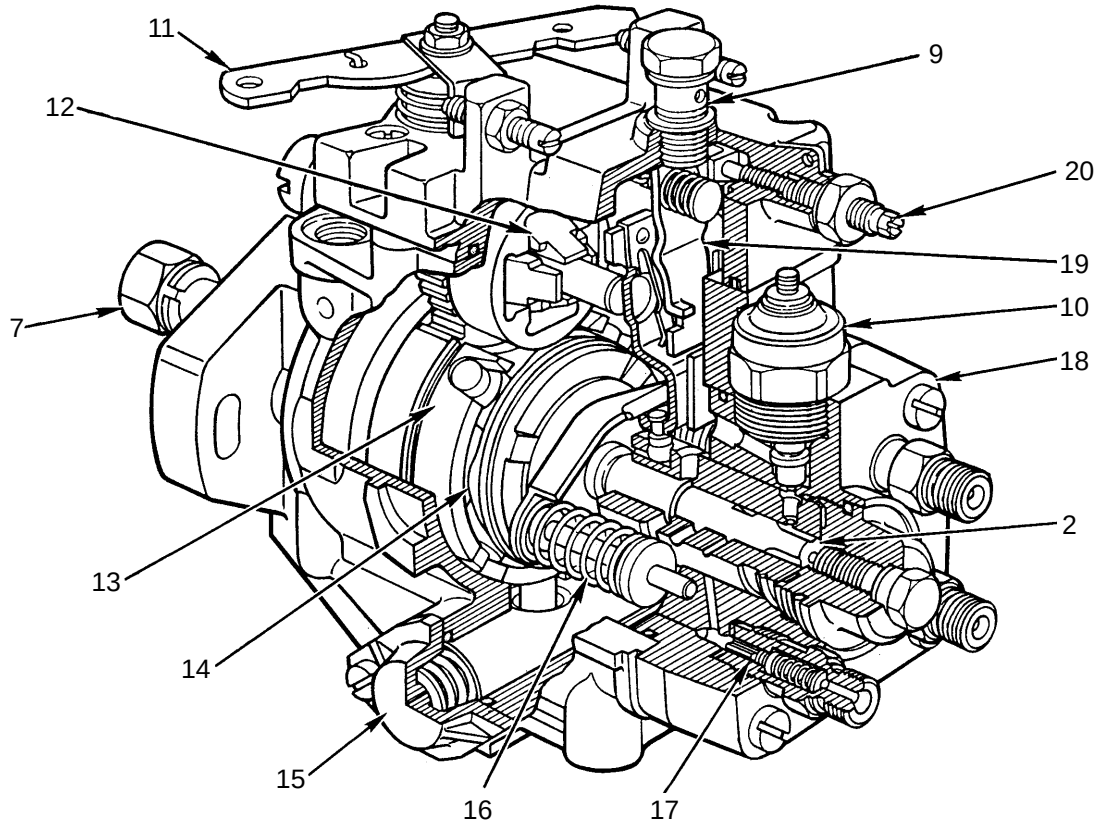


FIGURE 2. THE FUEL SYSTEM, FUEL INJECTION PUMP, MODEL VE

Operation, Fuel Injection Pump, Model VE (See FIGURE 2.)

The parts of the fuel system include the fuel tank, injection pump and governor, fuel filters, and injectors. A basic diagram of the fuel system with the fuel injection pump, Model VE is shown in FIGURE 2.

The magnet valve is controlled by the ignition switch. When the ignition switch is turned to **ON**, the coil in the magnet valve is energized. The magnet valve opens to permit fuel to flow into the pressure chamber for the plunger (2). When the ignition switch is turned to **OFF**, the magnet valve closes and stops the flow of fuel. The magnet valve permits the engine to be stopped quickly when the ignition switch is turned to **OFF**.

The drive shaft (7) is turned by the gear train in the engine. The fuel pump (5) is a rotary vane pump that takes fuel from the fuel tank through the water separator. The pressure of the fuel oil from the fuel pump increases when the speed of the drive shaft increases. The regulator valve controls the pressure of the fuel oil to the specifications set by the manufacturer. The fuel oil flows into the inlet for the distributor head (18) to the pressure chamber for the plunger (2). The cam disk (14) rotates the plunger (2) and moves the plunger in and out of the plunger barrel. The plunger (2) increases the pressure of the fuel oil. The rotation of the plunger aligns the passages with the ports in the distributor head (18). Each port in the distributor head has a fuel pipe connected to a fuel injector. The fuel flows to the fuel injector.

The overflow valve (9) in the injection pump is a by–pass valve that permits some fuel oil to return the the fuel tank. The overflow valve keeps the fuel oil at a constant pressure in the plunger chamber so that the fuel flow to the fuel injectors is even.

See FIGURE 3. A control sleeve (6) slides on the plunger and partially opens a passage in the plunger to control the amount of fuel oil sent to the fuel injectors. This control sleeve is controlled by both the control lever and the mechanical governor. The control lever is connected to the accelerator pedal for the lift truck.

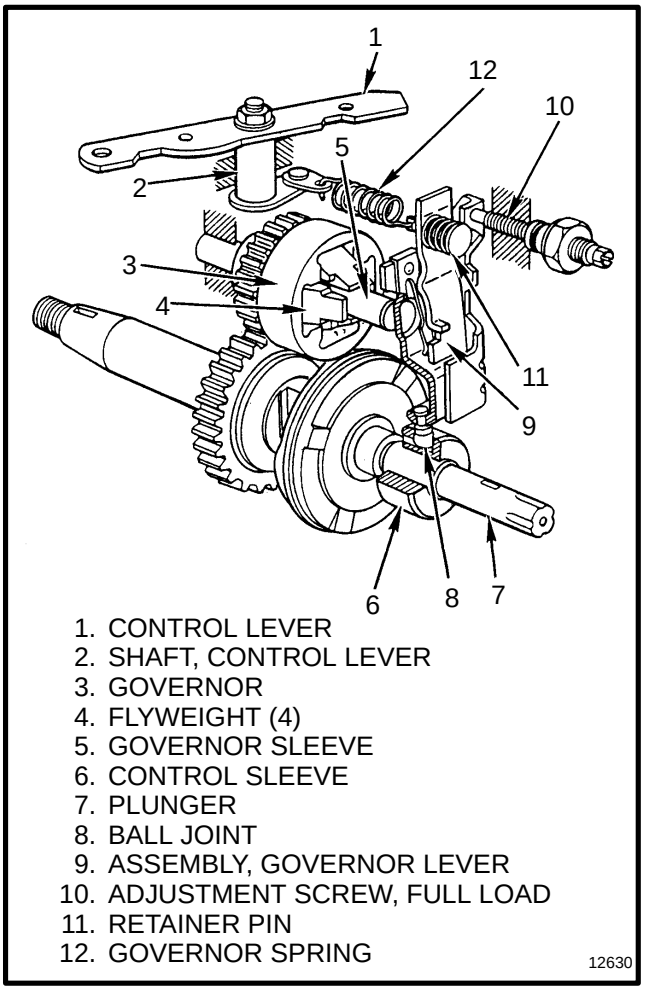


FIGURE 3. SPEED CONTROL, FUEL INJECTION PUMP, MODEL VE

Operation, Fuel Injection Pump, Model PE4A

The parts of the fuel system include the fuel tank, injection pump and pneumatic governor, fuel filter, injectors and the air control valve. The fuel pump is fastened to the side of the fuel injection pump and is actuated by the cam shaft in the fuel injection pump. The fuel pump takes fuel from the fuel tank and sends it through the fuel filter. The fuel goes from the fuel filter to the fuel reservoir in the fuel injection pump. The fuel injection pump sends the correct amount of high pressure fuel to each fuel injector. The high pressure fuel opens the push rod (valve) in the fuel injector to send a spray of fuel into the combustion chamber. A basic diagram of the fuel system is shown in FIGURE 4.

The parts of the fuel injection pump are shown in FIGURE 5. The camshaft in the injection pump actuates the four plunger assemblies. Each of these plunger assemblies sends fuel under high pressure to the fuel injectors. The fuel injection pump is turned by the camshaft gear.

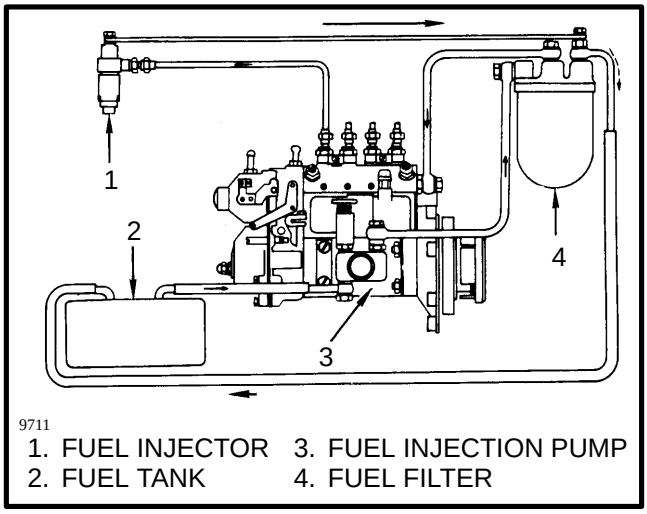


FIGURE 4. THE FUEL SYSTEM, FUEL INJECTION PUMP, MODEL PE4A

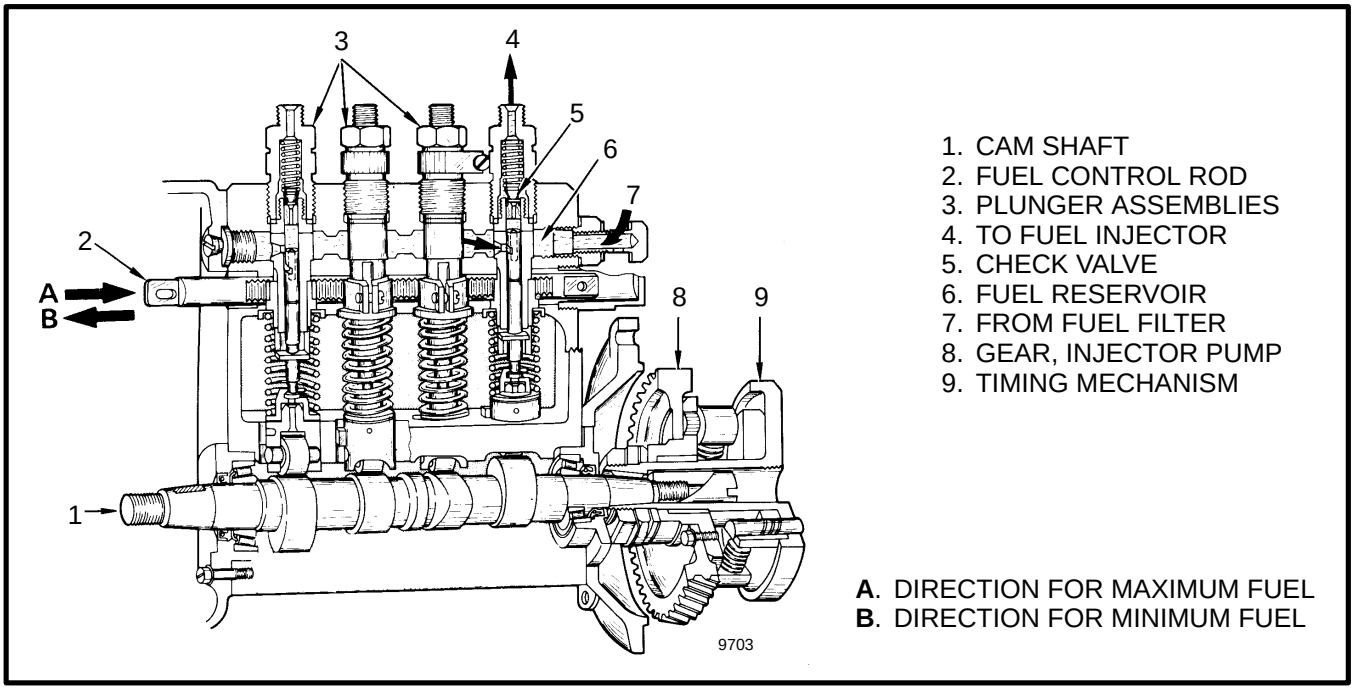


FIGURE 5. FUEL INJECTION PUMP, MODEL PE4A

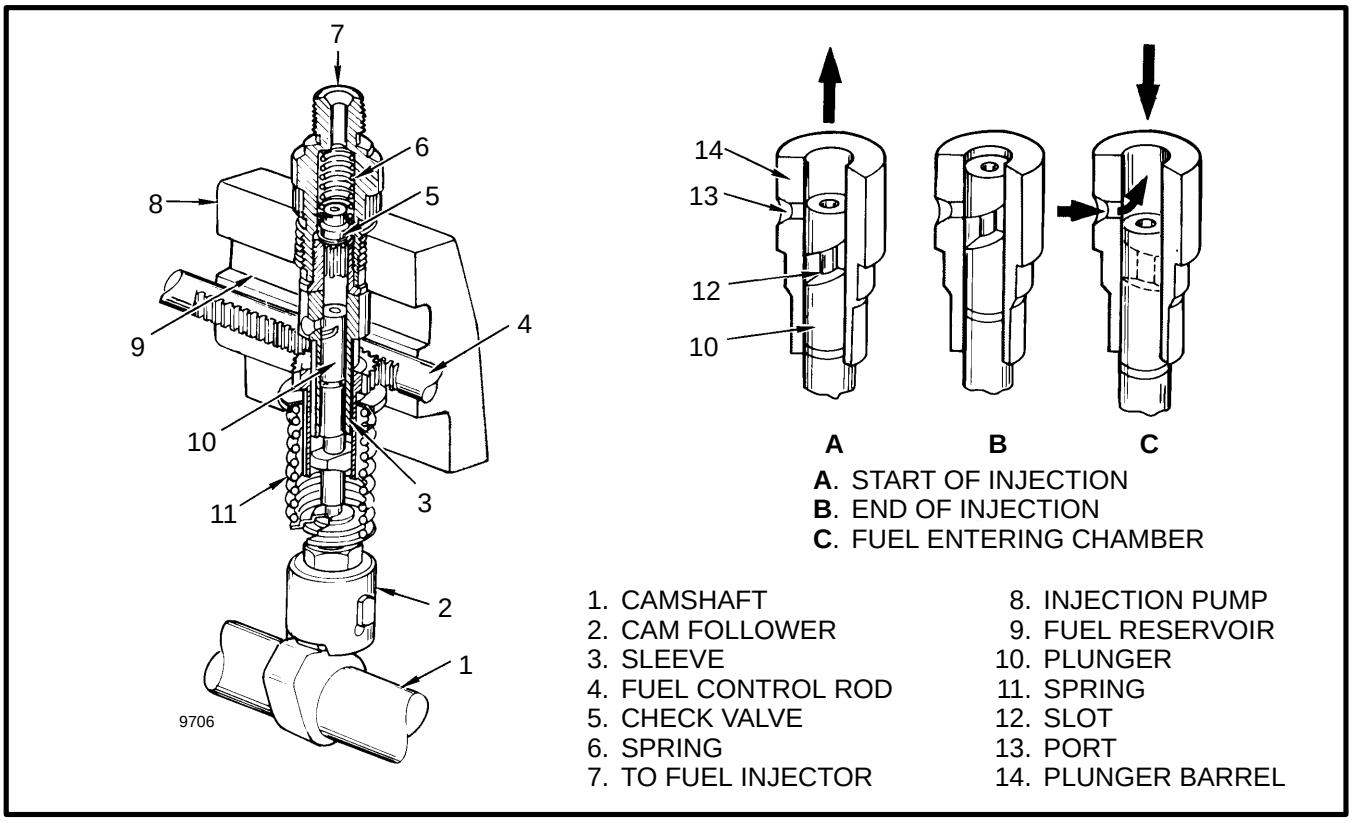


FIGURE 6. PLUNGER ASSEMBLY, FUEL INJECTION PUMP, MODEL PE4A

The fuel pump gives a constant supply of fuel to the fuel reservoir that is in the injection pump. The position of the ports in each plunger assembly are in this fuel reservoir. When a plunger is at the bottom of its stroke, fuel passes through the port and enters the chamber above the plunger. As the camshaft rotates, it begins to push the plunger up and close the port. The pressure of the fuel increases in the chamber which pushes the check valve open. Then the fuel is flows with high pressure to the fuel injector.

Fuel injection from the pump stops when the slot in the plunger is even with the port. Now the pressure of the fuel immediately lowers in the chamber which causes the check valve to close. The fuel in the chamber flows through the plunger and then through the port.

See FIGURE 6. The volume of fuel that is sent to the injectors is controlled by the position of the slot in the plunger. Rotation of the plunger will change the volume of injection since the slot is at an angle. Each of the plungers has a pinion that connects to the fuel control rod. The position of the slots in the plungers is changed by the movement of the fuel control rod. The movement of the fuel control rod is controlled by the pneumatic governor mechanism.

Pneumatic Governor For Fuel Injection Pump, Model PE4A (See FIGURE 7.)

The pneumatic governor controls the speed of the engine by moving the fuel control rod. Movement of the fuel control rod changes the volume of fuel that is sent to the injectors. The fuel control rod moves during changes of pressure that occur at the venturi in the air control valve. The governor is installed to the fuel injection pump.

The governor has two chambers that are separated by a diaphragm. Each chamber is connected to the air inlet valve by a hose. The diaphragm is connected to the fuel control rod. The rear chamber has a spring. The spring pushes the diaphragm and the fuel control rod to the position for maximum fuel. This chamber is connected by a hose (red) to the venturi (low pressure) section of the air control valve. The other chamber is connected by a hose (green) to the top (normal pressure) of the air inlet valve. The amount that the fuel control rod moves is

controlled by the difference of pressures between the two chambers.

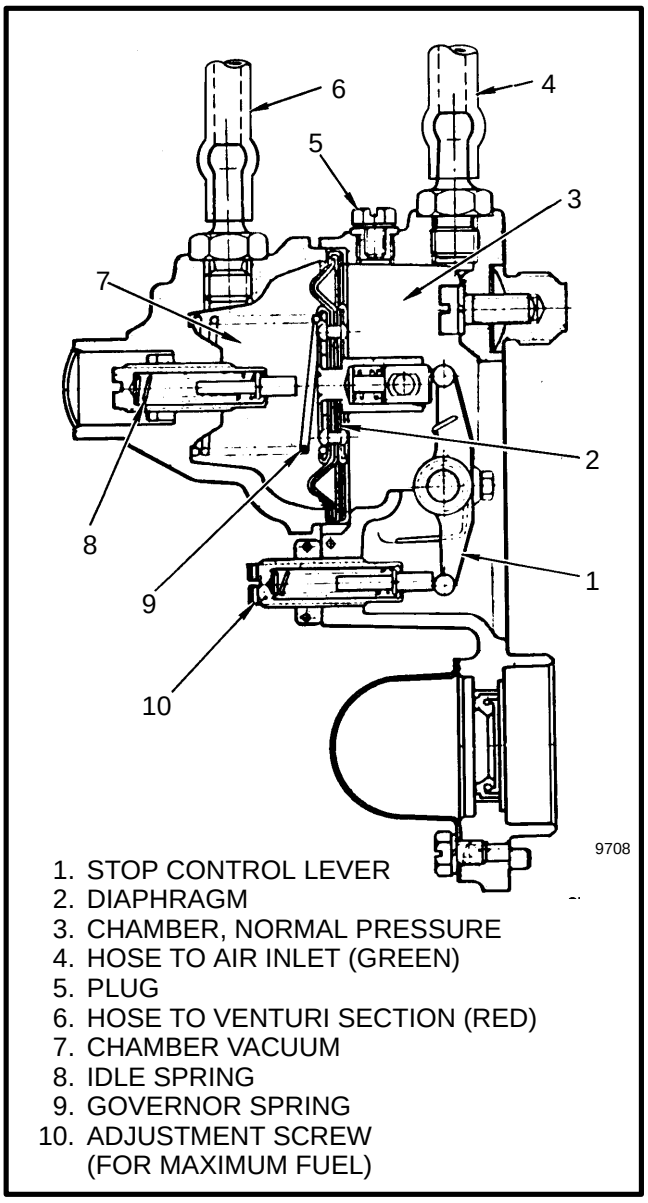


FIGURE 7. PNEUMATIC GOVERNOR

When the engine is not operating, the pressure in both chambers is equal. During this condition, the spring pushes the diaphragm and the fuel control rod to the position for maximum fuel. When the engine is at low speed, there is high vacuum at the venturi section of the air control valve. Since the rear chamber is connected to the venturi, there is also high vacuum in the chamber. The normal pressure in the front chamber pushes the diaphragm and fuel control rod in the direction for minimum fuel. When a load is put on the engine, the flow of air through the venturi decreases. The pressure increases in the rear chamber, which allows the spring to push against the diaphragm. Now the fuel control rod moves to the position for maximum fuel. When the load on the engine decreases, the flow of air through the venturi increases. The pressure decreases in the rear chamber. Now the normal pressure in the front chamber pushes the diaphragm and fuel control rod in the direction for minimum fuel.

Inlet Manifold For Fuel Injection Pump, Model PE4A (See FIGURE 8.)

The inlet manifold has an air control valve (throttle plate) and shut–off valve. The movement of the throttle plate is controlled by the accelerator pedal. The hoses from the pneumatic governor are connected to the air control valve described the earlier paragraphs. The shut–off valve prevents the engine from running backwards by stopping the air supply.

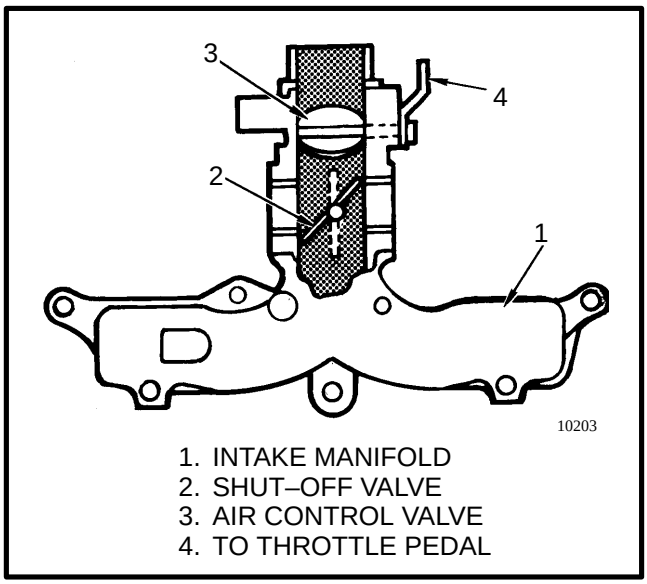


FIGURE 8. AIR CONTROL VALVE

FUEL INJECTION PUMP (ALL MODELS)

Removal

1. Disconnect the fuel lines from the fuel injection pump. Remove clamps as necessary so that the fuel lines are not bent.

2. Remove the bolts that hold the fuel injection pump to the engine. Move the fuel injection pump away from the timing gear case so that the drive gear is disengaged from the timing gear train.

NOTE: A liquid sealant was applied between the fuel injection pump and the timing gear case. Sometimes it is necessary to lightly hit the fuel injection pump with a soft hammer to loosen it from the timing gear case.

3. Remove the nine capscrews and remove the cover for the timing gear case. The fuel injection pump can not be installed again unless the timing gears are correctly aligned.

Installation

CAUTION

Do not turn the crankshaft or the camshaft if the idler gear is removed and the valve mechanism is installed. If either shaft is turned, damage will occur to the valve mechanism. To prevent damage to the valve mechanism, remove the rocker arm assembly when working on the timing gears.

NOTE: If the engine is installed in the lift truck, the letters on the timing gears can be difficult to see to align the position of the gears. Some service people use a light and a mirror to see the letters on the timing gears.

1. See FIGURE 9. Align the marks **X** and **Y** on the crankshaft gear (1), idler gear (2), and camshaft gear (3). Make sure that mark **ZZ** on the camshaft gear (3) is in the correct position for the installation of the fuel injection pump.

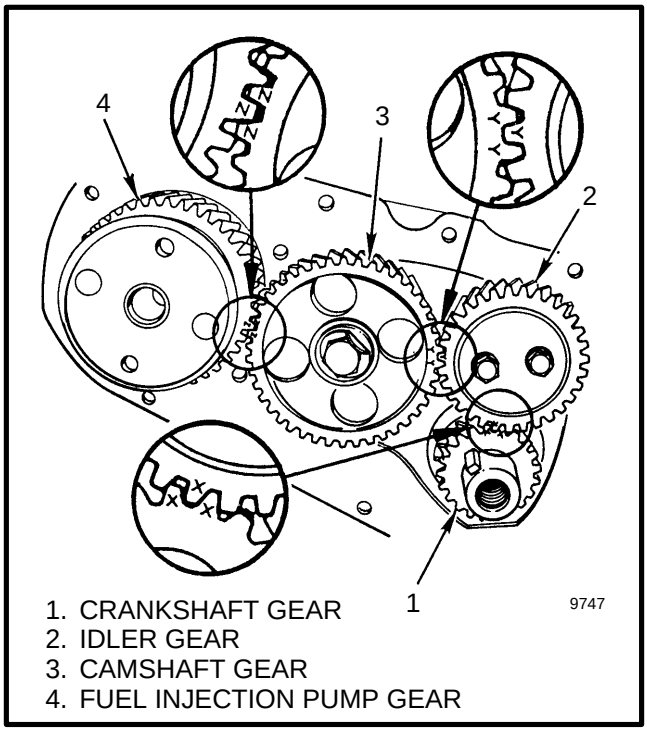


FIGURE 9. TIMING GEARS, ALIGNMENT

2. Put a thin coat of liquid sealant on both surfaces of the gasket that is installed between the fuel injection pump and the timing gear case. Install the fuel injection pump in the timing gear case. Make sure that the mark **Z** on the gear for the fuel injection pump is aligned with the mark **ZZ** on the camshaft gear as shown in FIGURE 9.

3. Install the timing gear cover. See Timing Gear Cover, Installation for the procedure.

REMOVAL AND INSTALLATION OF THE ENGINE

NOTE: The removal and installation procedures for the engine are not included in this section. See the section, **THE FRAME, 100 SRM 505** for the correct procedures.

CYLINDER HEAD AND VALVE MECHANISM

Cylinder Head, Removal

1. Disconnect the battery cables at the battery.

2. Drain the cooling system.

3. Remove the connection between the air cleaner and the air control valve.

4. Disconnect the throttle linkage and the hoses from the air control valve then remove the inlet manifold.

5. Remove the exhaust manifold.

6. Remove the coolant hose to the thermostat housing. Remove the clamps for the engine wiring that are on the thermostat housing and the side of the cylinder head.

7. Remove the wire to the cold start aid system.

8. Loosen and disconnect the fuel lines from the injectors and from the injector pump.

9. Remove the oil line from back of the cylinder head.

10. Remove the rocker arm cover.

11. Loosen the valve adjusting nuts until all the push–rods are free to rotate.

12. Remove the rocker arm assembly. Remove the outer bolts first then work toward the center of the assembly.

13. Remove the push rods. Keep the push rods in the correct order so that they will be installed in the same positions.

14. Loosen the cylinder head bolts in two or three steps in the sequence shown in FIGURE 10. Do not completely loosen the bolts during the first sequence. Lift the cylinder head from the engine block.

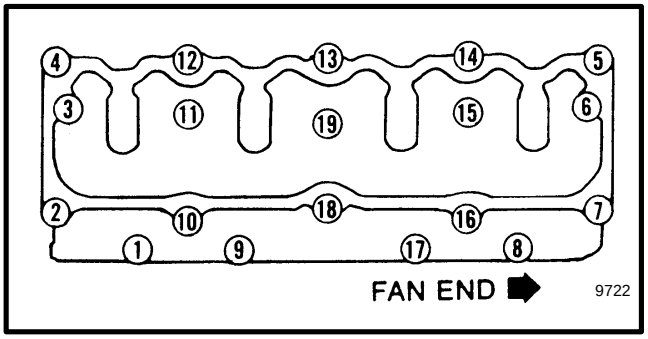


FIGURE 10. LOOSENING SEQUENCE FOR REMOVAL OF THE CYLINDER HEAD

Valve Guides, Replacement

Check the valve guides for wear by measuring the clearance between the valve guide and the valve stem. To measure the clearance, see FIGURE 11.

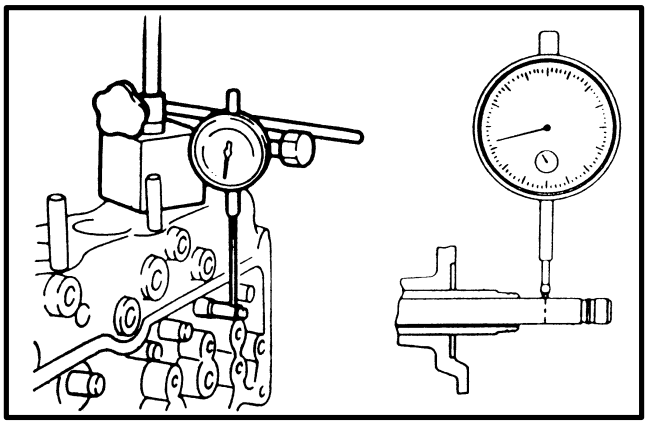


FIGURE 11. CHECK THE VALVE GUIDE CLEARANCE

Install the valve into the valve guide. Set the dial indicator to zero. Move the valve stem from side to side and note the highest reading. If the value exceeds the limits specified, replace both the valve and the valve guide.

	Standard	Limit
Intake Valve–mm	0.039–0.069	0.20
in	(0.0015–0.0027)	(0.008)
Exhaust Valve–mm	0.064–0.093	0.25
in	(0.0025–0.0037)	(0.0098)

NOTE: During valve guide replacement, use a special tool (HYSTER part number 320910).

Remove the valve guides with the special tool as shown in FIGURE 12.

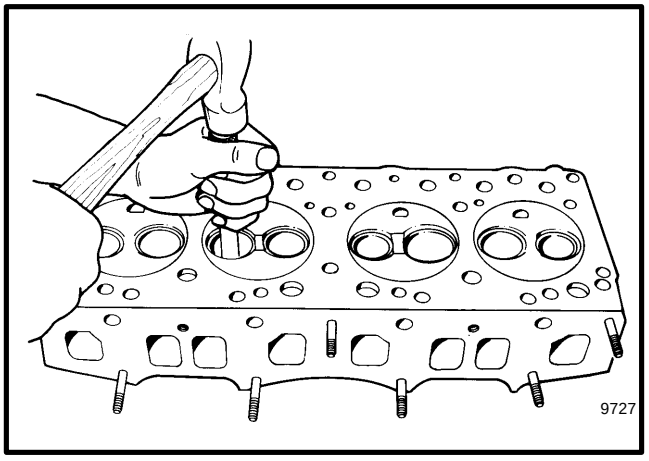
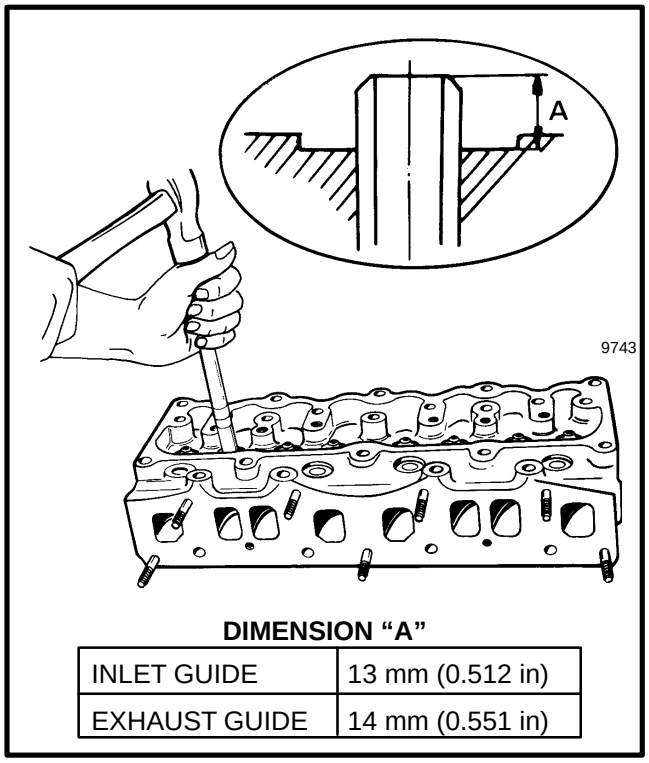


FIGURE 12. VALVE GUIDES, REMOVAL

Use the special tool shown in FIGURE 13. to install the valve guides. Put the valve guides in dry ice for 20 minutes. Apply clean engine oil to the valve guide during installation. Install the inlet valve guide so that it extends

13 mm (0.512 in) above the surface of the cylinder head. Install the exhaust valve guide so that it extends 14 mm (0.551 in) above the surface of the cylinder head.



DIMENSION "A"

INLET GUIDE	13 mm (0.512 in)
EXHAUST GUIDE	14 mm (0.551 in)

FIGURE 13. VALVE GUIDES, INSTALLATION

Cylinder Head, Inspection And Repair

Check the surface of the cylinder head for distortion. Use a straight edge and a thickness gauge as shown in FIGURE 14. Do the measurement in the positions shown. If the amount of distortion is more than 0.2 mm (0.008 in), the cylinder head needs repair. If the amount of distortion is more than 0.4 mm (0.016 in), replace the cylinder head.

NOTE: If the cylinder head needs grinding, make sure that the combustion chamber plugs do not need replacement. The cylinder head needs grinding after the replacement of a combustion chamber plug. See the section Combustion Chamber Plugs, Inspection And Repair for more information. After grinding the cylinder head surface, also check the depth of the valves as described in the valve mechanism section.

Check the surface of the cylinder head for distortion at the location for the inlet and the exhaust manifold. If the amount of distortion is more an 0.20 mm (0.08 in), the cylinder head needs repair.

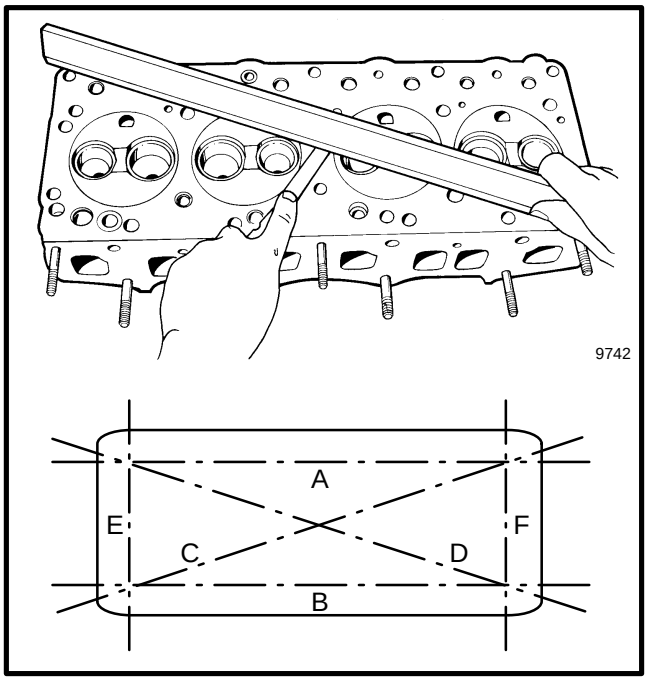


FIGURE 14. CHECK THE CYLINDER HEAD FOR DISTORTION

Combustion Chamber Plugs, Inspection And Repair

Carefully clean the surface of the cylinder head completely. Inspect the combustion chamber plugs for cracks. Also check their position in the cylinder head. The minimum depth of the plug is 0.02 mm (0.001 in) below the surface of the cylinder head. If the depth of the plug is beyond the specification, replace the plug.

Remove a combustion chamber plug that needs replacement as shown in FIGURE 15. Replace the heat shield also during replacement of a combustion chamber plug.

Combustion Chamber Plugs, Installation

1. Install a new combustion chamber plug by aligning the ball of the plug with the groove in the cylinder head. Lightly hit the plug with a plastic hammer.

2. Use a press to push the plug into the cylinder head. Keep the pressure of the press to a limit of 12,000 pounds (5 500 kg) during installation of the plugs.

3. After the combustion chamber plugs are installed, grind the surface of the cylinder head. The surface of the combustion chamber plugs must be even with the surface of the cylinder head.

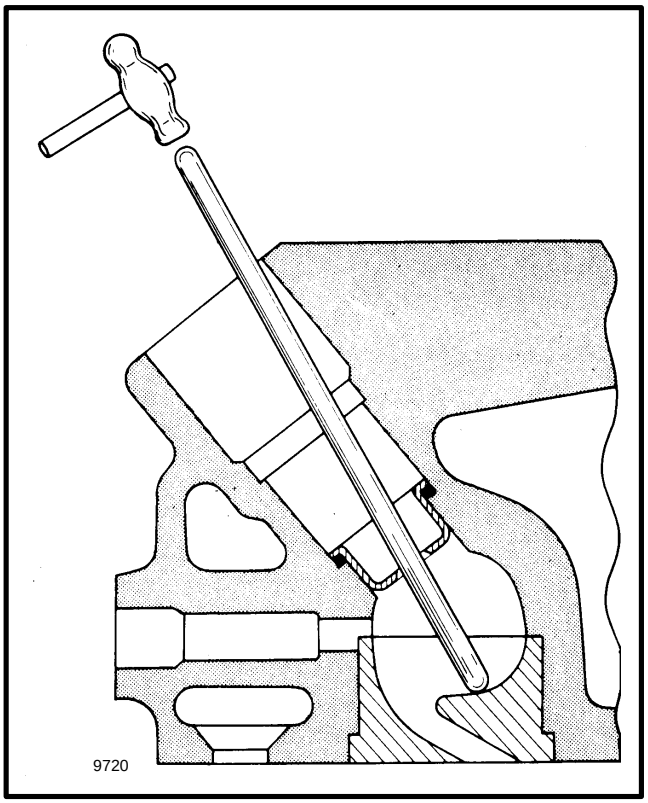


FIGURE 15. COMBUSTION CHAMBER PLUG, REMOVAL

NOTE: After grinding the cylinder head, check the depth of the valves. See the valve specifications in FIGURE 17.

4. Install a new heat shield as shown in FIGURE 16.

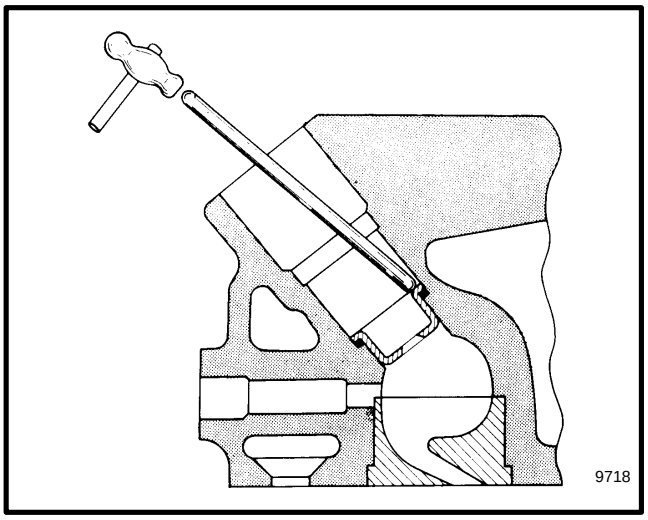


FIGURE 16. HEAT SHIELD, INSTALLATION

Valves, Inspection And Repair

1. Inspect the stem of each valve for wear. Use a micrometer to measure the outside diameter at the positions shown in FIGURE 17. If the measurement is less than the valve specification, replace both the valve and the valve guide.

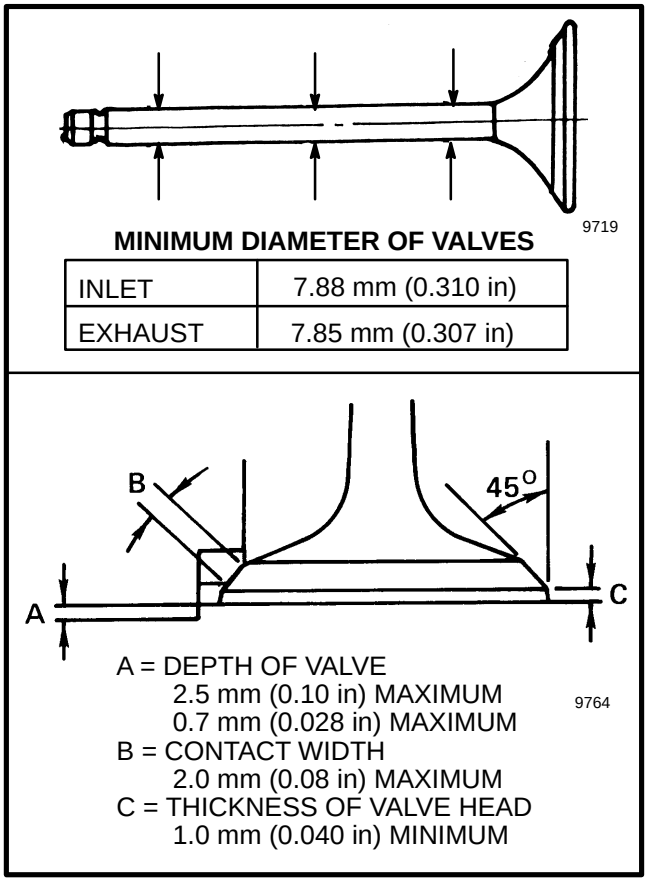


FIGURE 17. VALVE SPECIFICATIONS

2. Inspect the surface of the valves for wear and damage.

3. If the valves need grinding, see the valve specifications in FIGURE 17.

Valve Seat, Inspection

Inspect the valve seats for wear. First check the depth of the valve. The maximum depth of the valve head below the surface of the cylinder head is 2.5 mm (0.1 inch). If the measurement of the depth is more than the specification, replace the valve seat. Also check the width of contact from the valve. If the width is more than 2.0 mm (.08 inch) repair the valve seat. The specifications for the valve seats are shown in FIGURE 18.

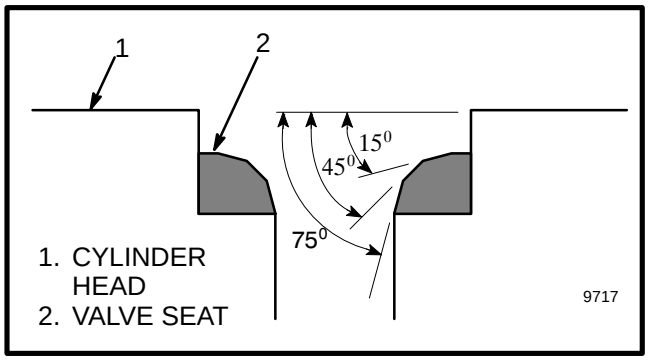


FIGURE 18. VALVE SEAT SPECIFICATIONS

Valve Seat, Removal

1. Use an electric welder and make a weld all the way around the valve seat. At the end of the weld allow the welding rod to be welded to the valve seat. Make sure that you do not make a weld between the valve seat and the cylinder head.

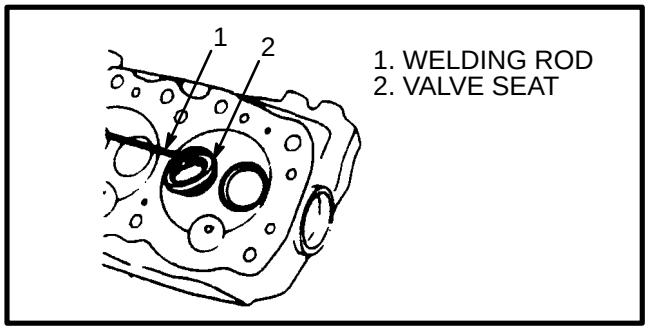


FIGURE 19. VALVE SEAT REMOVAL

2. Let the cylinder head cool for five minutes then use the welding rod to remove the valve seat.

Valve Seat, Installation

1. Clean the bore for the valve seat.

2. Put the valve seats in dry ice for 20 minutes.

3. Use a press to install a new valve seat.

4. After installation, check the depth of the valve and the width of contact. See FIGURE 17.

Valve Spring, Inspection

Check the valve springs for damage. The specifications for the valve springs are shown in FIGURE 20.

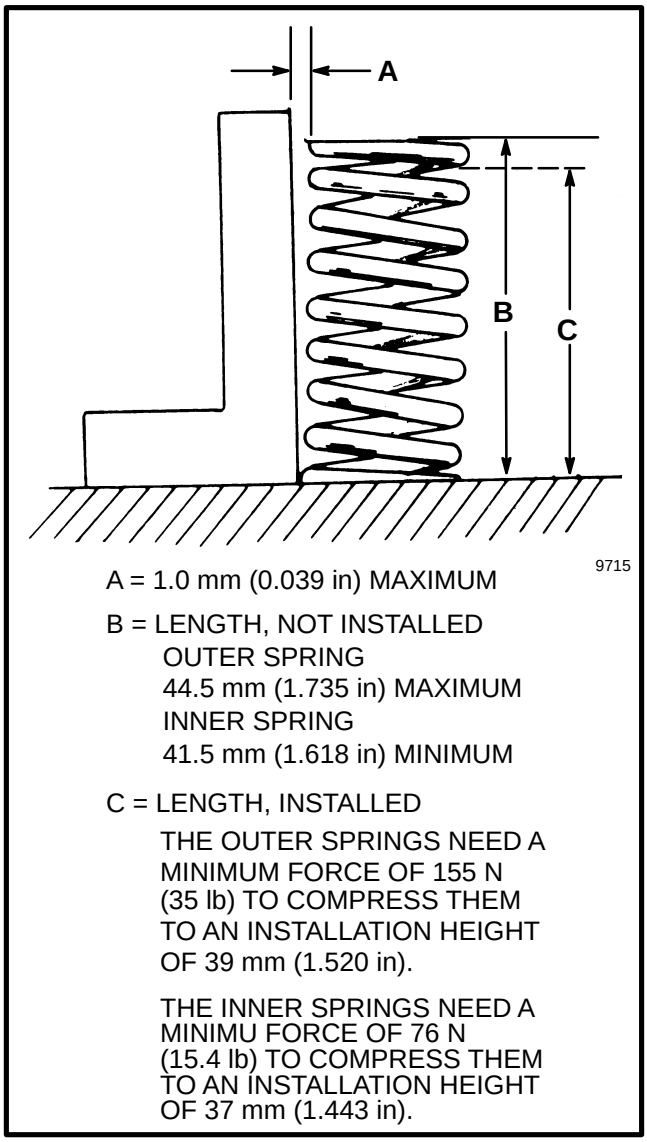


FIGURE 20. VALVE SPRING SPECIFICATIONS

Install the inner and outer valve springs with the painted end down (the end with the fine pitch).

Rocker Arms, Inspection And Assembly

To disassemble the rocker arm assembly, remove the snap ring from the end of the shaft. Push the spring, rocker arms and the brackets from the shaft. Make sure to keep the parts in their correct order.

1. Check the rocker arm shaft as shown in FIGURE 21. Turn the shaft and make a note of the highest and the lowest reading on the dial indicator. If the difference between the readings is below 0.6 mm (.024 inch), use a press to straighten the shaft. Do not apply heat to the

shaft. If the difference between the readings is more than 0.6 mm (.024 inch), replace the shaft.

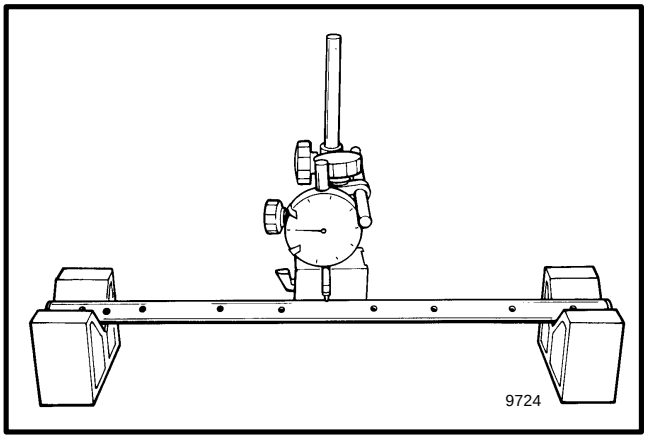


FIGURE 21. CHECK THE ROCKER ARM SHAFT

2. Check the rocker arm shaft for wear. Use a micrometer and measure the diameter of the shaft at the locations for the rocker arms. If the diameter at any of the locations is smaller than 18.85 mm (.75 inch), replace the rocker arm shaft.

3. Inspect the rocker arms for wear and cracks. Find the clearance between the rocker arm and the rocker arm shaft. If the clearance is more than 0.2 mm (0.008 inch), replace the bushing for the rocker arm.

4. Check the push rods for damage and replace as necessary.

5. Assemble the rocker arm assembly as shown in FIGURE 22. Apply engine oil to the parts during assembly. Two of the rocker arms have a chamfer. Make sure these rocker arms go at each end of the shaft.

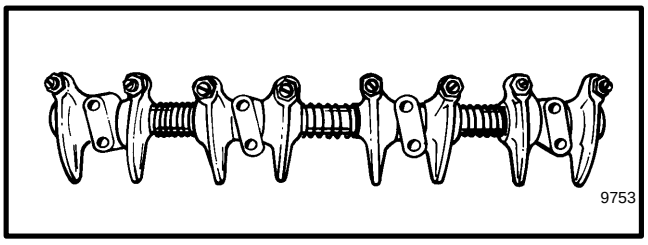


FIGURE 22. ROCKER ARM ASSEMBLY

6. Install the rocker arm assembly to the cylinder head during installation of the cylinder head.

Installation Of The Cylinder Head

1. Clean the surface of the cylinder head and the surface of the crankcase.

2. Install the cylinder head gasket on the crankcase so that the “TOP” mark is up. Do not use a sealant on the gasket.

3. Install the cylinder head.

4. Apply a thin layer of clean engine oil on the threads of the cylinder head bolts. Install and tighten the bolts to a torque of 65 N.m (47 lbf ft) in the sequence shown in FIGURE 23. Use the sequence again and tighten the bolts to a final torque of 78 N.m (58 lbf ft).

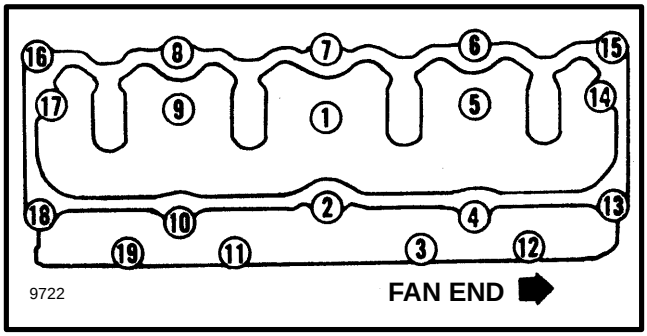


FIGURE 23. TIGHTENING SEQUENCE FOR INSTALLATION OF THE CYLINDER HEAD

5. Apply engine oil to the push rods then install them to the engine.

6. Install the rocker arm assembly. Tighten the bolts evenly to a torque of 17 N.m (13 lbf ft). Tighten the bolts for the inner brackets first.

7. Install new washers for the fuel injectors. Install the fuel injectors to the cylinder head.

8. Install the fuel lines and the fuel filter.

9. Install a new gasket for the inlet and exhaust manifold. Install the gasket so that the mark “TOP” is up and toward the outside. Install the manifolds.

10. Install the cold start aid system.

11. Install the two oil lines to the cylinder head.

12. Install the linkage to the air control valve. Install the two hoses for the governor to the air control valve. The red hose goes to the venturi section of the top of the air control valve.

⚠ CAUTION

Do not damage the hoses for the governor system during installation. If the hoses have leaks, the governor will not operate correctly.

13. Install the thermostat housing to the cylinder head.

14. Install the coolant hoses to the thermostat housing.

15. Adjust the valves as described in Checks and Adjustments.

16. Install the rocker arm cover and the air cleaner.

17. Fill the cooling system with coolant.

TIMING GEAR CASE

Removal

NOTE: The engine used in the H2.00–3.20XM (H40–65XM) units does not have the idler gear for the hydraulic pump.

1. Remove the fan and the fan belt.

2. Remove the crankshaft pulley

3. Remove the capscrews that hold the timing gear cover to the timing gear case. Remove the timing gear cover.

4. Remove the oil deflector ring from the crankshaft gear. See FIGURE 28.

5. Use a dial indicator to check the clearance between the timing gears before removing the gears. The maximum amount of clearance between all the gears is 0.3 mm (0.012 inch).

6. Use a thickness gauge to measure the clearance between the idler gear and the retainer. See FIGURE 24. The maximum amount of clearance between the parts is 0.2 mm (0.008 in).

7. Remove the hydraulic pump and the retainer plate for the hydraulic pump drive gear.

8. Remove the fuel injection pump.

⚠ CAUTION

Do not turn the camshaft or the crankshaft when the idler gear is removed and the valve mechanism is installed. If either shaft is turned, damage will occur to the valve mechanism. To prevent damage to the valve mechanism, remove the rocker arm assembly when working on the timing gears.

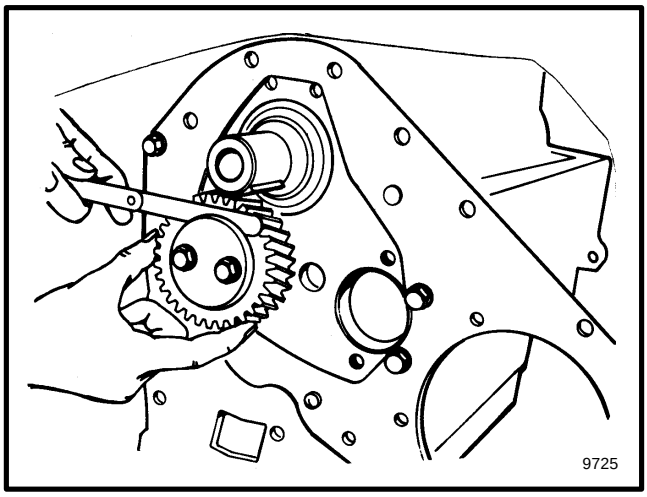


FIGURE 24. CHECK THE CLEARANCE BETWEEN THE IDLER GEAR AND THE RETAINER PLATE

9. See FIGURE 25. Remove the retainer plate from the idler gear (2) for the camshaft. Remove the idler gear. Remove the shaft for the idler gear.

10. Remove the camshaft gear (3) and camshaft as described in the section for the Camshaft.

11. Remove the bearing and idler gear (5) for the hydraulic pump.

12. Use a puller to remove the crankshaft gear (1). Remove the key from the crankshaft.

13. Remove the outer bearing (6) and the drive gear for the hydraulic pump.

14. Remove the rear bearing for the drive gear for the hydraulic pump from the timing gear case.

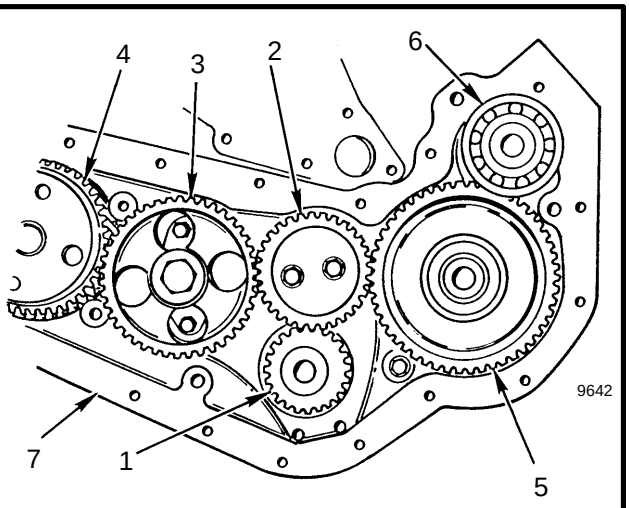
15. Remove the capscrews that hold the timing gear case to the crankcase. Remove the timing gear case.

Installation

NOTE: The engine used in the H2.00–3.20XM (H40–65XM) units does not have the idler gear for the hydraulic pump.

1. See FIGURE 25. Install the timing gear case (7) to the crankcase. Use a new gasket during installation. Tighten the capscrews evenly.

2. Install the crankshaft gear (1) and key.



1. CRANKSHAFT GEAR
2. IDLER GEAR TO CAMSHAFT
3. CAMSHAFT GEAR
4. FUEL INJECTION PUMP GEAR
5. IDLER GEAR TO HYDRAULIC PUMP
6. OUTER BEARING FOR HYDRAULIC PUMP GEAR
7. TIMING GEAR CASE

FIGURE 25. ARRANGEMENT OF THE TIMING GEARS

⚠ CAUTION

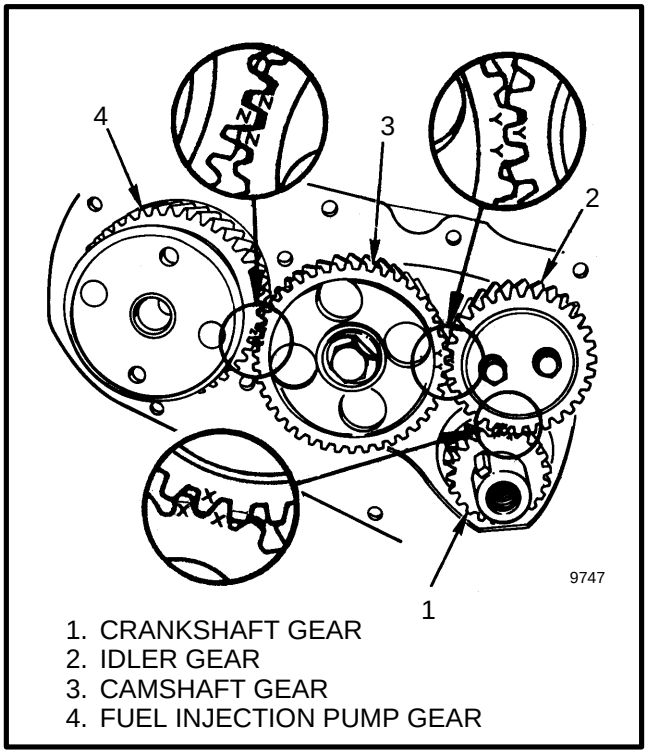
Do not turn the crankshaft or the camshaft when the idler gear is removed and the valve mechanism is installed. If either shaft is turned, damage will occur to the valve mechanism. To prevent damage to the valve mechanism, remove the rocker arm assembly when working on the timing gears.

3. Install the smaller idler gear (2). Align the mark **XX** on the crankshaft gear and the mark **X** on the idler gear as shown in FIGURE 26. Install the retainer for the idler gear so that the side with the chamfer is away from the gear. Tighten the two capscrews to a torque of 26 N.m (19 lbf ft).

4. Install the camshaft as described in the section for the Camshaft. Align the mark **YY** on the camshaft gear with the mark **Y** on the idler gear during installation.

5. Install the fuel injection pump. See FUEL INJECTION PUMP, Installation. Align the mark **ZZ** on the camshaft gear with the mark **Z** on the injection pump gear during installation.

6. See FIGURE 25. Install the larger idler gear (5) in the timing gear case. The bearing will be installed later.



1. CRANKSHAFT GEAR
2. IDLER GEAR
3. CAMSHAFT GEAR
4. FUEL INJECTION PUMP GEAR

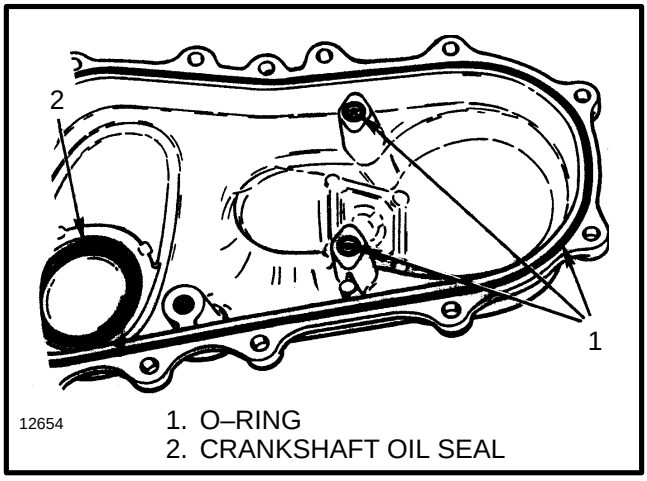
FIGURE 26. TIMING GEARS, ALIGNMENT

7. Install the timing gear cover as follows:

q. Install a new oil seal for the crankshaft in the timing gear cover. Fill the space between the lips of the oil seal with grease.

b. Install new O–rings in the timing gear cover. See FIGURE 27.

c. Install the drive gear and outer bearing for the hydraulic pump in the timing gear cover.



1. O–RING
2. CRANKSHAFT OIL SEAL

FIGURE 27. TIMING GEAR COVER

d. See FIGURE 28. Install the oil deflector ring at the front of the crankshaft gear. The flange must be installed next to the crankcase gear.

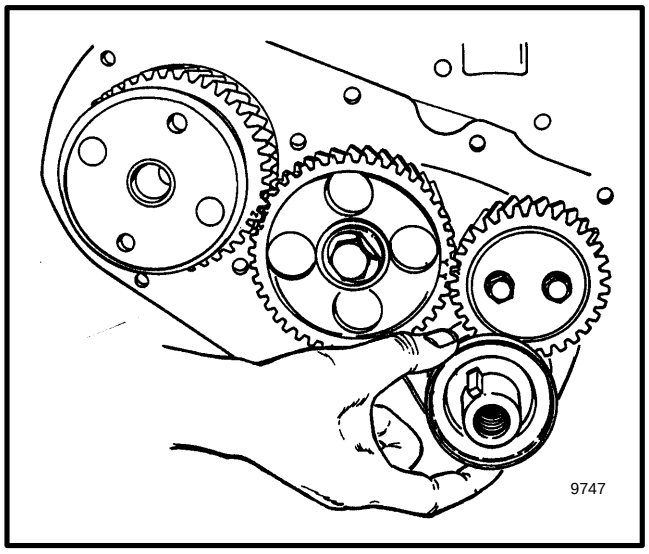


FIGURE 28. OIL DEFLECTOR RING

e. Install the timing gear cover. Tighten the capscrews evenly.

f. Remove the plate on the timing gear cover for the larger idler gear.

g. Install the bearing for the large idler gear into the timing gear cover.

h. Install the inner bearing for the hydraulic pump drive gear as shown in FIGURE 29. Install the retainer plate for the bearing and install the hydraulic pump.

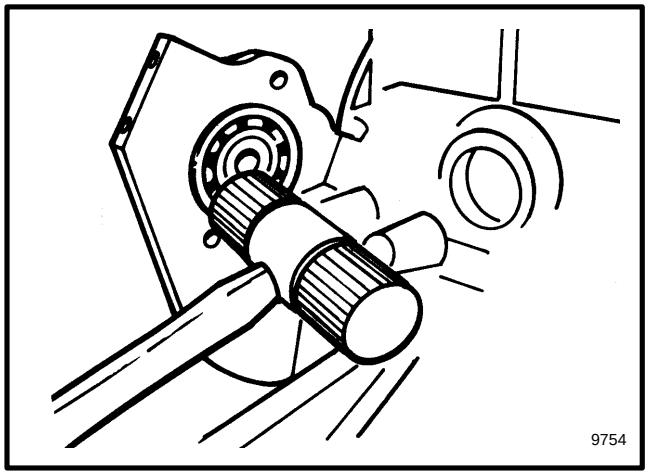


FIGURE 29. BEARING INSTALLATION, HYDRAULIC PUMP GEAR

i. Install the oil line to the timing gear cover.

j. Install the crankshaft pulley. Tighten the bolt to 190 N.m (140 lbf ft).

k. Install the drive belt and the fan. Adjust the tension of the drive belt. See the section, **PERIODIC MAINTENANCE** for the correct procedure.

CAMSHAFT

Removal

1. Remove the valve mechanism and the push rods as described in Cylinder Head and Valve Mechanism.

2. Remove the timing gear cover.

3. Turn the engine so that it is upside down.

4. Remove the sump pan and then the oil pump.

5. Rotate the camshaft as necessary to get access to the capscrews for the thrust plate. See FIGURE 30. Remove the bolts for the thrust plate.

6. Carefully remove the camshaft.

7. Remove the sump pan to get access to the cam followers.

8. Use a magnet or a suction cup to remove the cam followers from the bottom of the crankcase.

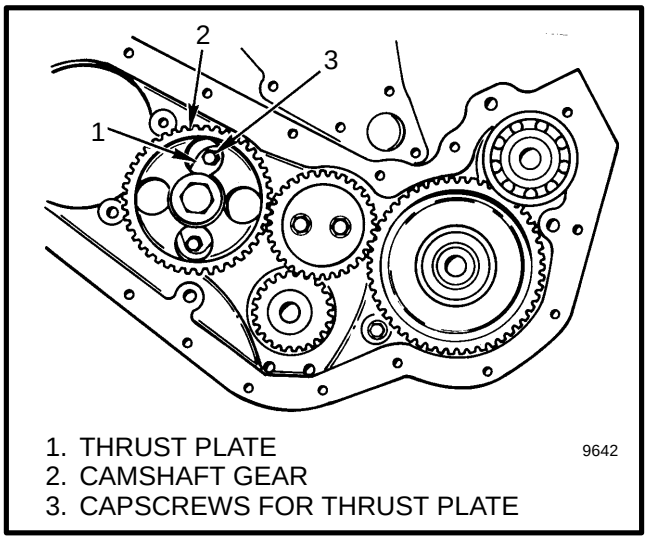


FIGURE 30. ACCESS TO THE THRUST PLATE FOR THE CAMSHAFT

Inspection

Use a micrometer to check the wear of the camshaft. Measure the areas of the camshaft as shown in FIGURE 31. If any of the measurements are less than the specifications shown in FIGURE 31., replace the camshaft. Also see the Engine Specifications, Camshaft.

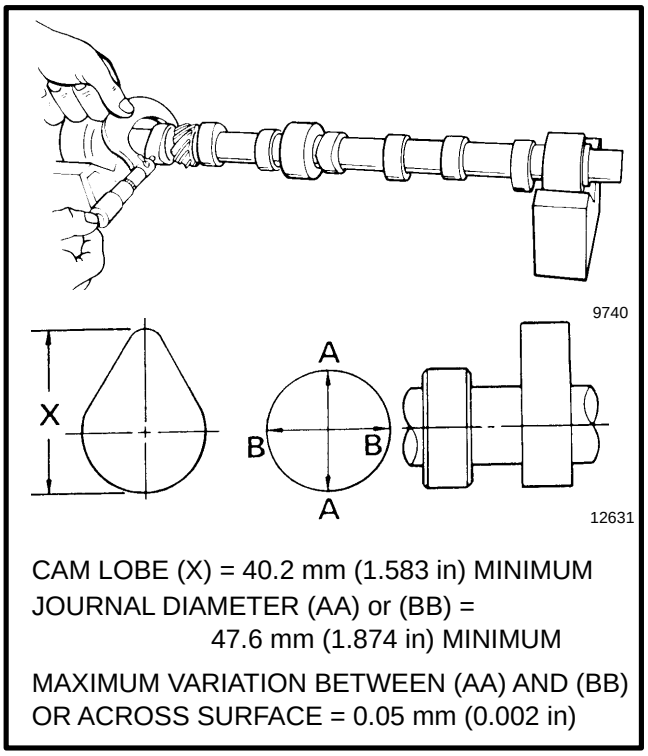


FIGURE 31. CAMSHAFT SPECIFICATIONS

Check the camshaft as shown in FIGURE 32. Rotate the camshaft and look at the dial indicator. If the difference between the highest and lowest reading is more than 0.1 mm (0.004 in), replace the camshaft.

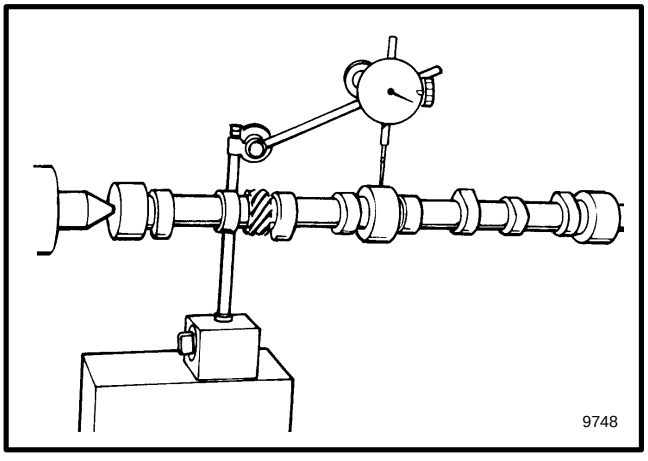


FIGURE 32. CAMSHAFT INSPECTION

Measure the amount of clearance between the thrust plate and the end of the camshaft as shown in FIGURE 33. If the amount of clearance is beyond 0.2 mm (0.008 inch), replace the thrust plate.

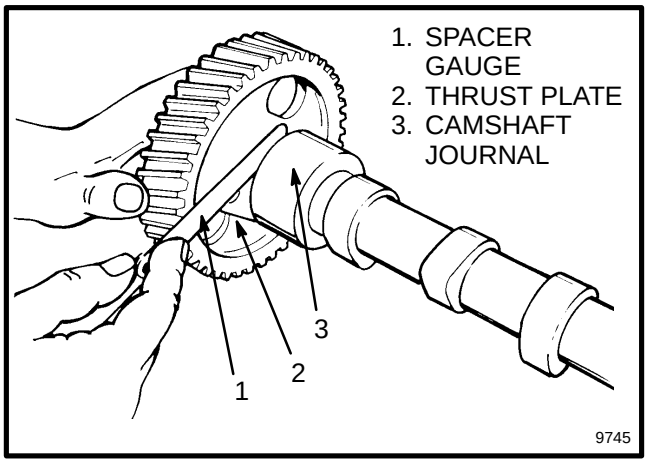


FIGURE 33. CHECK THE CLEARANCE BETWEEN THE CAMSHAFT AND THE THRUST PLATE

Camshaft Bearings

NOTE: A special tool is necessary to remove and replace the camshaft bearings. The HYSTER part number for the tool is Part No. 320905.

Inspect the surface of the bearings for wear and damage. Replace the bearings as necessary.

Check the clearance between the bearings and the camshaft. If the clearance is more than 0.15 mm (0.006 in), replace the camshaft bearings.

⚠ CAUTION

During installation of the camshaft bearings, the ports for oil in the bearing must be aligned with the ports in the crankcase.

Cam Followers

Inspect the contact surface of the cam follower for damage and wear.

Replace a cam follower as necessary. Measure the outside diameter of the cam follower. If the diameter of the cam follower is less than 12.95 mm (.510 inch), replace the cam follower.

CAMSHAFT, INSTALLATION

1. Apply clean engine oil to the cam followers and install them in the crankcase.

2. Apply clean engine oil to the bearings for the camshaft.

⚠ CAUTION

If the camshaft bearings were replaced, make sure the ports for oil are aligned before installation of the camshaft.

3. Carefully install the camshaft in the crankcase.

4. Install the thrust plate to the camshaft. Tighten the bolts that hold the thrust plate to the timing gear case to a torque of 19 N.m (14 lbf ft).

5. Install the key for the camshaft gear. Install the gear in the correct position as described in Timing Gear Case, Installation**.** Tighten the bolt that holds the gear to the camshaft to a torque of 108 N.m (80 lbf ft).

6. Install the push rods and the valve mechanism as described in Installation Of The Cylinder Head.

7. Install the oil pump and the sump pan.

CRANKSHAFT AND MAIN BEARINGS

Crankshaft, Removal

1. Remove the flywheel (see Flywheel, Removal) and the flywheel housing.

2. Remove the timing gear case as described in Timing Gear Case, Removal.

3. Remove the cylinder head as described in Cylinder Head Removal.

4. Remove the oil sump.

5. Remove the oil pump.

6. Remove the caps for the connecting rods. Remove the connecting rod and piston as an assembly.

7. Remove the caps for the main bearings. Remove the outer caps first and work toward the center cap.

8. Before removing the crankshaft, measure the clearance between the crankshaft and thrust bearings at the middle main bearing location. See FIGURE 34. Move the crankshaft fully forward before making the measurement. The maximum amount of clearance (axial clearance) is 0.3 mm (0.012 inch). If the amount of axial clearance is greater than the specification, then the thrust bearings must changed.

9. Remove the crankshaft. Keep the main bearings for the crankshaft in their correct order.

Crankshaft, Inspection And Repair

1. Visually inspect the crankshaft for wear, cracks or other damage. Replace the crankshaft if it has cracks.

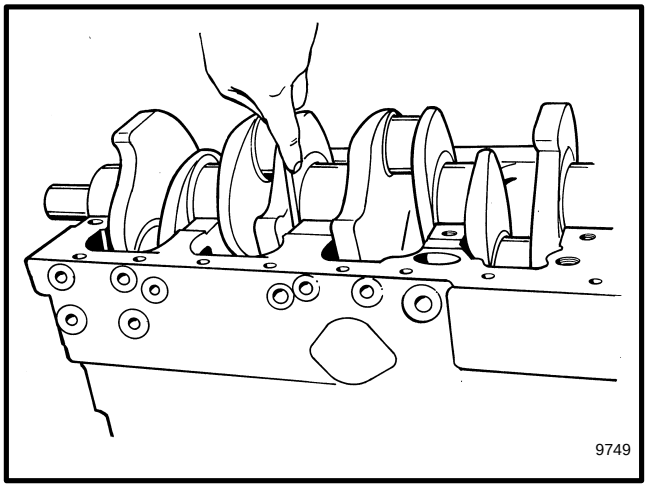


FIGURE 34. CHECK THE CLEARANCE BETWEEN THE CRANKSHAFT AND THRUST BEARINGS

2. Check the crankshaft as shown in FIGURE 35. Rotate the crankshaft one turn and check the reading on the dial indicator. If the difference between the highest and the lowest reading is more than 0.06 mm (0.002 inch), repair or replace the crankshaft.

3. Use a micrometer to measure the journals for the bearings of the crankshaft. Make the measurements at the positions shown in FIGURE 36. The specifications are also shown in FIGURE 36.

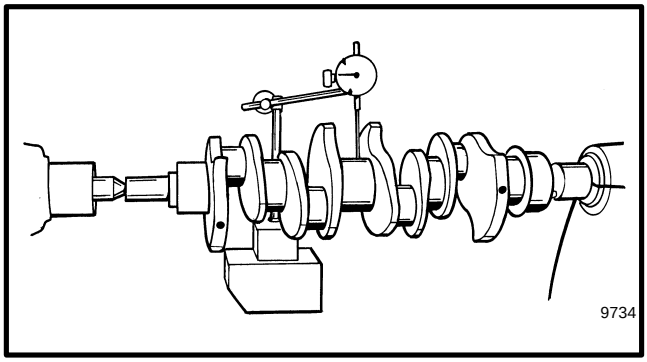


FIGURE 35. CRANKSHAFT INSPECTION

Main Bearings

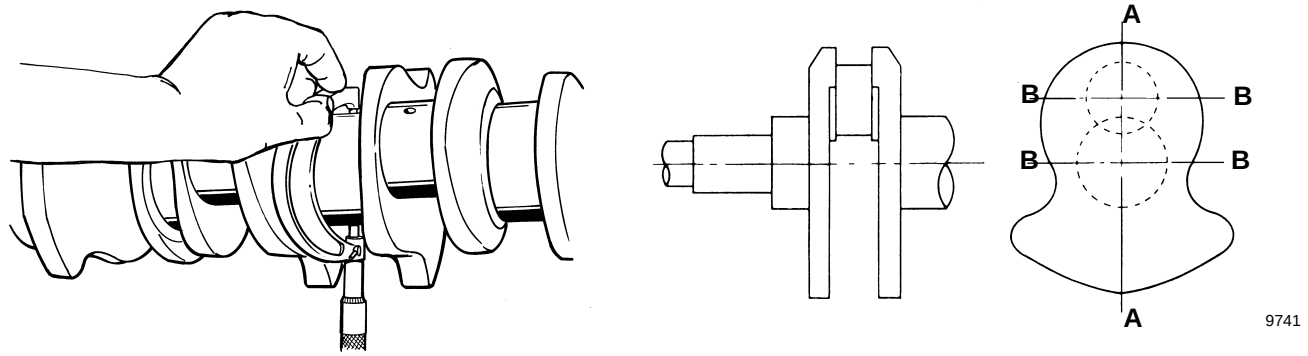
1. Visually inspect the main bearings for wear and damage. Replace the bearings as necessary.

2. Measure the clearance between the main bearings and the crankshaft. If the clearance is more than 0.12 mm (0.005 in), replace the main bearing.

Pilot Bearing

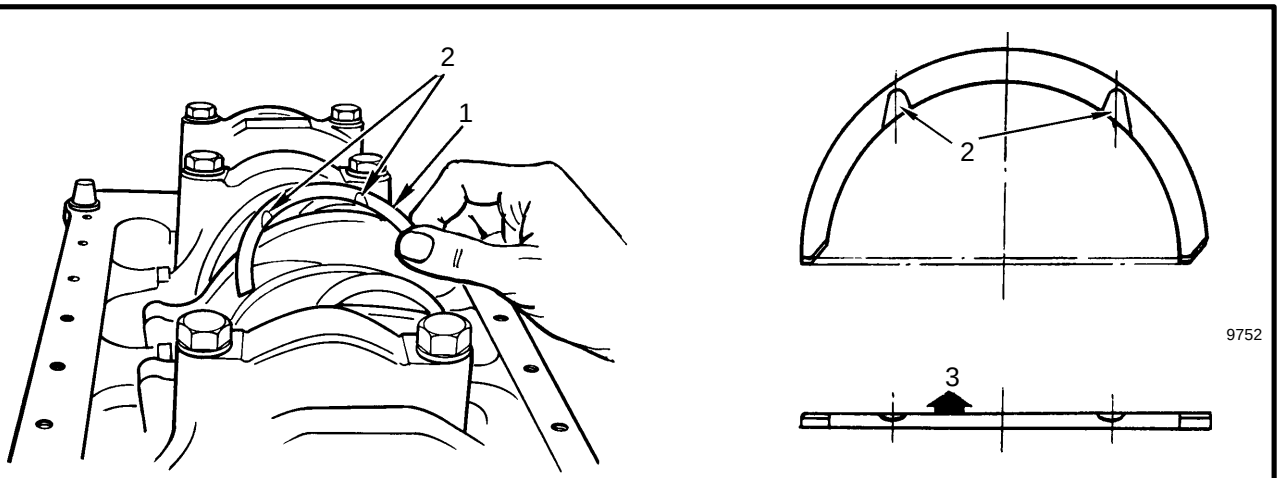
Inspect the pilot that is in the end of the crankshaft. If replacement of the bearing is necessary, use a special tool.

NOTE : The Hyster part number of the special tool for replacing the pilot bearing is 320909.



ITEM	MINIMUM* DIAMETER	MAXIMUM DIFFERENCE BETWEEN THE BEARINGS FOR EACH JOURNAL
JOURNALS FOR MAIN BEARINGS	69.95 mm (2.728 in)	0.05 mm (0.002 in)
JOURNALS FOR CONNECTING RODS	52.95 mm (2.065 in)	0.05 mm (0.002 in)
*When measurements are less than these values, grind the crankshaft and install undersize bearings.		

FIGURE 36. CRANKSHAFT SPECIFICATIONS



1. THRUST WASHER
2. GROOVES FOR OIL
3. THE GROOVES MUST BE TOWARD THE THRUST SURFACE OF THE CRANKSHAFT

FIGURE 37. INSTALLATION OF THE THRUST WASHERS

Crankshaft, Installation

1. Before installation of the crankshaft, make sure all the passages for oil in the crankshaft are clean.

2. Clean the main bearings. Install the main bearings in the crankcase. Apply clean engine oil to the surface of the bearings.

3. Carefully install the crankshaft.

4. Install the thrust bearings at the No. 3 main bearing location. Make sure that the grooves for oil in the thrust bearings are toward the crankshaft. See FIGURE 37. Push one end of the thrust bearing until both ends are even with the surface of the crankcase.

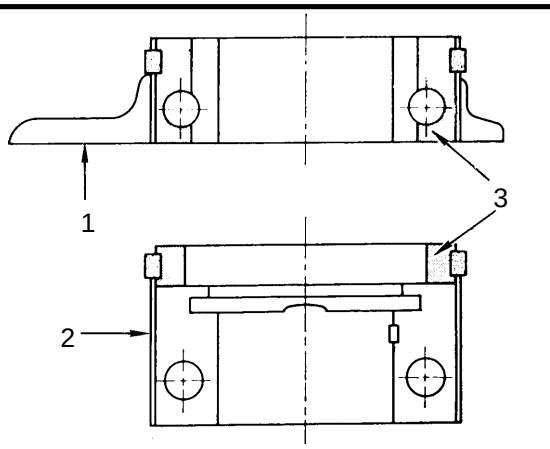
⚠ CAUTION

It is very important that the thrust bearings are installed correctly. If they are installed wrong, the crankshaft will be damaged because it will not receive correct lubrication. Install the thrust bearings so that the grooves for oil are toward the thrust surface of the crankshaft.

5. Install the main bearings into the bearing caps. Apply clean engine oil to the surface of the bearings and install the bearing caps. Apply a sealant to the areas shown in FIGURE 38. to the No. 1 and No. 5 bearing caps.

NOTE: The No.2 and No. 4 bearing caps have the same shape. The bearing cap that has the mark "A" on it is the No. 2 bearing cap.

During installation of the main bearing caps, adjust the position of the No. 1 and No. 5 caps. The outer surface of each bearing cap must be even with the surface of the crankcase. Tighten the bolts for the main bearing caps to a torque of 70 foot pounds (95 N.m) while the crankshaft is rotated. Start at the No. 3 main bearing and work toward each end so that the No. 1 and No. 5 main bearing caps are tightened last. Repeat the tightening sequence and tighten the bolts to a final torque of 120 foot pounds (163 N.m).



1. CAP FOR NO. 1 MAIN BEARING
2. CAP FOR NO. 5 MAIN BEARING
3. APPLY SEALANT TO THESE AREAS

FIGURE 38. APPLICATION OF SEALANT TO THE BEARING CAPS

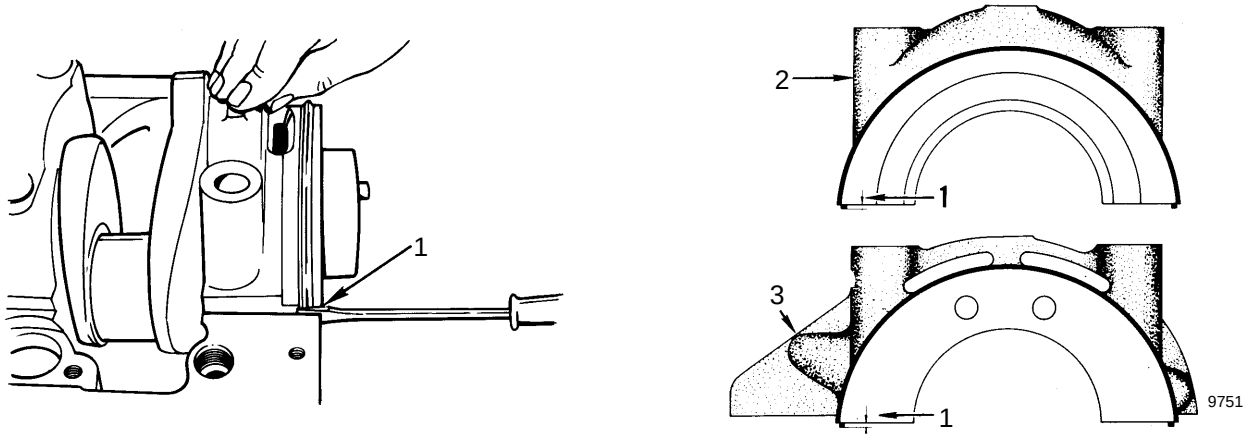
6. Install the oil seals in the grooves of the No. 1 and No. 5 main bearing caps. Apply a sealant to them during installation. Use a screwdriver to push the seals approximately 0.5 mm (.020 inch) below the surface of the crankcase. See FIGURE 39.

7. Install the timing gear case as described in Timing Gear Case, Installation.

8. Install the connecting rods as described in Connecting Rods, Assembly And Installation.

9. Install the oil pump.

10. Apply a sealant to the oil sump then install it to the crankcase.



1. PUSH THE END OF THE SEAL APPROXIMATELY 0.5 mm (0.020 in) BELOW THE SURFACE OF THE CRANKCASE.
2. NO. 5 MAIN BEARING CAP
3. NO. 1 MAIN BEARING CAP

FIGURE 39. OIL SEAL INSTALLATION

FLYWHEEL AND RING GEAR, H2.00–3.20XM (H40–65XM)

Flywheel, Removal (See FIGURE 41. and FIGURE 42.)

1. Remove the capscrews for the flywheel, then remove the flywheel.

2. If necessary, remove the flywheel housing and the braces.

Ring Gear, Replacement (See FIGURE 40.)

⚠ WARNING

Wear eye protection for this operation to prevent eye injury from metal chips. You will be using a hammer and chisel to break the ring gear.

Before the ring gear is removed, check the position of the chamfer on the teeth.

1. Use a hammer and chisel to break the ring gear. Make sure that you do not damage the flywheel.

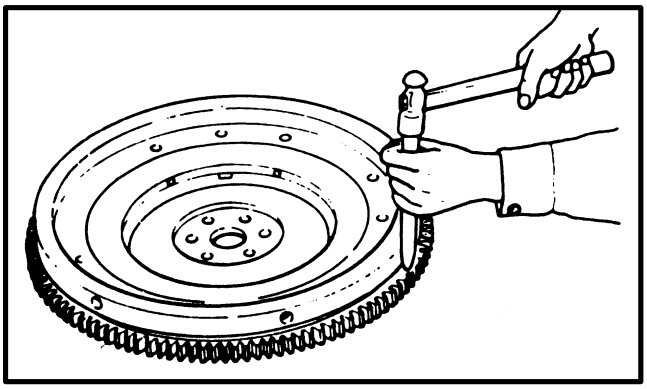


FIGURE 40. RING GEAR REMOVAL

2. The ring gear must be heated before it can be installed on the flywheel. Use an oven that has a temperature control. Make sure that the ring gear is not heated to more than 200°C (390°F).

⚠ WARNING

Hot parts. Wear protective clothing and gloves to prevent burns.

3. Install the ring gear on the flywheel. Make sure that the chamfer on the teeth is in the correct direction toward the starter.

Flywheel, Installation (See FIGURE 41. and FIGURE 42.)

1. Install the flywheel housing and flywheel as follows:

    a. If the flywheel housing was removed, install it on the engine. Install the capscrews and bolt. Tighten the special bolt (2) and nut first. Tighten the nut to 46 N.m (34 lbf ft). Tighten the other capscrews as shown in FIGURE 41.

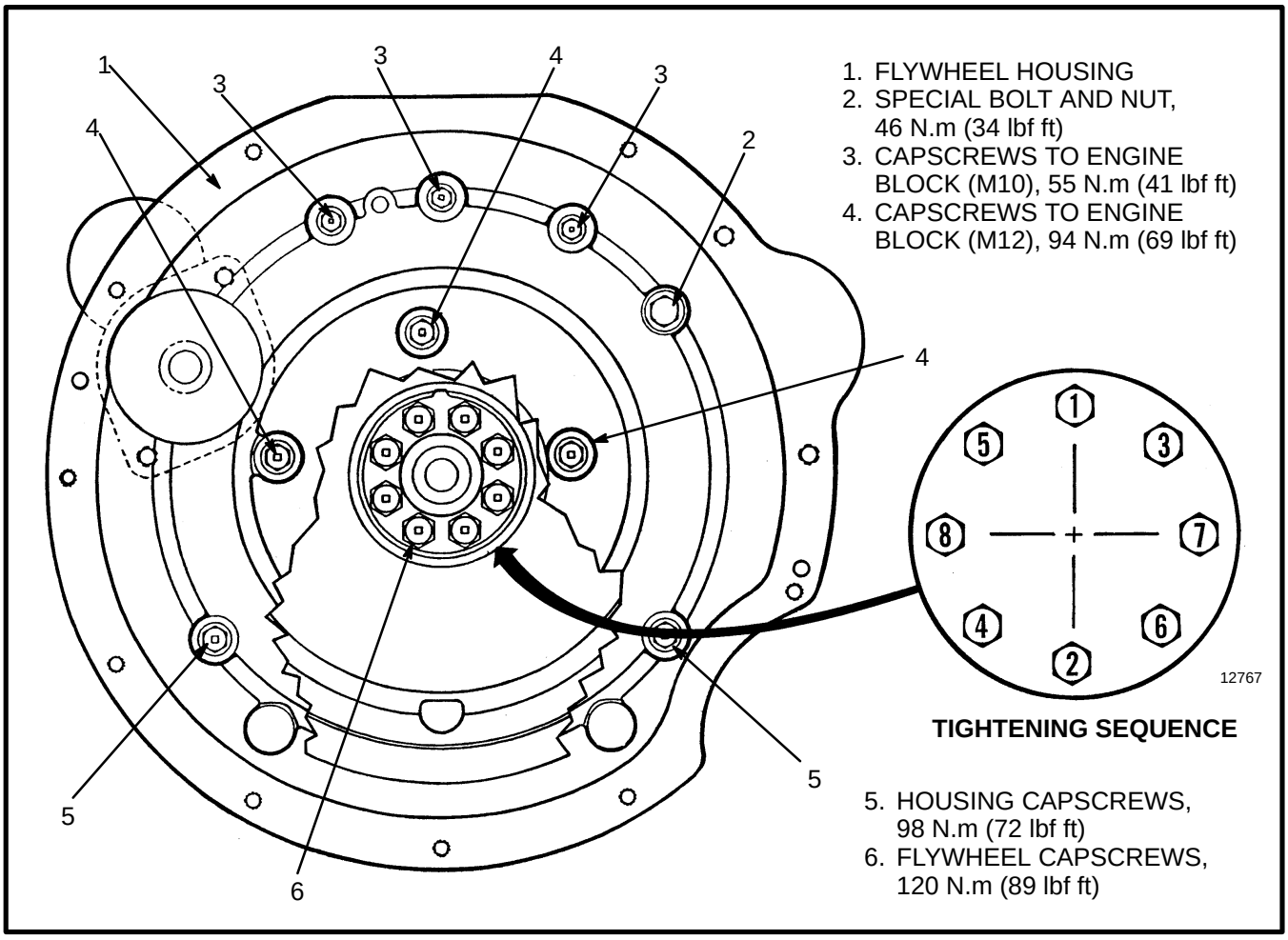


FIGURE 41. FLYWHEEL AND HOUSING, H2.00–3.20XM (H40–65XM)

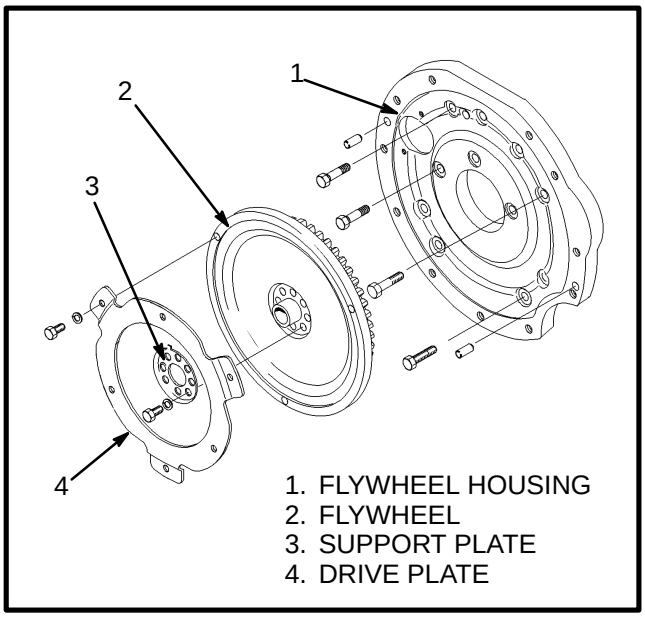


FIGURE 42. FLYWHEEL AND HOUSING, , H2.00–3.20XM (H40–65XM)

b. Install the flywheel on the crankshaft. Apply an adhesive sealant on the threads of the capscrews, then install the capscrews for the flywheel. Tighten the capscrews to 120 N.m (89 lbf ft) as shown in the sequence in FIGURE 41.

PISTONS AND CONNECTING RODS (See FIGURE 43.)

Pistons And Connecting Rods, Removal

1. Remove the cylinder head as described in **Cylinder Head, Removal**.

2. Remove the oil sump.

3. Clean the carbon from the top of each cylinder.

4. Remove the caps from the connecting rods. Keep the bearings in their correct order. Keep the connecting rod cap with the correct connecting rod.

5. Push the piston and rod assembly from the top of the cylinder.

Disassembly

During disassembly of the piston assemblies, keep the parts with the correct assembly. To remove the piston

pin, first remove the snap rings at each end of the pin. Then remove the piston pin as shown in FIGURE 44.

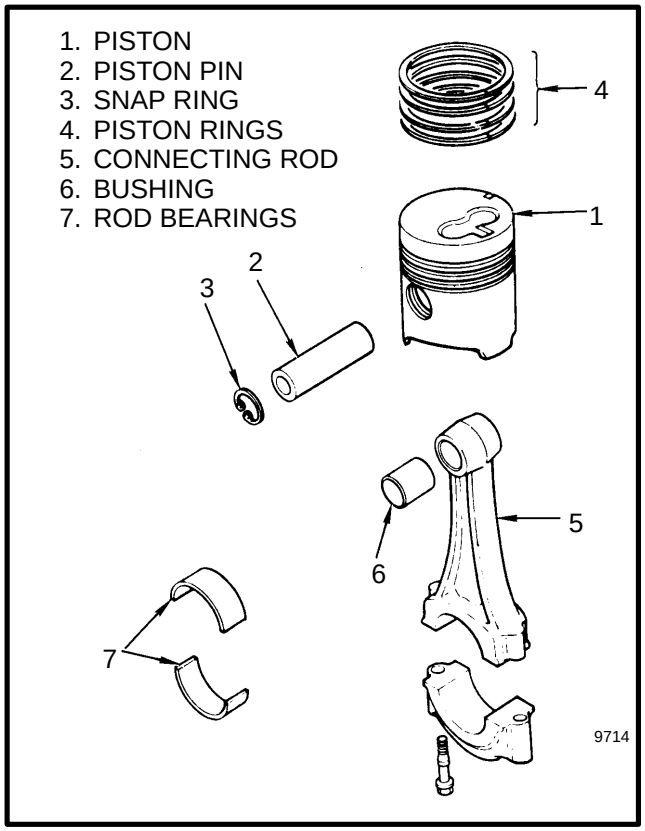


FIGURE 43. PISTON AND CONNECTING ROD ASSEMBLY

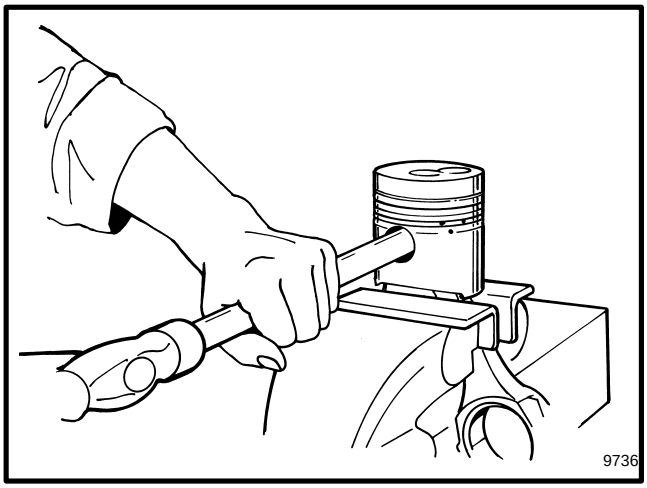


FIGURE 44. PISTON PIN, REMOVAL

Pistons, Inspection And Repair

1. Visually inspect the pistons for wear and cracks. Replace a piston that has damage.

2. Check the clearance between the piston and the cylinder liner. Remove the piston rings to make the measurement. Install a piston into its cylinder liner. Install the piston so that the front mark is toward the front of the engine. See FIGURE 48. Now put a 0.10 to 0.12 mm (0.004 to 0.005 inch) blade of a thickness gauge between the piston and the cylinder liner. Make sure to put the thickness gauge at the left side of the cylinder liner as shown in FIGURE 45. This area of the piston has the most wear. Install a 0 to 5 kg (0 to 10 pound) scale to the end of the thickness gauge. Push the piston toward the side of the cylinder liner that is opposite the thickness gauge. Now pull out the scale with the thickness gauge and check the reading on the scale. The clearance is correct if the amount of pull needed to remove the thickness gauge is 0.5 to 1.0 kg (1 to 2 pounds).

3. If the clearance is not correct, replace the piston or the cylinder liner. See the section for the crankcase for more information about the cylinder liners.

Piston Rings, Inspection And Repair

1. Measure the end clearance of each piston ring as shown in FIGURE 46. Install the piston ring into the cylinder where it will be used. Use a thickness gauge to measure the amount of end clearance. See the specifications for the clearance of the piston rings shown in FIGURE 46. If the end clearance for any of the piston rings is greater than 1.5 mm (0.060 in), replace the piston ring.

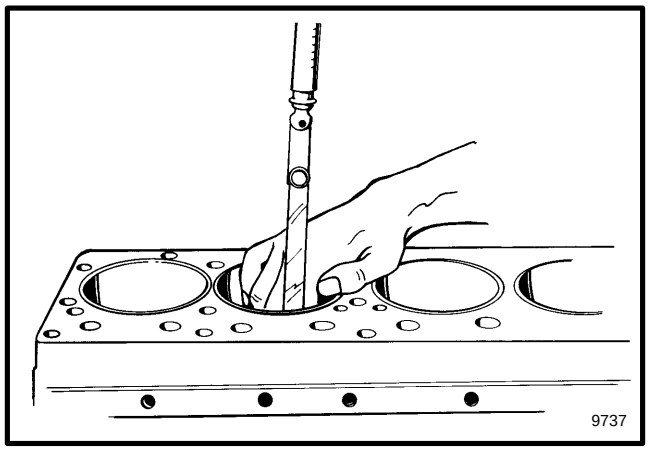
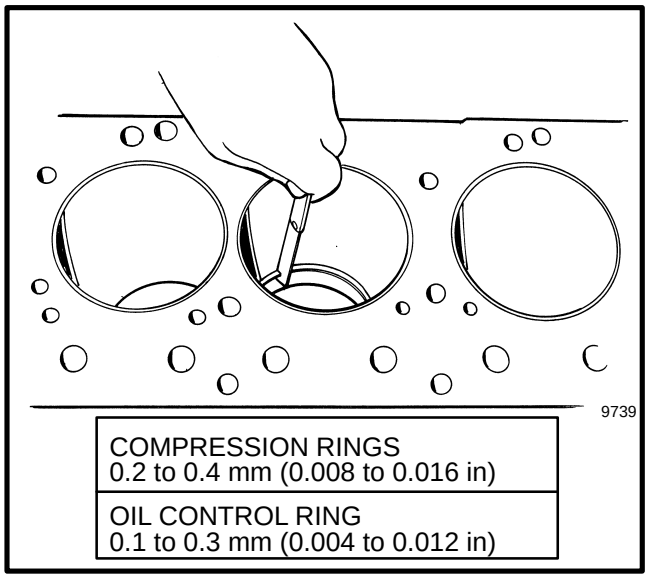


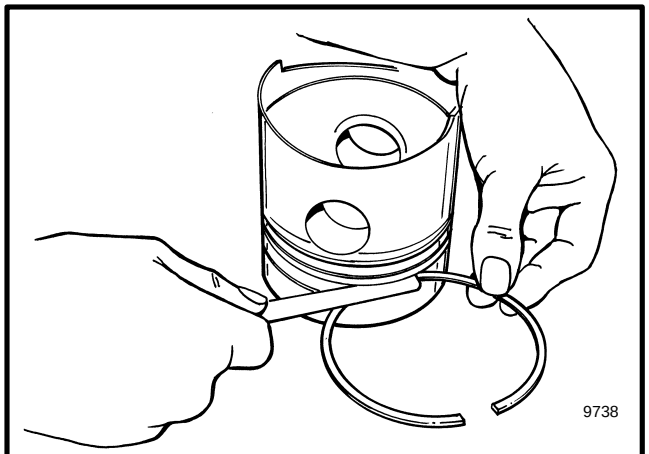
FIGURE 45. CHECK THE CLEARANCE BETWEEN THE PISTON AND THE CYLINDER LINER



COMPRESSION RINGS 0.2 to 0.4 mm (0.008 to 0.016 in)
OIL CONTROL RING 0.1 to 0.3 mm (0.004 to 0.012 in)

FIGURE 46. CHECK THE END CLEARANCE OF THE PISTON RING

2. Measure the clearance between the piston ring and the groove in the piston as shown in FIGURE 47. See the specifications for the clearance of the piston rings shown in FIGURE 47.



1st AND 2nd COMPRESSION RINGS 0.04 to 0.07 mm (0.002 to 0.003 in)
3rd COMPRESSION RING 0.03 to 0.05 mm (0.001 to 0.002 in)
OIL CONTROL RING 0.02 to 0.05 mm (0.001 to 0.002 in)

FIGURE 47. CLEARANCE BETWEEN THE PISTON RING AND THE GROOVE

Piston Pins, Inspection And Repair

1. Inspect the piston pins for wear. Measure the diameter of the pin. If the diameter of the piston pin is less than 26.97 mm (1.062 inch), replace the pin.

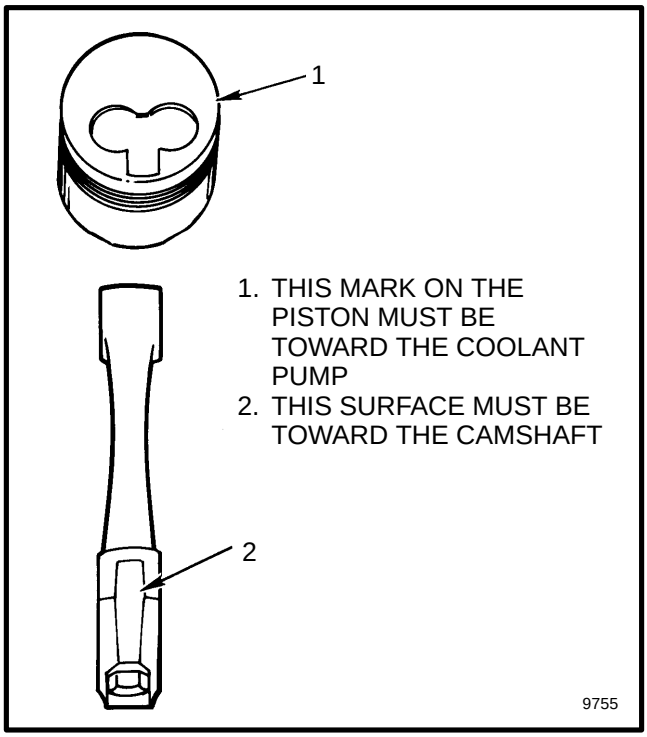
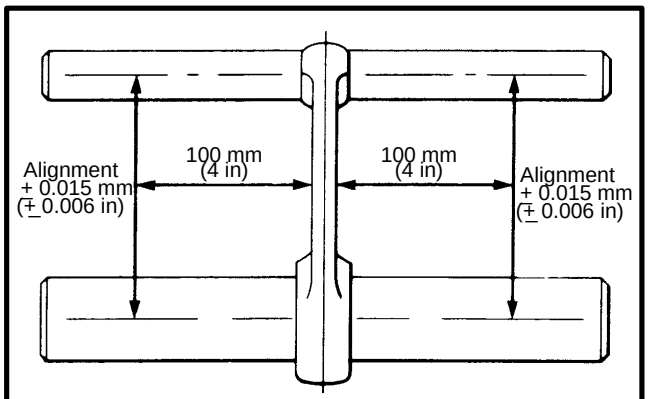


FIGURE 48. PISTON AND CONNECTING ROD ARRANGEMENT

2. During installation of the piston pin, heat the piston in warm oil. Then push the piston pin into the piston and through the connecting rod. See FIGURE 48. for the arrangement of the piston and connecting rod during assembly.



The large and small bores in the connecting rod must be square and parallel with each other within the limits of ± 0.20 mm (0.008 in). The measurement is made at 100 mm (4.0 in) on each side of the axis of the connecting rod. The alignment must be within the limits of ± 0.15 mm (0.006 in).

FIGURE 49. CHECK THE ALIGNMENT OF THE CONNECTING ROD

Connecting Rods, Inspection And Repair

1. Clean and inspect the parts for wear and damage. Check the alignment of the connecting rods with a test fixture. See FIGURE 49.

2. Check the clearance between the bushing in the connecting rod and the piston pin. The maximum amount of clearance is 0.05 mm (0.002 inch).

3. Install the connecting rod on the crankshaft. Check the axial clearance between the connecting rod and the crankshaft as shown in FIGURE 50. The maximum clearance is 0.35 mm (0.014 inch).

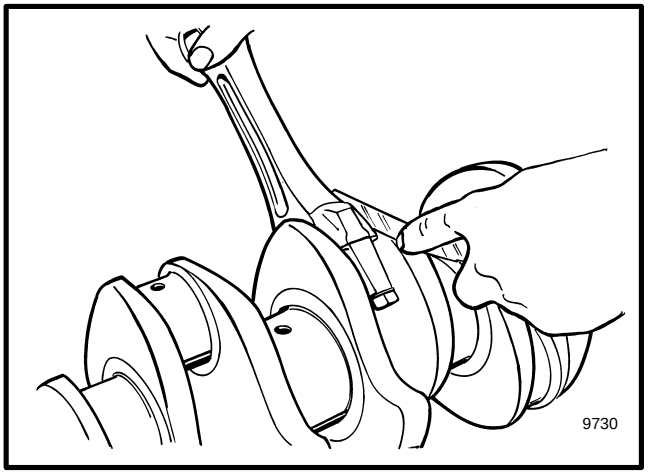


FIGURE 50. CHECK THE CLEARANCE BETWEEN THE CONNECTING ROD AND THE CRANKSHAFT

Pistons And Connecting Rods, Assembly And Installation

1. Assemble the connecting rod and the piston. Make sure that the connecting rod is installed as shown in FIGURE 48. Heat the piston in an oil bath to approximately 60°C (140°F) for easier installation of the piston pin. Install the snap rings.

2. Install the piston rings as shown in FIGURE 51. During installation, make sure that any identification marks on the piston rings are toward the top of the piston. Compression rings No. 2 and 3 are the same.

3. Install the half of the bearing in the connecting rod.

4. Apply clean engine oil to the piston rings and the journals for the connecting rods. Install the piston assemblies into the correct cylinders. During installation, the small mark on the top of the piston must be toward the end of the engine with the cooling fan. See FIGURE 52.

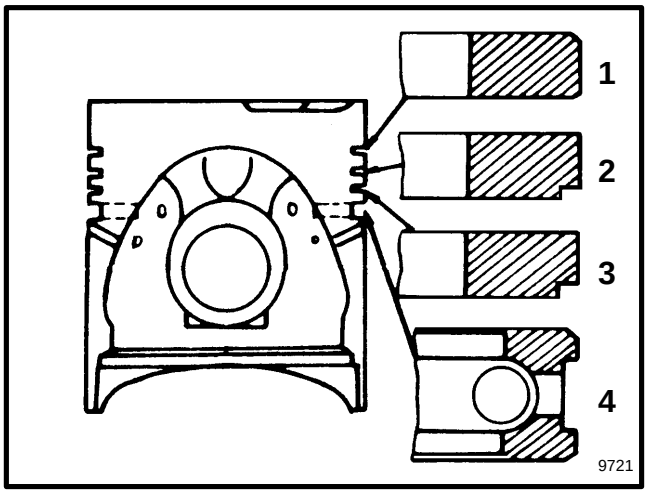


FIGURE 51. ASSEMBLY OF THE PISTON RINGS

5. Install the bearing in the cap for the connecting rod. Apply clean engine oil to the bearing surface and then install the cap on the connecting rod. Tighten the bolts to 81 N.m (60 lbf ft).

6. Install the cylinder head as described in Cylinder Head, Installation.

7. Install the oil sump. Apply a sealant to the oil sump during installation.

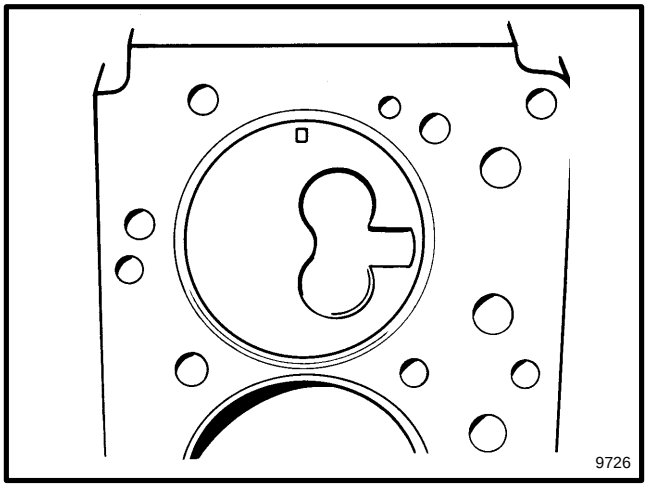


FIGURE 52. POSITION OF THE PISTON IN THE CYLINDER

CYLINDER BLOCK AND CYLINDER LINERS

Cylinder Liners, Inspection

Inspect the cylinder liner for wear and damage. Measure the inside diameter of each cylinder liner to find the amount of wear. Do the measurement of the liner at the area that is 15 mm (0.6 inch) below the surface of the

cylinder block. If the inside diameter of the cylinder liner is more than 86.20 mm (3.394 inch), replace the cylinder liner.

⚠ CAUTION

The cylinder liners have a chrome surface. Do not try to repair a cylinder liner that has damage. If a cylinder liner has damage, replace the cylinder liner.

Replacement Of A Cylinder Liner

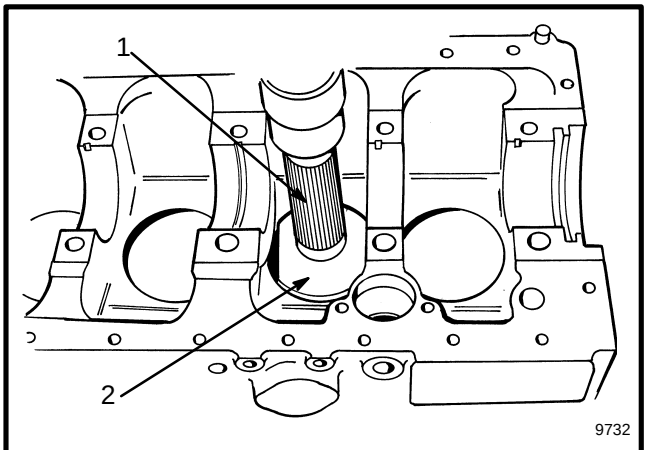
NOTE: The following special tools are needed to replace the cylinder liner:

a. Cylinder liner remover (Hyster Part No. 320901)

b. Special shaft (Hyster Part No. 320902)

c. Installation tool (Hyster Part No. 320903)

1. To remove the cylinder liner, install the remover tool and the special shaft tool to the bottom of the cylinder liner. Use a press to push the liner from the cylinder block. See FIGURE 53.



1. CYLINDER LINER REMOVER, ISUZU PART NO. 5–8840–2039–0
2. PRESS

FIGURE 53. CYLINDER LINER, REMOVAL

2. Before installation of the cylinder liners, check the surface of the cylinder block for distortion. Make the measurements at the positions shown in FIGURE 54. If the amount of distortion is more than 0.2 mm (0.008 in), repair the surface of the cylinder block. The maximum amount of machining that is permitted is 0.4 mm (0.016 in).

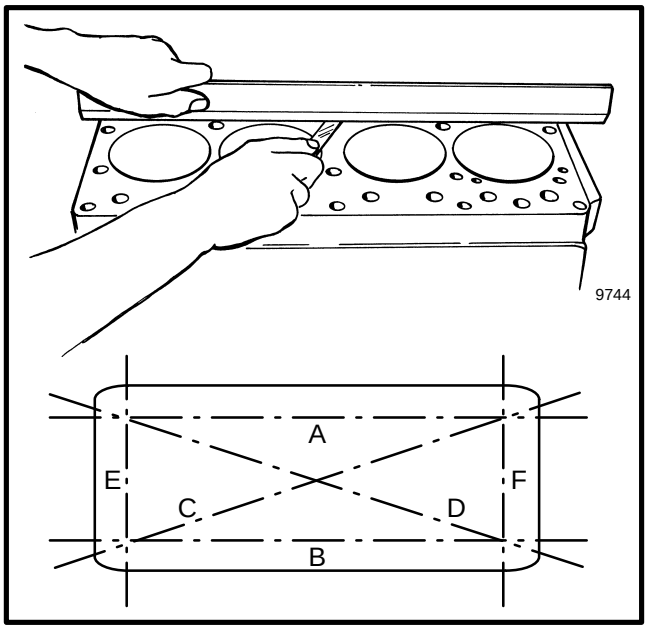
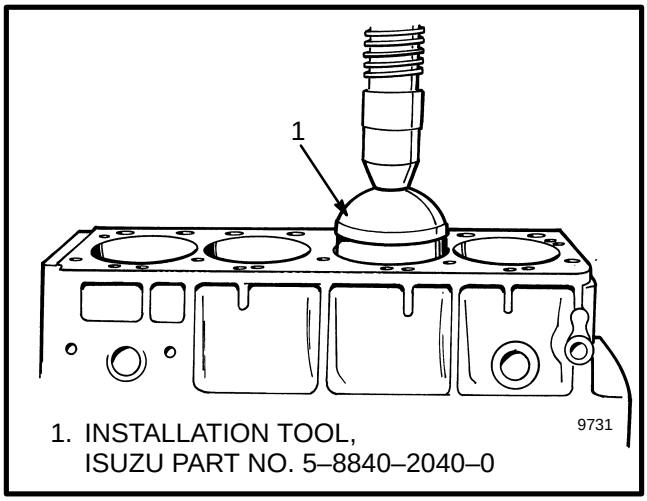


FIGURE 54. CHECK THE SURFACE OF THE CYLINDER BLOCK FOR DISTORTION

⚠ CAUTION

The cylinder liners can be easily damaged. Be careful when handling them. Do not handle cylinder liners more than necessary because a rust inhibitor is on their surface.



1. INSTALLATION TOOL, ISUZU PART NO. 5–8840–2040–0

FIGURE 55. CYLINDER LINER, INSTALLATION

3. Apply oil to the outside surface of the cylinder liner. Use a press and the special installation tool to install the cylinder liner. See FIGURE 55.

4. Measure the position of the cylinder liner. The cylinder liner must extend 0.10 mm (0.004 in) above the surface of the crankcase. See FIGURE 56.

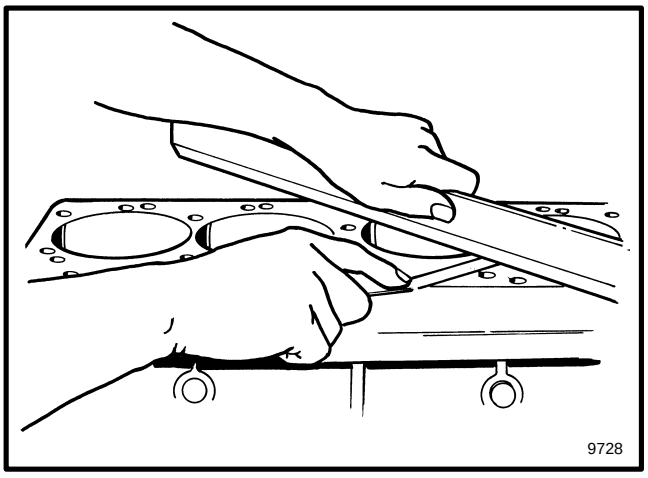


FIGURE 56. MEASURE THE CYLINDER LINER POSITION

⚠ CAUTION

The cylinder liners have a chrome surface. After installation of the cylinder liners, their surfaces must not be machined.

5. Check the clearance between the cylinder liner and the piston. See Pistons and Connecting Rods for more information.

LUBRICATION SYSTEM

Oil Pump, Removal And Disassembly (See FIGURE 57.)

1. Remove the oil sump.

2. Remove the oil pump with the oil tube from the crankcase.

2. Check the clearance between the rotors as shown in FIGURE 58. and FIGURE 59. If the clearances are greater than 0.13 mm (0.005 inch), replace the rotors.

3. Remove the filter assembly, the pump cover and the vane.

4. Remove the retainer pins from the shaft to remove the rotor and the pinion.

Oil Pump, Inspection

1. If the oil pump is worn so that the performance is decreased, the oil pump must be replaced. Check the clearances between the rotors and the surface of the pump body. If the clearance is greater than 0.15 mm (0.006 inch), replace the rotor and the vane.

3. Check the end clearances of the rotor. If the clearance is greater than 0.27 mm (.011 inch), replace the oil pump. See FIGURE 60.

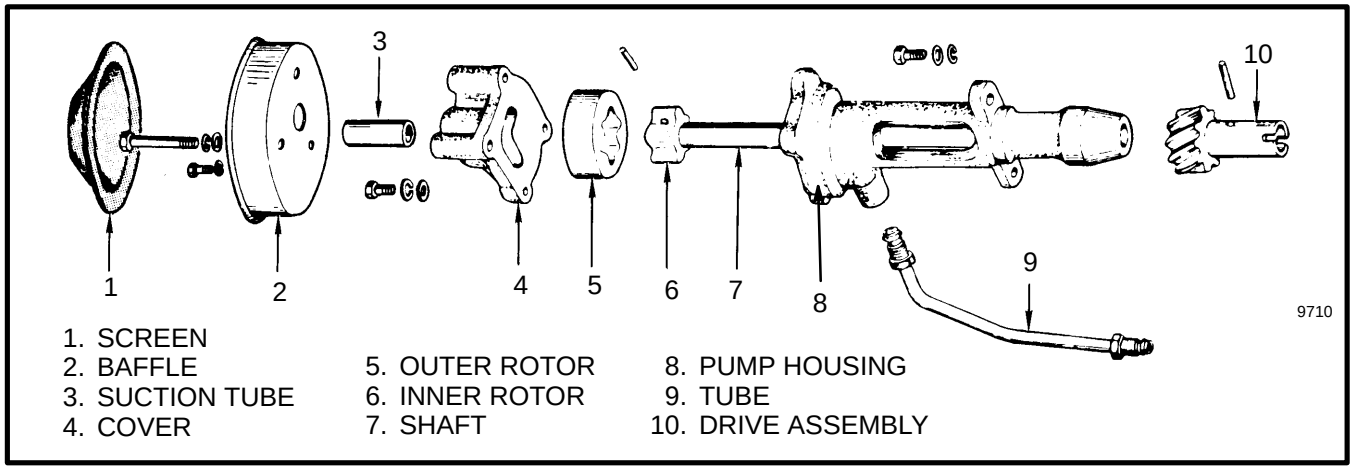


FIGURE 57. OIL PUMP

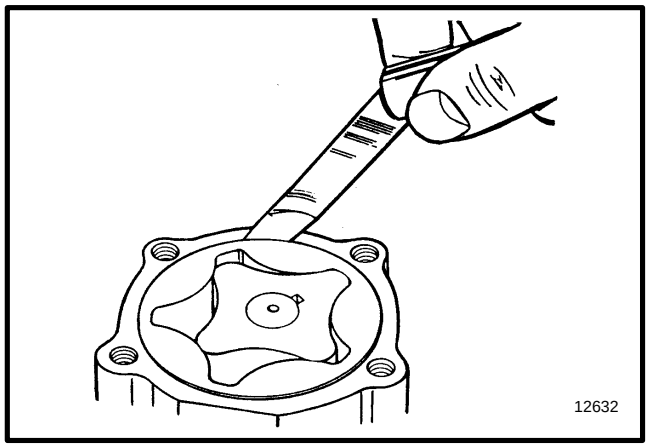


FIGURE 58. CHECK THE CLEARANCE OF THE OUTER ROTOR

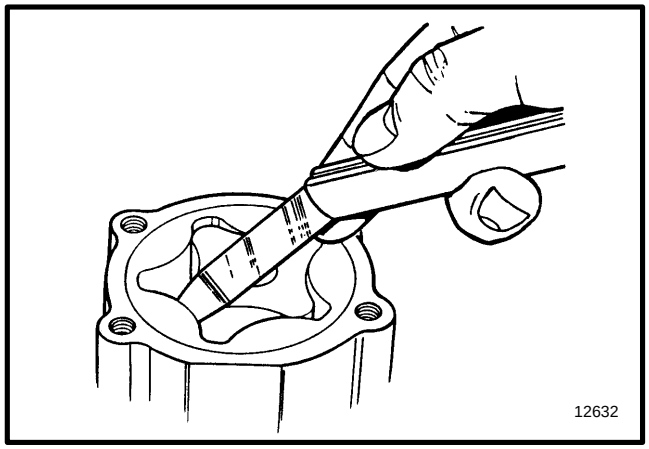


FIGURE 59. CHECK THE CLEARANCES OF THE INNER ROTOR

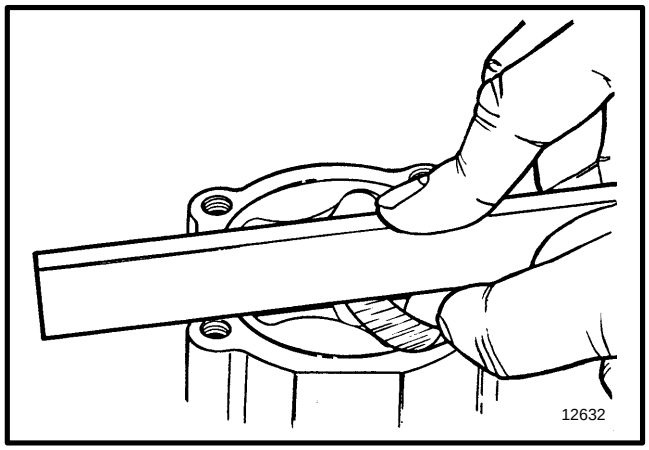


FIGURE 60. CHECK THE END CLEARANCES OF THE ROTOR

Oil Pump, Assembly And Installation (See FIGURE 57.)

1. Install the shaft (7) in the pump body.

2. Install the inner rotor (6) and the drive gear assembly (10). Install the retainer pins.

3. Install the outer rotor (5), cover (4) and the screen assembly (1, 2, and 3).

4. Install the oil tube (8) so that it is loosely fastened to the oil pump.

5. Install the oil pump in the crankcase. Connect the oil tube and tighten the fittings.

6. Install the oil sump.

Oil Filter

NOTE: Isuzu diesel engines installed in later production lift trucks use an oil filter as shown in FIGURE 61. Isuzu diesel engines installed in earlier production lift trucks use an oil filter with a separate filter element as shown in FIGURE 62.

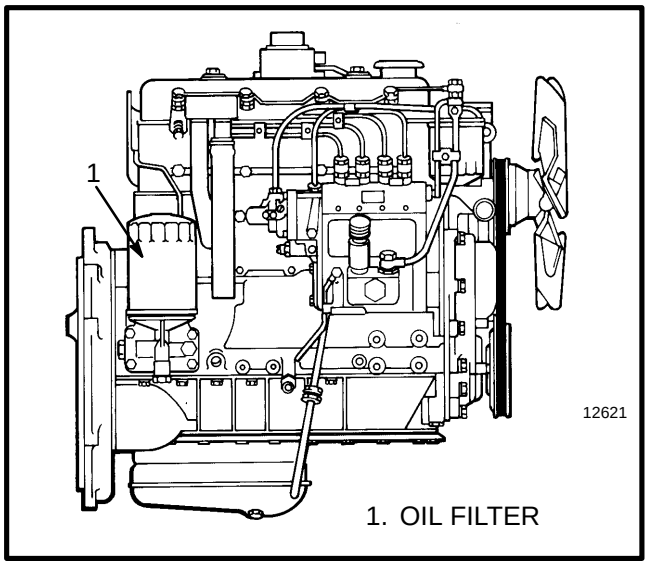


FIGURE 61. OIL FILTER ASSEMBLY, LATER PRODUCTION

Later Production. Replace the oil filter as described in the section, **PERIODIC MAINTENANCE**. Change the oil filter at the same time engine oil is changed. Use the correct oil according to the specifications. Install a new filter. Apply clean oil to the gasket of the new filter. Turn the filter until the gasket touches, then tighten 1/2

to 3/4 turn with your hand. Start the engine. Check the area around the oil filter for leaks.

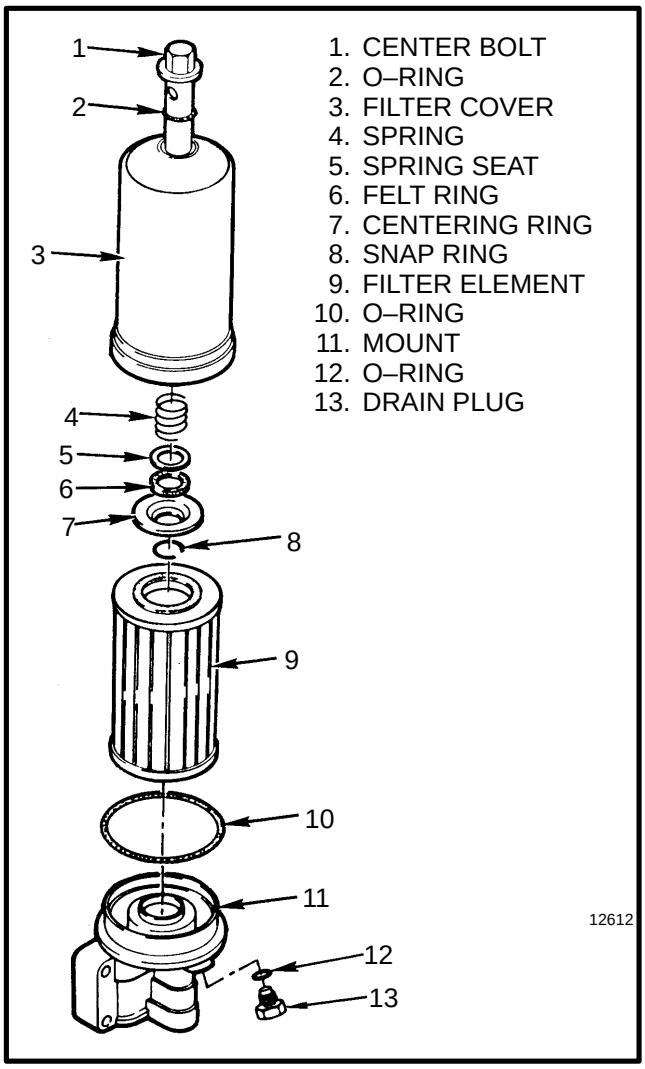


FIGURE 62. OIL FILTER, EARLIER PRODUCTION ISUZU ENGINES

Earlier Production. Replace the oil filter as described in the section, **PERIODIC MAINTENANCE**. The relief valve opens to release pressure at 560 to 620 kPa (80 to 90 psi). Change the oil filter at the same time engine oil is changed. Use the correct oil according to the specifications. See FIGURE 62. Remove the drain plug (14) in the mount for the filter and drain the oil. Loosen the center bolt and remove the filter cover (3) and filter element (9). Clean the filter cover and install a new filter element. Make sure the O–rings and other parts are in their correct positions. Tighten the center bolt for the filter cover. Check for leaks when the engine can be operated.

COOLING SYSTEM

Coolant Pump, Removal

1. Drain the cooling system

2. Remove the fan belt, the fan, and the pulley.

3. Remove the hoses from the coolant pump.

4. Remove the coolant pump from the engine.

Coolant Pump, Disassembly (See FIGURE 63.)

⚠ CAUTION

Do not use a hammer to disassemble parts of the coolant pump. Some parts are cast iron and can be broken if they are hit with a hammer.

1. Remove the cover (10) and gasket (9) from the body (2) of the coolant pump.

2. Use a press and adapter or a special puller (Hyster Part No. 368758) to remove the hub (1).

3. Remove the set screw (3) that holds the bearing unit in the pump body.

4. Use a press to push the shaft from the impeller (8).

5. Remove the seal unit (7) from the shaft.

Coolant Pump, Assembly And Installation

1. Install the bearing unit so that the holes for the set screw are aligned. See FIGURE 63. Install the set screw.

2. Install the seals. Apply a thin coat of silicone oil to the ceramic disk during installation.

3. Use a press to install the impeller. The clearance between the impeller and the pump body must be 0.3 to 0.6 mm (0.012 to 0.024 inch).

4. Install the rear cover.

5. Install the hub. Push the hub on the shaft until the distance between the surface of the hub and the surface of the rear cover is 110.7 to 111.3 mm (4.14 to 4.16 inch).

6. Install the coolant pump.

7. Adjust the tension of the fan belt as described in the section **PERIODIC MAINTENANCE**.

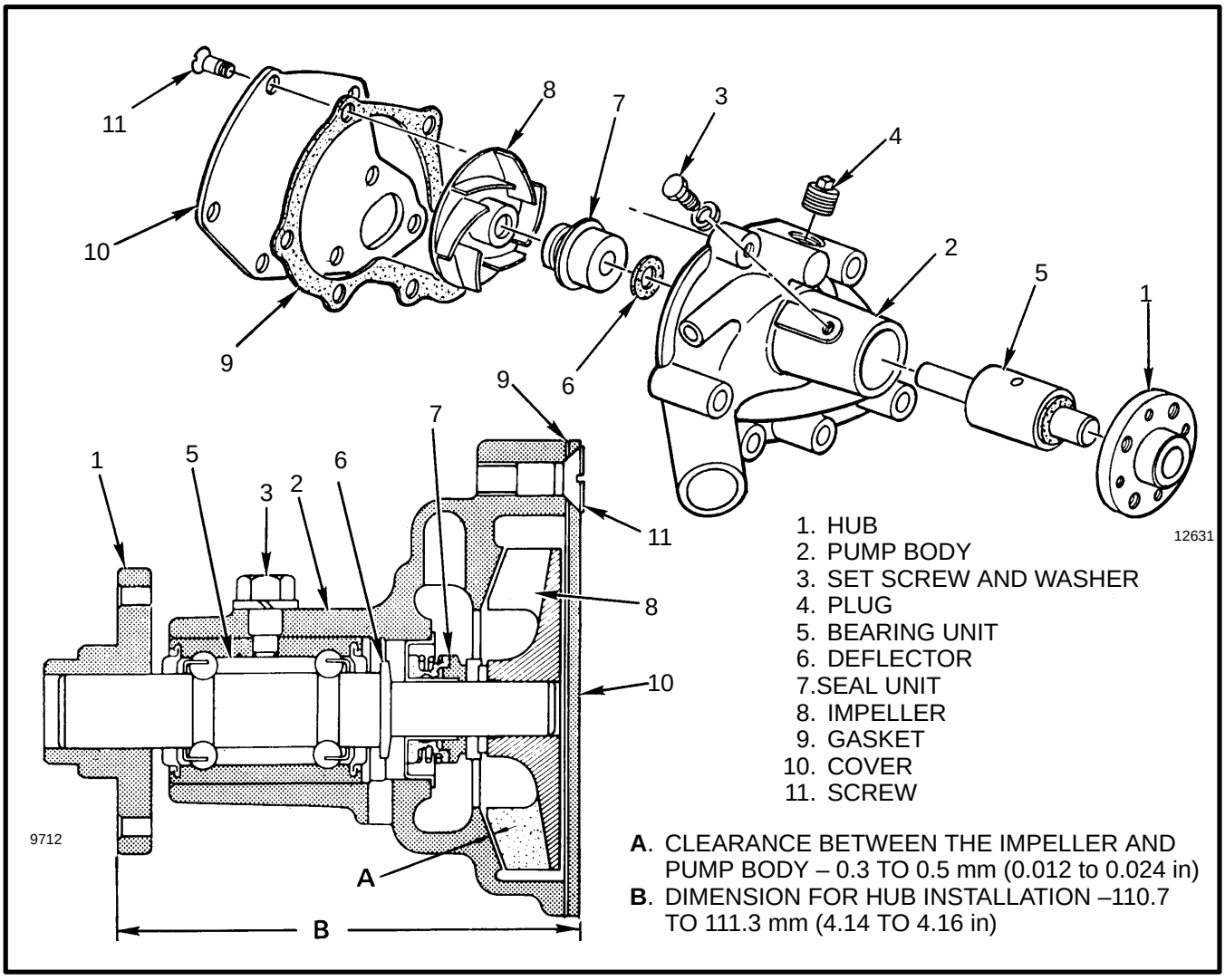


FIGURE 63. COOLANT PUMP

Thermostat, Replacement

1. Drain the cooling system so that the coolant level is below the thermostat position and disconnect the top hose from the outlet connection.

2. Remove the capscrews and remove the outlet connection.

3. Remove the thermostat.

4. Make sure that the surfaces for the joint in the outlet are clean. Install a new thermostat in the housing.

5. Use a new gasket and install the outlet connection. Tighten the capscrews.

6. Connect the top hose and fill the cooling system.

CHECKS AND ADJUSTMENTS

VALVE CLEARANCE ADJUSTMENT

NOTE: Before you check the clearance of the valves, check the torque of the bolts for the rocker arm assembly. The correct torque is 17 N.m (13 lbf ft).

Number 1 cylinder is at the end of the engine with the fan. The exhaust valve is the first valve in the sequence.

The valve clearance is measured between the top of the valve stem and the rocker arm as shown in FIGURE 64.

Valve clearance (cold)

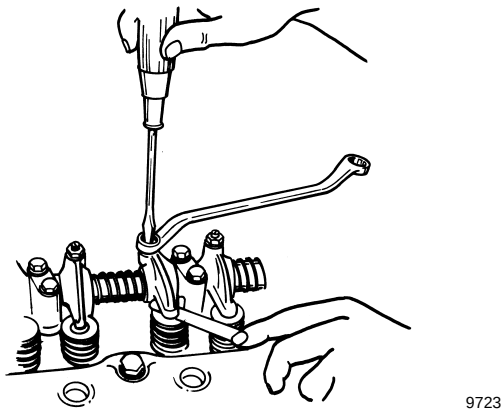
Inlet	0.45 mm (0.018 in)
Exhaust	0.45 mm (0.018 in)

1. Remove the valve cover. Rotate the crankshaft until the **number 1** piston is at TDC on the compression

stroke. In this position, both rocker arms for the number 1 cylinder will be loose.

2. Adjust the valves that are marked “A” in the table of FIGURE 64. Do the adjustments when the engine is cold. The correct valve clearance for all valves is 0.45 mm (0.018 in).

3. Rotate the crankshaft 360°. At this position, the **number 4** piston will be at TDC on the compression stroke. Adjust the valves that are marked “B” in the table of FIGURE 64.



CYLINDER							
1		2		3		4	
E	I	I	E	E	I	I	E
A	A	A	B	A	B	B	B

E = EXHAUST I = INTAKE

A – ADJUST THESE VALVES WHEN No. 1 PISTON IS AT TDC ON THE COMPRESSION STROKE

B – ADJUST THESE VALVES WHEN No. 4 PISTON IS AT TDC ON THE COMPRESSION STROKE

FIGURE 64. VALVE CLEARANCE ADJUSTMENT

CHECK THE TIMING OF THE FUEL INJECTION PUMP, MODEL VE

1. Remove the capscrew (2) from the center of the distributor head (1) as shown in FIGURE 65. Use a dial indicator so that the movement of the plunger can be measured. The movement of the plunger can be measured through the hole in the distributor head where the capscrew was removed.

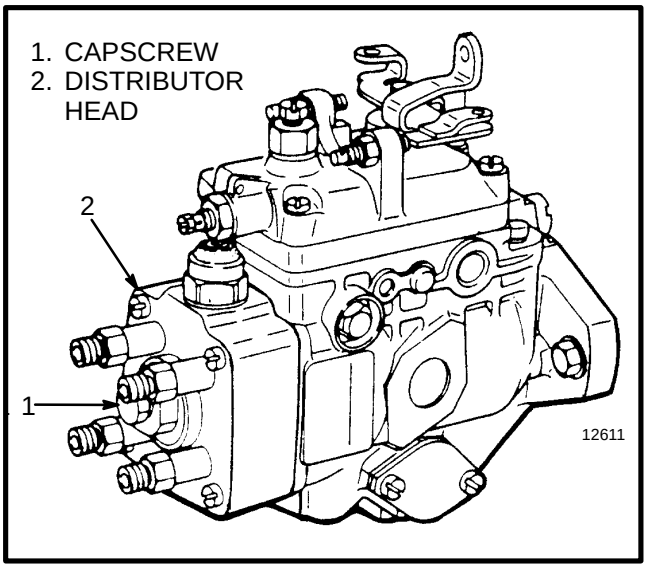


FIGURE 65. FUEL INJECTION PUMP, MODEL VE

2. Rotate the crankshaft until the number one piston is at TDC on the compression stroke. Read the mark for timing on the crankshaft pulley that is aligned with the indicator on the gear case shown in FIGURE 66. Rotate the crankshaft before and after TDC to find the maximum movement of the plunger toward the end of the distributor head.

3. Rotate the crankshaft counterclockwise approximately 30_. Now rotate the crankshaft clockwise slowly.

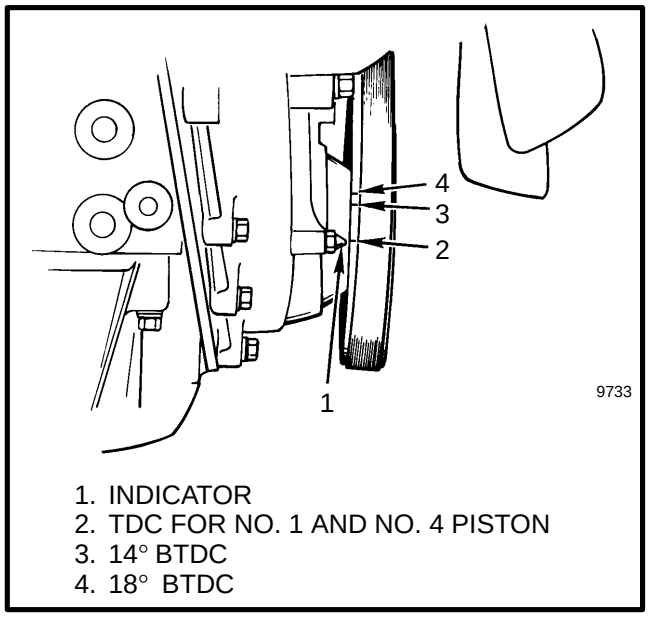
4. Stop rotating the crankshaft when the plunger is 0.50 mm (0.020 in) less than its maximum movement found in step 2.

5. Read the mark for timing on the crankshaft pulley that is aligned with the indicator on the gear case. See FIGURE 66. The correct timing for injection is 14° BTDC.

6. If the timing is not correct, loosen the fuel injection pump and rotate it as necessary. Repeat the procedure described in step 5 until the timing is correct.

7. Remove the dial gauge and install the capscrew in the distributor head.

8. Remove the air from the fuel system. The procedure is described in **Remove the Air From the Fuel System**.



1. INDICATOR
2. TDC FOR NO. 1 AND NO. 4 PISTON
3. 14° BTDC
4. 18° BTDC

FIGURE 66. TIMING MARKS

CHECK THE TIMING OF THE FUEL INJECTION PUMP, MODEL PE4A

Two persons are necessary to check the timing of the fuel injection pump. One person must look at the flow of fuel from the injection pump. The other person must rotate the crankshaft very slowly and smoothly.

1. Remove the fuel line between the fuel injection pump and the **number one cylinder**.

2. Remove the special fitting at the fuel injection pump for the **number one cylinder**. See FIGURE 67. Remove the spring and the check valve. Now install the special fitting to the injection pump without the spring and check valve.

3. Make sure there is enough fuel in the fuel tank.

4. Rotate the crankshaft until the number one piston is at TDC on the compression stroke. Now rotate the crankshaft counterclockwise approximately 30°.

5. Operate the hand pump on the injection pump. Fuel will flow from the special fitting. Continue to operate hand pump while the other person slowly and smoothly rotates the crankshaft clockwise. Tell the person that rotates the crankshaft to stop at the exact time when you see the flow of fuel stop from the special fitting. This moment is when fuel injection starts for the **number one cylinder**. At this condition, read the mark for timing on the crankshaft pulley that is aligned with the indicator on the gear case. See FIGURE 66. The correct timing for injection is 14° BTDC.

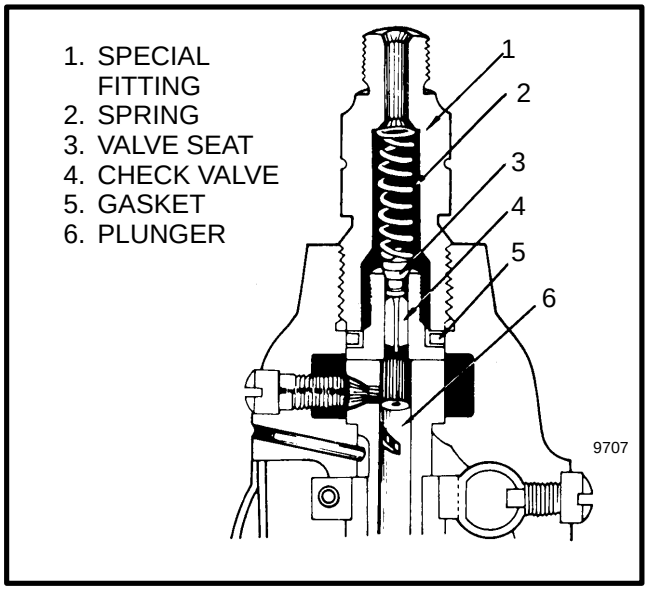


FIGURE 67. PLUNGER ASSEMBLY, FUEL INJECTION PUMP, MODEL PE4A

6. If the timing is not correct, loosen the fuel injection pump and rotate it as necessary. Repeat the procedure described in step 5 until the timing is correct.

7. Remove the special fitting and install the spring and the check valve. Install the special fitting and then install the fuel line.

8. Remove the air from the fuel system. The procedure is described in Remove the Air From the Fuel System.

FUEL INJECTORS

The engine will run roughly if a fuel injector does not operate correctly. To find which fuel injector has a problem, operate the engine at approximately 1000 rpm. Loosen and tighten the connection to the inlet of each fuel injector in a sequence. When the connection to the defective fuel injector is loosened, there will not be a change in the engine speed.

⚠ WARNING

Do not put your hands on fuel lines under pressure. Fuel oil can be injected into your body by the hydraulic pressure.

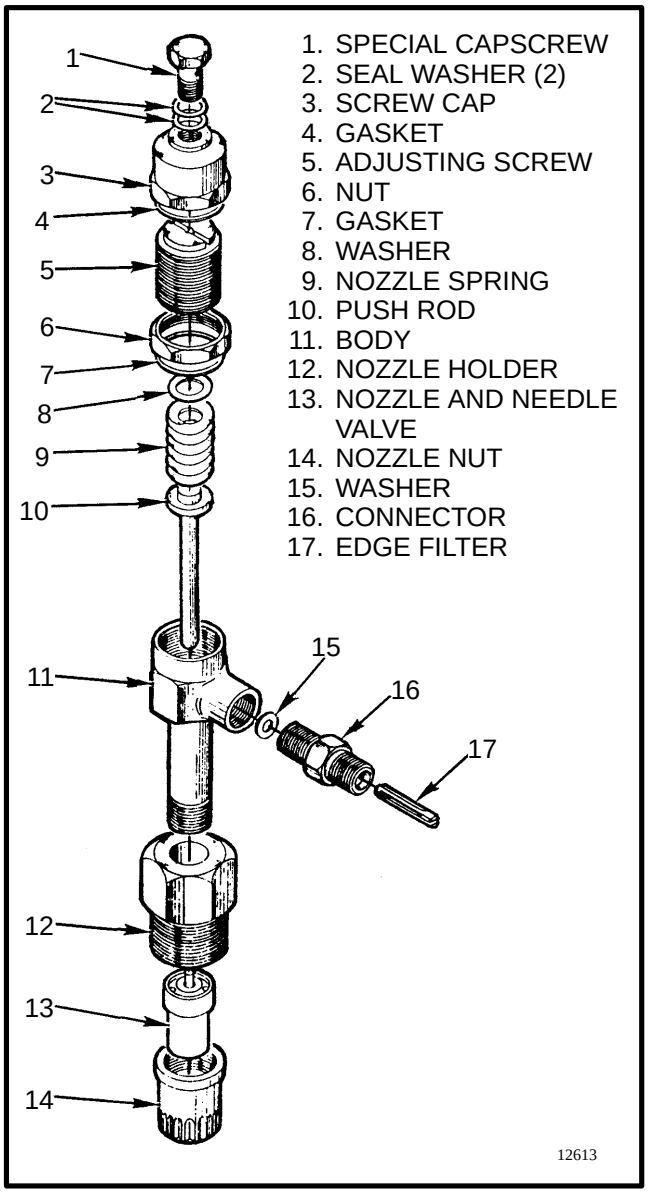


FIGURE 68. FUEL INJECTOR, DIESEL ENGINES

Fuel Injectors, Removal

1. See FIGURE 68. Disconnect the fuel return line from the fuel injector. Remove the special capscrew (1) at the top of the fuel injector to disconnect the special “banjo” fitting for the fuel return line.

2. Disconnect the high pressure line at the inlet to the fuel injector. Do not bend the fuel line.

3. Use a wrench to turn the nozzle holder (12) and remove the fuel injector and the copper washer from the cylinder head.

Fuel Injectors, Inspection

NOTE: The inspection and repair of fuel injectors require special tools and training. Many users have a special repair service make repairs on injectors. Fuel injector nozzles that have a defect will cause black smoke in the exhaust, a decrease in engine power, and an increase in engine noise.

1. Carefully clean the parts of the fuel injector in a mineral oil solvent. The needle valves are specially fitted. Do not use an abrasive on the fitted areas of the needle valve. To prevent corrosion, do not touch the fitted ares of the needle valve with your fingers.

2. Carefully check all parts for wear and damage. See FIGURE 68. The nozzle and needle valve (13) must be replaced if there is any wear or damage. Hold the nozzle and needle valve in a vertical position. Pull the needle valve upward approximately !P3 of its length and release it. The needle must lower smoothly into its seat by its own weight. If the needle valve does not pass this test, the nozzle and needle valve (13) must be replaced.

3. The operation of the fuel injector must be checked with an injection tester. See FIGURE 69. The injection tester uses a special oil for calibration tests.

Special oils for calibration tests:

SHELL (UK)	Calibration fluid C
SHELL (worldwide)	Calibration fluid B
ESSO	Calibration fluid IL 1838
CASTROL	Calibration oil 8327

4. Check the spray pattern of the nozzle. See FIGURE 69. If the spray pattern is not correct, the needle valve does not fit the valve seat correctly. Remove carbon deposits or replace parts as required.

⚠ WARNING

Make sure that the nozzle of the injector is away from the operator during a test. Test oil can be injected into your body by the hydraulic pressure.

5. Use an injector tester to check the pressure at which the nozzle operates. The correct pressure is 11.9 MPa (1705 psi).

6. See FIGURE 68. To change the pressure at which the nozzle operates, turn the adjustment screw (5).

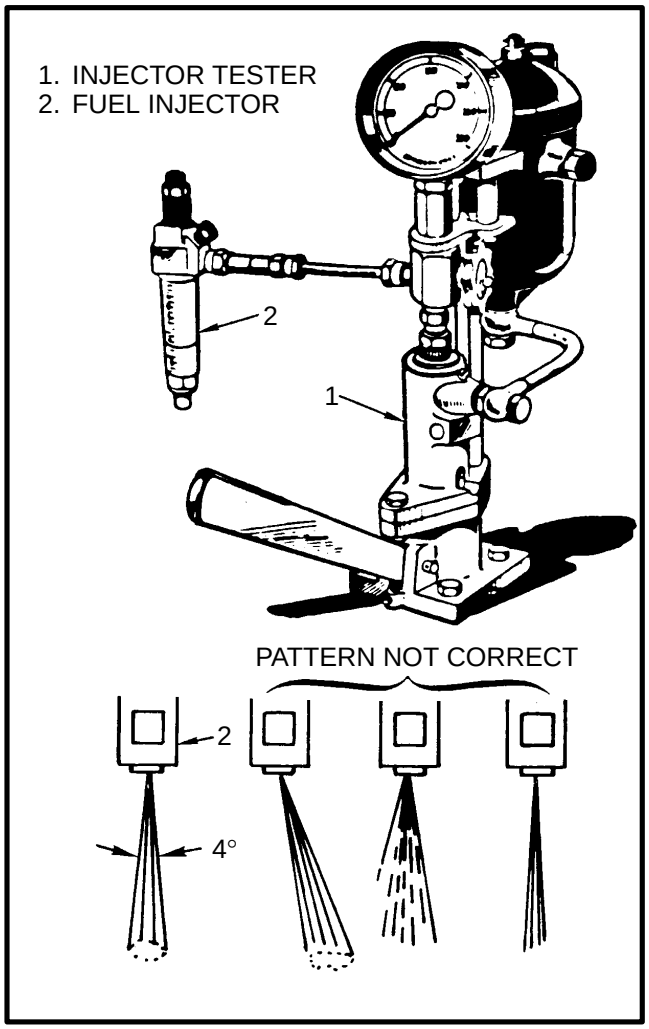


FIGURE 69. CHECK THE FUEL INJECTORS

Fuel Injectors, Installation

1. See FIGURE 68. Use a new copper washer with the replacement fuel injector. Install the fuel injector and copper washer in the cylinder head.

2. Install the high pressure line and tighten the connections to 18 N.m (13 lbf ft). Install the line clamps if they were removed.

3. Install new seal washers (2) and connect the fuel return line to the fuel injector.

4. Remove the air from the fuel system. See **Remove Air From The Fuel System.**

5. When the engine can be operated, check for fuel leaks.

DIESEL FUEL FILTERS

NOTE: Engines that have a fuel injection pump, model VE, have a water separator in the bottom of the fuel filter. A sender unit in the bottom of the fuel filter illuminates an indicator light on the instrument panel if there is water in the water separator.

Engines that have a fuel injection pump, model PE4A, do not have a water separator. The fuel filter must be replaced according to the schedule shown in the section **PERIODIC MAINTENANCE.** If there is a problem with water in the diesel fuel in your area, the fuel filter must be changed more frequently than the schedule.

Filter Replacement, Models <u>With</u> A Water Separator

1. See FIGURE 70. Disconnect the two sender wires from the bottom of the fuel filter. Remove the fuel filter from its mount. Remove the parts that include the sender unit from the bottom of the fuel filter.

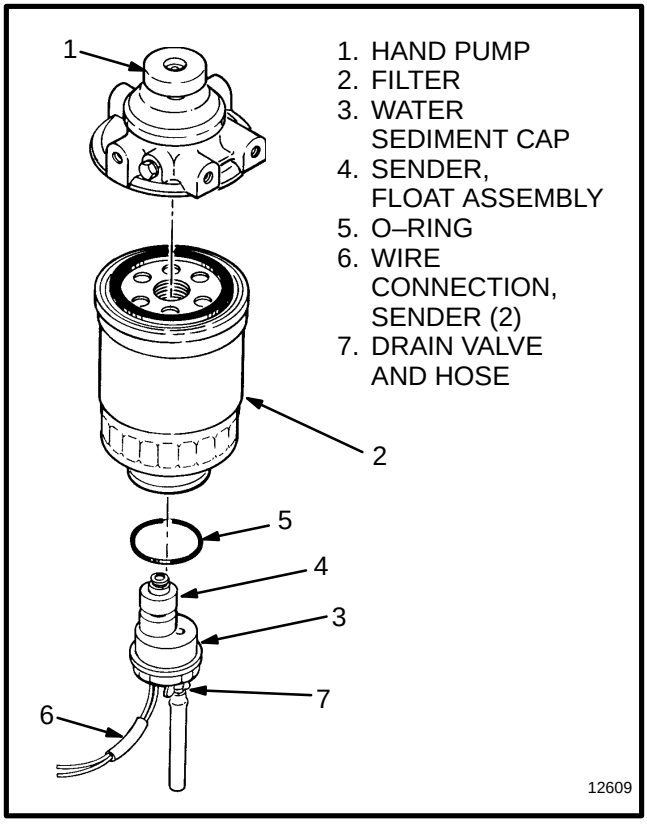


FIGURE 70. FUEL FILTER WITH A WATER SEPARATOR

2. Install the parts that include the sender unit in the new fuel filter. Use a new O–ring between the fuel filter and the sender unit. Lubricate the O–ring with diesel fuel when it is installed. When the engine can be operated, check for leaks.

Filter Replacement, Models Without A Water Separator

See FIGURE 71. Remove and discard the filter element. Put oil on the seal of the new filter and install it. When the engine can be operated, check for leaks.

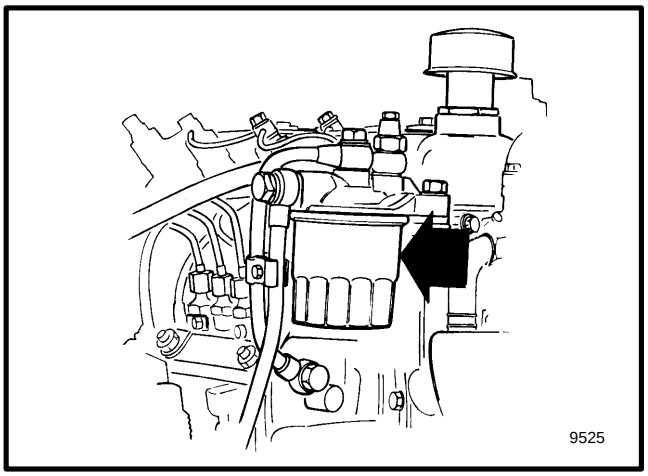


FIGURE 71. FUEL FILTER WITHOUT A WATER SEPARATOR

Filter For The Fuel Injection Pump, Model PE4A

See FIGURE 72. A small filter is in the special bolt where the fuel line is connected to the fuel injection pump. Remove the special bolt and fuel filter (1). Clean the filter in mineral oil solvent and check for damage. Replace the filter (1) if it is damaged or has a restriction and can not be cleaned.

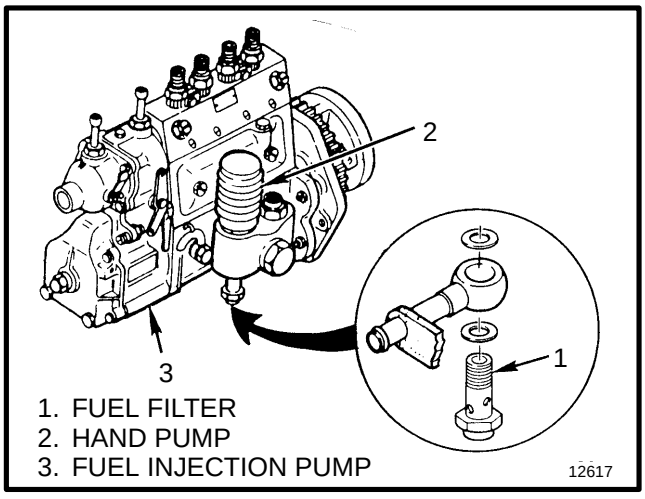


FIGURE 72. FILTER, FUEL INJECTION PUMP, MODEL PE4A

REMOVE AIR FROM THE FUEL SYSTEM

NOTE: The fuel injection pump will normally remove small amounts of air from the fuel system when the engine is started. If the fuel pump, fuel injection pump, or the fuel filter is empty, it is necessary to disconnect a fitting and fill the components of the fuel system before the engine will start.

The fuel injection pump, Model VE, has a rotary vane fuel pump inside of the fuel injection pump. The fuel injection pump must be filled with fuel before the engine will start. A hand pump is installed in the top of the fuel filter. See FIGURE 70. This hand pump can be used to fill the fuel system before trying to start the engine. The following procedure is for diesel engines with a fuel injection pump, Model VE:

a. Make sure there is fuel in the fuel tank.

b. Loosen a fitting on the outlet of the fuel system component that must be filled with fuel. Push the plunger of the hand pump several times until the air is removed and the component is filled with fuel. Tighten the fitting.

The fuel injection pump, Model PE4A, has a hand pump on the side of the fuel injection pump. This hand pump can be used to fill the fuel system before trying to start the engine. (See FIGURE 73.) The following procedure is for diesel engines with a fuel injection pump, Model PE4A:

a. Make sure there is fuel in the fuel tank.

b. Loosen the vent screw (2) at the drive end of the injection pump. Push the plunger of the hand pump several times until the air is removed and the component is filled with fuel. Tighten the vent screw.

c. Loosen the vent screw (3) on the other end of the injection pump. Push the plunger of the hand pump several times until the air is removed and the component is filled with fuel. Tighten the vent screw.

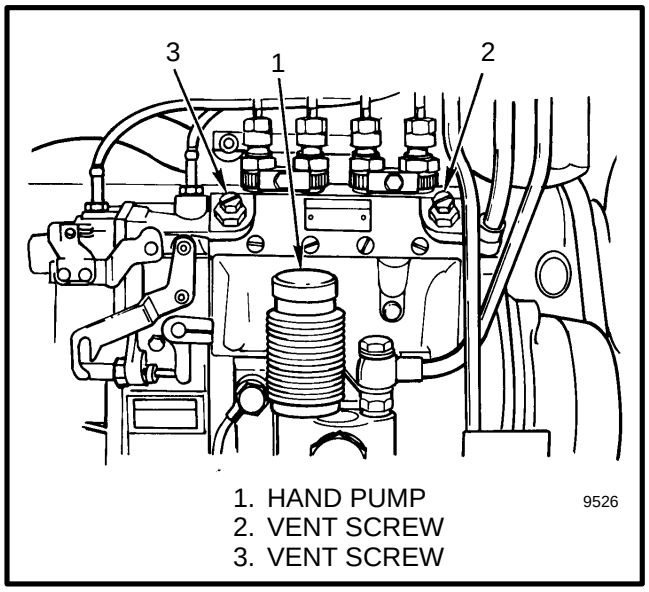


FIGURE 73. FUEL INJECTION PUMP, MODEL PE4A

Throttle Linkage, Adjustment

1. Adjust the throttle linkage so that the throttle plate is fully open when the throttle pedal or Monotrol pedal touches the floor. Make the adjustment by changing the length of the cable where it is installed to the bracket on the inlet manifold.

2. Adjust the stop for the throttle pedal so that the throttle plate is completely closed when the pedal is released. The stop is under the throttle pedal.

Idle Speed, Adjustment

The stop screw at the linkage for the throttle plate controls the idle speed of the engine. Turn the screw as necessary to get the specification. The correct idle speed is 600 to 650 rpm for S/H1.25–3.00XL (S/H25–60XL) units and 725±25 rpm for the H2.00–3.20XM (H40–65XM) units.

Check The Elements For The Cold Start Aid System

Check the condition of the glow plugs for the cold start aid system. See the section **THE ELECTRICAL SYSTEM** for more information.

ENGINE SPECIFICATIONS

Engine Data

Power Rating at 2700 rpm	36 kW (48 bhp)
Type	4 – stroke diesel
Firing order	1–3–4–2
Displacement	2369 cm^3 (144.5 in^3)
Bore	86 mm (3.386 in)
Stroke	l02 mm (4.016 in)
Compression ratio	20 : 1
Fuel injection timing (static)	14° BTDC
Fuel injector – nozzle pressure	1706 psi (11.94 MPa)
Governed speed	
– S1.25–3.00XL (S25–60XL) units	2500 to 2600 rpm
– H1.25–3.00XL (H25–60XL)	2900 to 3000 rpm
– H2.00–3.20XM (H40–65XM)	2600–2700 rpm
Idle speed	
– S/H1.25–3.00XL (S/H25–60XL)	600–650 rpm
– H2.00–3.20XM (H40–65XM)	725 ± 25 rpm
Valve clearance (cold)	Inlet 0.45 mm (0.018 in) Exhaust 0.45 mm (0.018 in)

Cooling System

Thermostat	82°C (180°F)

Cylinder Head And Valve Mechanism

Maximum distortion of cylinder head. See FIGURE 14.	0.2 mm (0.008 in)
Thickness of cylinder head – Production limit	91.95 to 92.05 mm (3.620 to 3.624 in)
Minimum thickness of head in service	91.0 mm (3.583 in)
Valve seat specifications: See FIGURE 18.	
Maximum depth of valve seat	2.5 mm (0.10 in)
Clearance between valve and guide	
– Inlet	0.20 mm (0.008 in) maximum
– Exhaust	0.25 mm (0.010 in) maximum
Diameter of inlet valve stem	7.88 mm (0.3102 in)
Angle of inlet valve face	45°

Depth of inlet valve below cylinder head
– Production 0.7 mm (0.276 in) minimum
– Service limit 2.5 mm (0.100 in) maximum

Diameter of exhaust valve stem
7.85 mm (0.314 in) minimum

Angle of exhaust valve face 45°

Depth of exhaust valve below cylinder head
0.7 mm (0.276 in) minimum
2.5 mm (0.100 in) maximum

Inner valve spring, installed length 37 mm (1.46 in)

Outer valve spring, installed length 39 mm (1.54 in)

Rocker arm shaft, diameter
– Production 19.0 mm (0.748 in)
– Service limit l8.85 mm (0.742 in) maximum

Rocker arms, clearance between bushing and shaft
– Production limit 0.01 to 0.05 mm
– Service limit 0.2 mm (0.008 in)

Cam followers (tappets), outside diameter
– Production 13.0 0.512 mm
– Service limit 12.95 mm (0.510 in)

Camshaft (See FIGURE 31.)

Cam lobes
– Production 40.6 mm (1.598 in)
– Service limit 40.2 mm (1.583 in)

Bearing journals, diameter
– Production 48.0 mm (1.889 in)
– Service limit 47.6 mm (1.874 in)

Variation from front to rear of a cam lobe or a bearing journal:
– Production limit less than 0.03 mm (0.001 in)
– Service limit 0.05 mm (0.002 in)

Clearance between journals and bearings
– Production limit 0.03 to 0.09 mm (0.0012 to 0.0035 in)
– Service limit 0.15 mm (0.006 in)

Axial Clearance
– Production limit 0.05 to 0.114 mm (0.002 to 0.0045 in)
– Service limit 0.2 mm (0.008 in)

Idler Gear Shaft

Diameter
– Production 45.0 mm (1.772 in)
– Service limit more than 0.1 mm (0.004 in)

Clearance between idler gear shaft and bushing
– Production 0.025 to 0.085 mm (0.001 to 0.0033 in)
– Service limit more than 0.2 mm (0.008 in)

Crankshaft

Crankshaft “run–out”
– Production limit less than 0.03 mm (0.0012 in)
– Service limit 0.06 mm (0.0024 in)

Clearance between journals and bearings
– Production limit 0.018 to 0.065 mm (0.0007 to 0.0025 in)
– Service limit 0.12 mm (0.005 in)

Diameter of main bearing journal
– Production limit 70.00 to 69.97 mm (2.756 to 2.755 in)
– Service limit 69.00 mm (2.7165 in)

Diameter of connecting rod journal
53.00 to 52.96 mm (2.0866 to 2.0850 in)
– Service limit 52 mm (2.047 in)

Available undersize bearings:
–0.25 mm (–0.010 in)
–0.50 mm (–0.020 in)
–0.75 mm (–0.030 in)
–1.00 mm (–0.039 in)

Axial Clearance
– Production limit 0.010 mm (0.0039 in)
– Service limit 0.3 mm (0.012 in)

Pistons

Clearance between pistons and liner
0.146 to 0.166 mm (0.0057 to 0.0065 in)

Piston Rings No. 1, and 2 clearance in groove
– Production limit 0.045 to 0.070 mm (0.0018 to 0.0028 in)
– Service limit 0.3 mm (0.012 in)

Piston Ring No. 3 clearance in groove
– Production limit 0.030 to 0.055 mm (0.0012 to 0.0022 in)
– Service limit 0.3 mm (0.012 in)

Oil Control Ring Clearance in Groove
– Production limit 0.020 to 0.054 mm (0.0008 to 0.0021 in)
– Service limit 0.15 mm (0.006 in)

Piston ring end clearance No. 1, 2, and 3
Piston rings 0.2 to 0.4 mm (0.008 to 0.016 in)

Oil control ring 0.1 to 0.3 mm (0.004 to 0.012 in)

Connecting Rods

Clearance between bushing and piston pin
– Production limit 0.008 to 0.020 mm (0.0003 to 0.0008 in)
– Service limit 0.5 mm (0.0197 in)

Piston pin, outside diameter
– Production limit 26.995 to 27.000 mm (1.0628 to 1.0630 in)
– Service limit 26.97 mm (1.0618 in)

Cylinder Liners

Diameter
– Production 86.00 mm (3.3858 in)

Wear limit (measured 15 mm below top of cylinder liner) 86.20 mm (3.3937 in)

Cylinder Liners, Replacement*

If the cylinder bore diameter is
88.001 to 88.010 mm (3.4646 to 3.4650 in)
use Grade 1
Outside diameter 88.011 to 88.020 mm (3.4650 to 3.4653 in)

If the cylinder bore diameter is
88.011 to 88.020 mm (3.4650 to 3.4653 in)
use Grade 2
Outside diameter 88.021 to 88.030 mm (3.4654 to 3.4657 in)

If the cylinder bore diameter is
88.021 to 88.030 mm (3.4654 to 3.4657 in)
use Grade 3
Outside diameter 88.031 to 88.040 mm (3.4658 to 3.4661 in)

If the cylinder bore diameter is
88.031 to 88.040 mm (3.4658 to 3.4661 in)
use Grade 4
Outside diameter 88.041 to 88.050 mm (3.4662 to 3.4665 in)

Length 178 mm (7.12 in)

*See “Cylinder Block And Cylinder Liners” for additional information.

Lubrication System

Capacity with filter 5.2 liter (5.5 qt)

Oil pump, clearance between vane and rotor 0.02 to 0.13 mm (0.001 to 0.005 in)

Relief valve pressure 558 to 615 kPa (81 to 89 psi)

TORQUE SPECIFICATIONS

ITEM	SPECIFICATION
CAMSHAFT GEAR CAPSCREW	108 N.m (80 lbf ft)
CAMSHAFT THRUST PLATE CAPSCREW	19 N.m (14 lbf ft)
CRANKSHAFT PULLEY CAPSCREW	147 N.m (109 lbf ft)
CONNECTING ROD CAPSCREWS	78 N.m (58 lbf ft)
CYLINDER HEAD CAPSCREWS	78 N.m (58 lbf ft)
ENGINE MOUNT CAPSCREWS	
H2.00–3.20XM (H40–65XM), Right–Hand Side	55 N.m (41 lbf ft)
H2.00–3.20XM (H40–65XM), Left–Hand Side	40 N.m (30 lbf ft)
FLYWHEEL CAPSCREWS	
Units except H2.00–3.20XM (H40–65XM)	70 N.m (58 lbf ft)
H2.00–3.20XM (H40–65XM)	120 N.m (89 lbf ft)
IDLER GEAR CAPSCREW	26 N.m (19 lbf ft)
MAIN BEARING CAPSCREWS	160 N.m (120 lbf ft)
REAR OIL SEAL CAPSCREWS	49 N.m (36 lbf ft)
ROCKER ARM BRACKET NUTS	29 N.m (22 lbf ft)