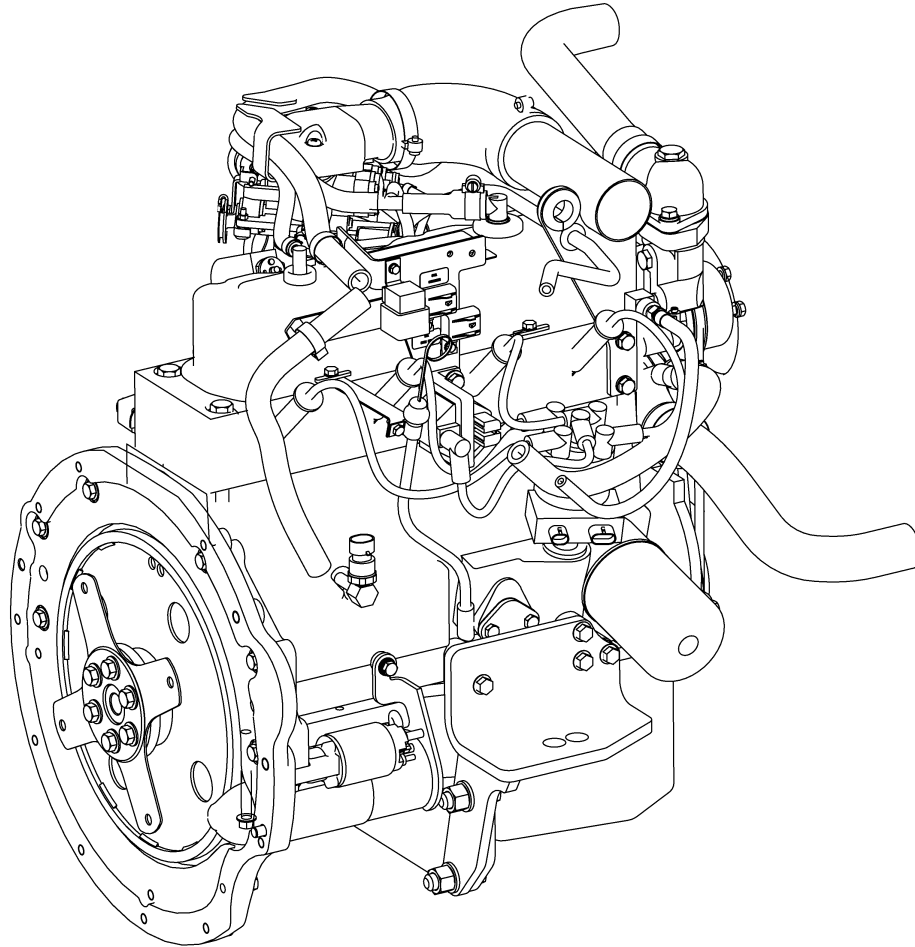


GM ENGINE REPAIR

GM 3.0 LITER ENGINE



HYSTER

SAFETY PRECAUTIONS

MAINTENANCE AND REPAIR

- When lifting parts or assemblies, make sure all slings, chains, or cables are correctly fastened, and that the load being lifted is balanced. Make sure the crane, cables, and chains have the capacity to support the weight of the load.
- Do not lift heavy parts by hand, use a lifting mechanism.
- Wear safety glasses.
- DISCONNECT THE BATTERY CONNECTOR before doing any maintenance or repair on electric lift trucks. Disconnect the battery ground cable on internal combustion lift trucks.
- Always use correct blocks to prevent the unit from rolling or falling. See HOW TO PUT THE LIFT TRUCK ON BLOCKS in the **Operating Manual** or the **Periodic Maintenance** section.
- Keep the unit clean and the working area clean and orderly.
- Use the correct tools for the job.
- Keep the tools clean and in good condition.
- Always use **HYSTER APPROVED** parts when making repairs. Replacement parts must meet or exceed the specifications of the original equipment manufacturer.
- Make sure all nuts, bolts, snap rings, and other fastening devices are removed before using force to remove parts.
- Always fasten a DO NOT OPERATE tag to the controls of the unit when making repairs, or if the unit needs repairs.
- Be sure to follow the **WARNING** and **CAUTION** notes in the instructions.
- Gasoline, Liquid Petroleum Gas (LPG), Compressed Natural Gas (CNG), and Diesel fuel are flammable. Be sure to follow the necessary safety precautions when handling these fuels and when working on these fuel systems.
- Batteries generate flammable gas when they are being charged. Keep fire and sparks away from the area. Make sure the area is well ventilated.

NOTE: The following symbols and words indicate safety information in this manual:



WARNING

Indicates a condition that can cause immediate death or injury!



CAUTION

Indicates a condition that can cause property damage!

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This section is for the following models:

GM 3.0 Liter Engine

General

This section contains the repair instructions for the GM 3.0L engine. The procedures to remove, disassemble, clean, repair, assemble, and install are included. Troubleshooting procedures, checks and adjustments, and engine specifications are provided at the end of the section.

Description

The engine block has four cylinders arranged in an in-line construction. From the cooling fan end of the engine, the cylinders are numbered 1-2-3-4. The firing order of the cylinders is 1-3-4-2. The cylinders are encircled by coolant jackets. See Figure 1, Figure 2, and Figure 3.

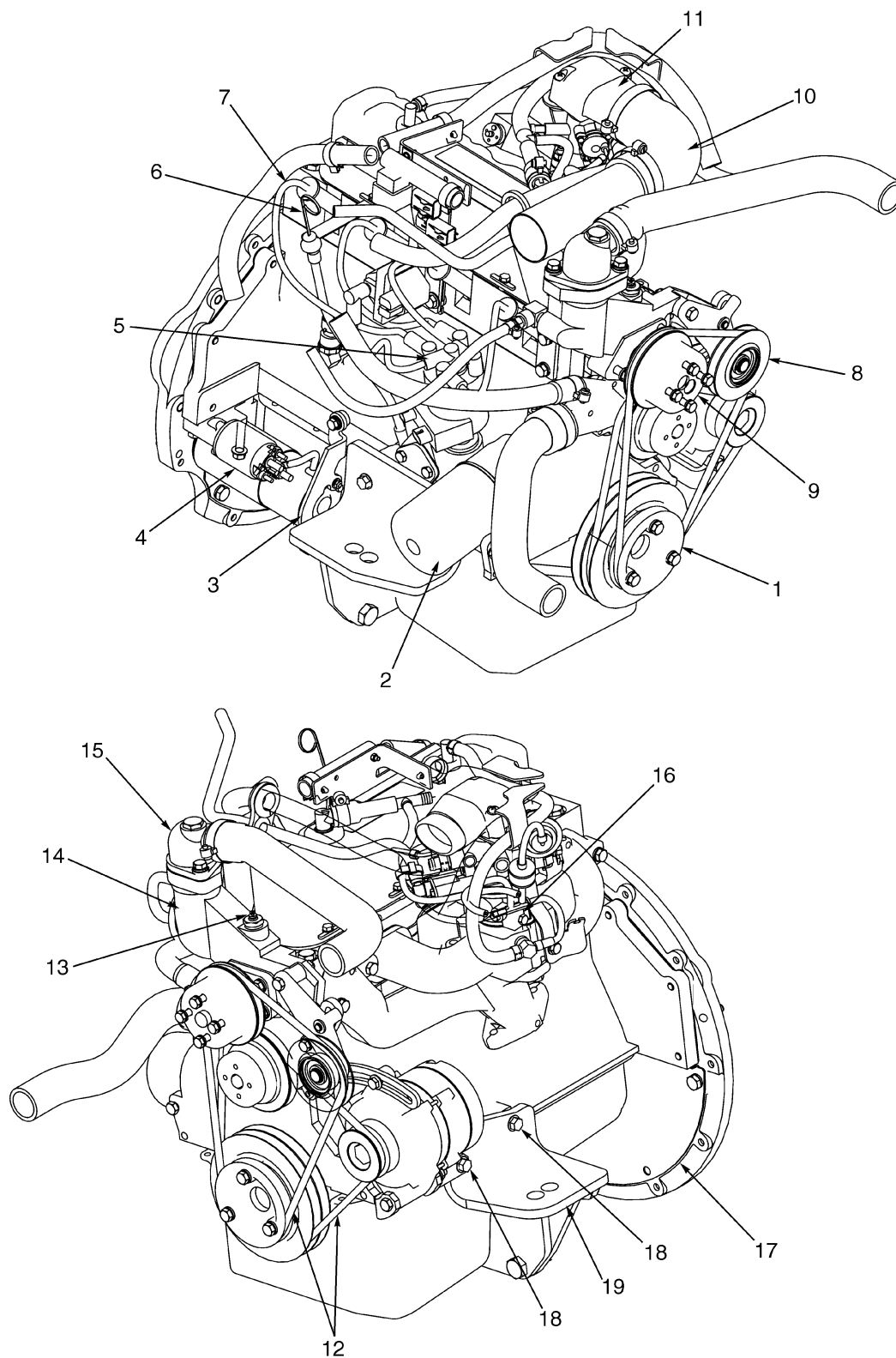
There is one intake and one exhaust valve per cylinder on the cylinder head. A spark plug is located between the valves in the side of the cylinder head. The valve guides are integral and the valve rocker arms are retained on individual threaded studs. The crankshaft has five main bearings that are held in place by crankshaft bearing caps. The crankshaft bearing caps are machined with the engine block for proper alignment and clearances. See Figure 4.

The camshaft is supported by four full round, sleeve type bearings. These bearings are a press fit into

the engine block. The camshaft timing sprocket is mounted to the front of the camshaft and is driven by the crankshaft sprocket.

The pistons are aluminum alloy and contain two compression rings and one oil control ring. The piston pins are a press fit in the connecting rods and a floating fit in the pistons.

The valve train is a ball-pivot type. Motion is transmitted from the crankshaft through the valve lifter and the valve push rod to the valve rocker arm. The valve rocker arm pivots on its ball and transmits the camshaft motion to the valve. The valve lifters keep all parts of the valve train in constant contact. Each lifter acts as an automatic adjuster and maintains zero lash in the valve train.

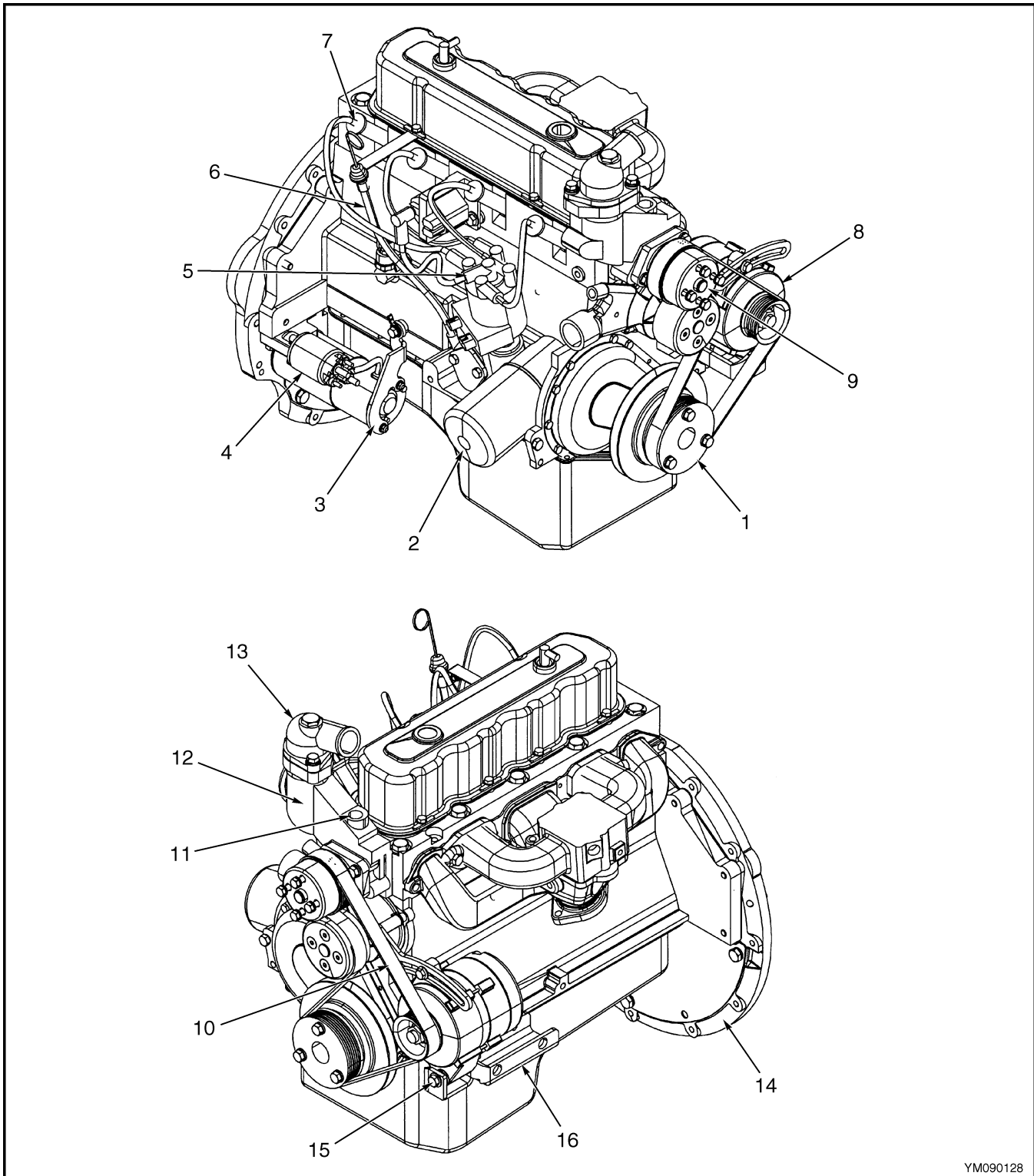


YM090118

Figure 1. Front View of GM 3.0 Liter Engine With V-Belts

Legend for Figure 1

- | | |
|-----------------------------|-------------------------------|
| 1. CRANKSHAFT PULLEY | 11. AIR INLET |
| 2. OIL FILTER | 12. V-BELTS |
| 3. STARTER MOUNTING BRACKET | 13. ENGINE TEMPERATURE SENDER |
| 4. STARTER | 14. THERMOSTAT HOUSING |
| 5. DISTRIBUTOR | 15. THERMOSTAT |
| 6. OIL DIPSTICK | 16. GOVERNOR |
| 7. SPARK PLUG | 17. FLYWHEEL COVER |
| 8. IDLER ASSEMBLY | 18. FLANGE CAPSCREW |
| 9. FAN DRIVE ASSEMBLY | 19. ENGINE MOUNTING BRACKET |
| 10. AIR INTAKE HOSE | |

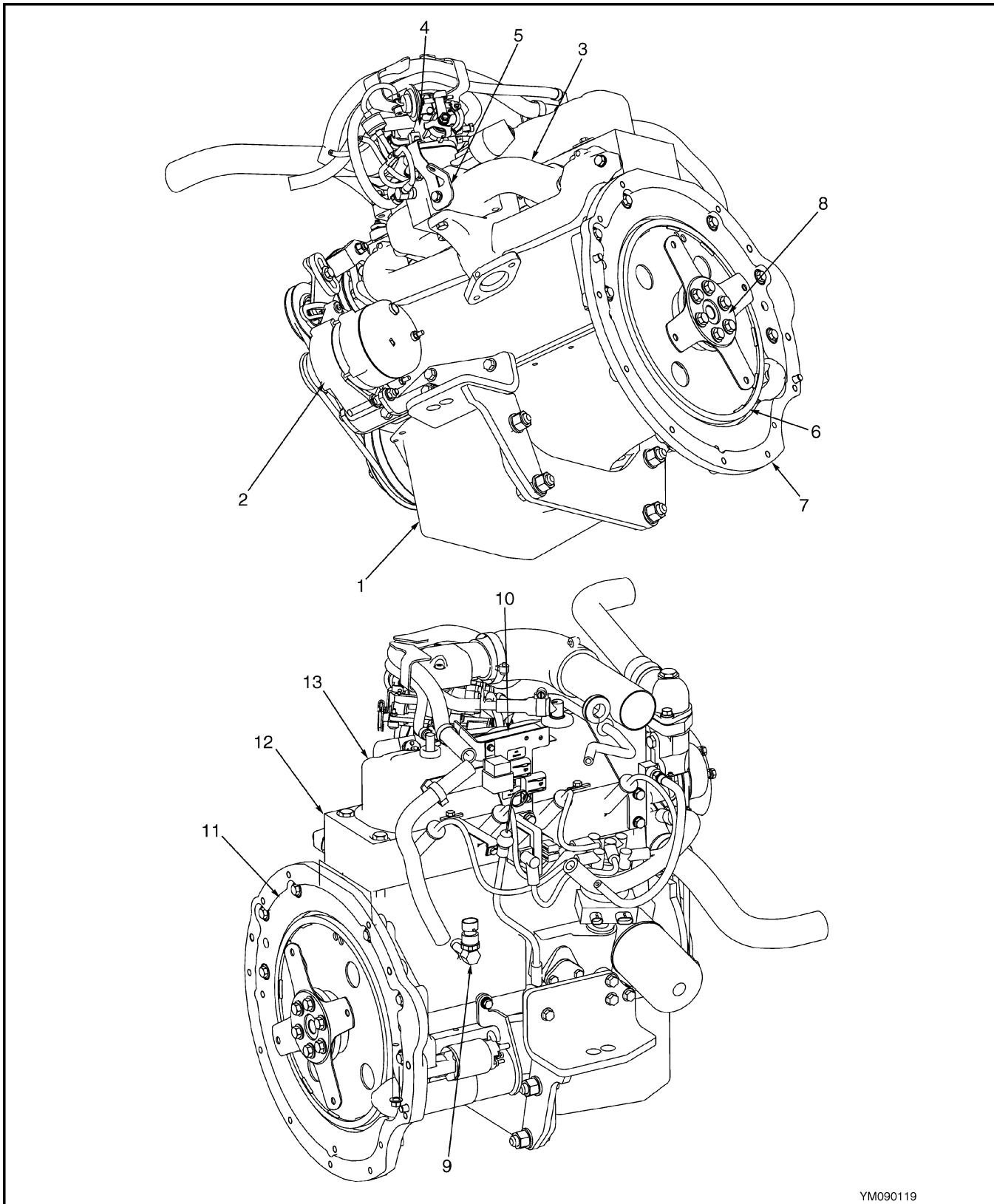


YM090128

Figure 2. Front View of GM 3.0 Liter Engine With Serpentine Belt

Legend for Figure 2

- | | |
|-----------------------------|-------------------------------|
| 1. CRANKSHAFT PULLEY | 9. FAN DRIVE ASSEMBLY |
| 2. OIL FILTER | 10. SERPENTINE BELT |
| 3. STARTER MOUNTING BRACKET | 11. ENGINE TEMPERATURE SENDER |
| 4. STARTER | 12. THERMOSTAT HOUSING |
| 5. DISTRIBUTOR | 13. THERMOSTAT |
| 6. OIL DIPSTICK | 14. FLYWHEEL COVER |
| 7. SPARK PLUG | 15. FLANGE CAPSCREW |
| 8. IDLER ASSEMBLY | 16. ENGINE MOUNTING BRACKET |

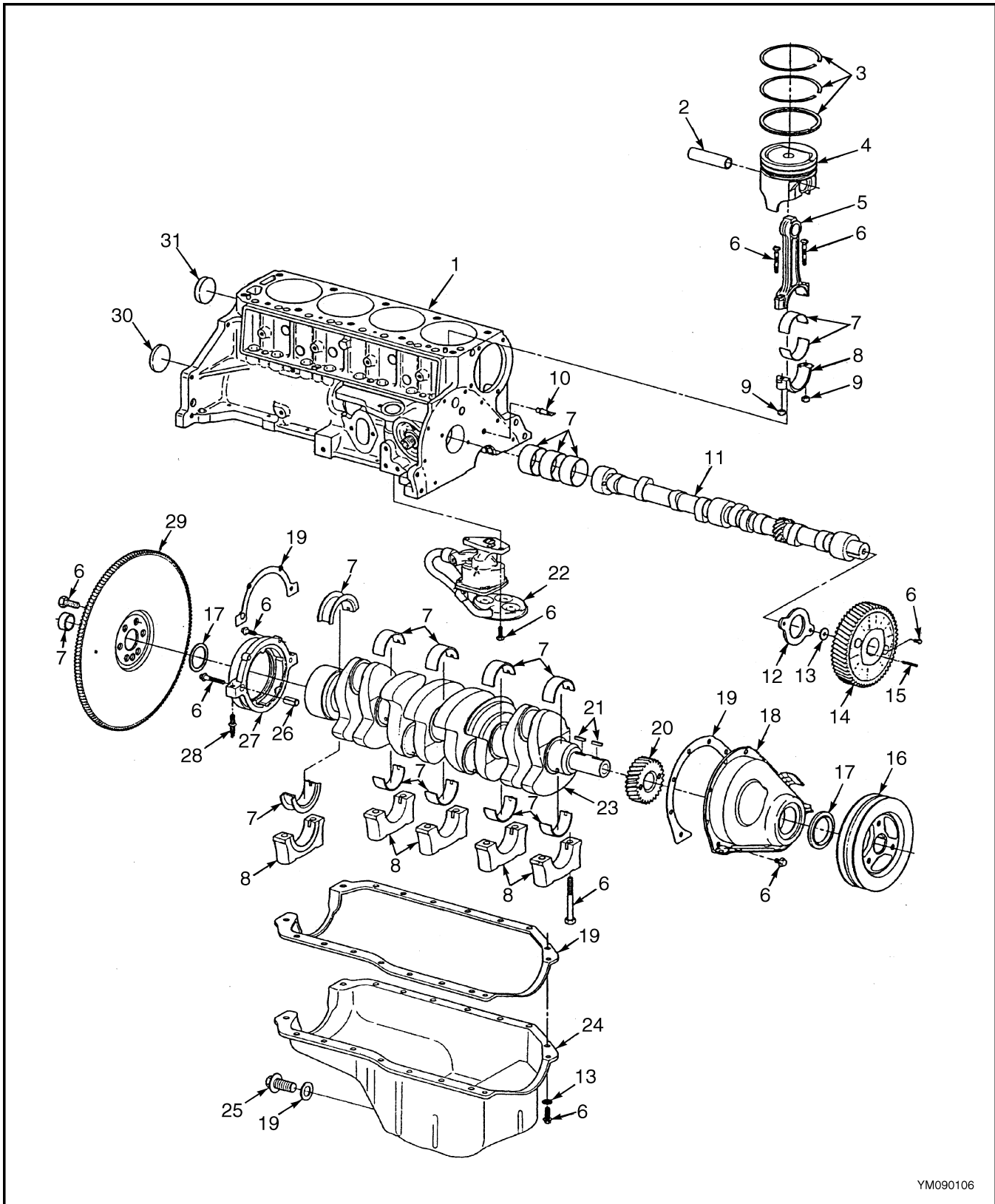


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Figure 3. Rear View of GM 3.0 Liter Engine

Legend for Figure 3

- | | |
|----------------------------|-----------------------------|
| 1. OIL PAN | 8. FLYWHEEL RETAINER PLATE |
| 2. ALTERNATOR | 9. OIL PRESSURE SENDER |
| 3. INTAKE/EXHAUST MANIFOLD | 10. ENGINE FUSES AND RELAYS |
| 4. CARBURETOR ASSEMBLY | 11. FLYWHEEL COVER |
| 5. THROTTLE BRACKET | 12. CYLINDER HEAD |
| 6. FLYWHEEL | 13. ROCKER ARM COVER |
| 7. FLYWHEEL HOUSING | |



Legend for Figure 4

- | | |
|-----------------------------|-------------------------------------|
| 1. ENGINE BLOCK | 17. SEAL |
| 2. WRIST PIN | 18. ENGINE FRONT COVER |
| 3. PISTON RINGS | 19. GASKET |
| 4. PISTON | 20. TIMING GEAR (CRANKSHAFT) |
| 5. PISTON ROD | 21. CRANKSHAFT KEYWAY |
| 6. BOLT | 22. OIL PUMP |
| 7. BEARINGS | 23. CRANKSHAFT |
| 8. BEARING CAP | 24. OIL PAN |
| 9. NUT | 25. OIL DRAIN PLUG |
| 10. OIL NOZZLE | 26. PIN |
| 11. CAMSHAFT | 27. CRANKSHAFT RETAINER ASSEMBLY |
| 12. CAMSHAFT PLATE RETAINER | 28. STUD |
| 13. LOCKWASHER | 29. ENGINE FLYWHEEL |
| 14. TIMING GEAR (CAMSHAFT) | 30. CAMSHAFT REAR BEARING HOLE PLUG |
| 15. CAMSHAFT WOODRUFF KEY | 31. ENGINE BLOCK CORE PLUG |
| 16. CRANKSHAFT PULLEY | |

Engine Removal and Installation



WARNING

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

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

Put a DANGEROUS FIBERS warning label on the container. Discard dangerous fiber 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:

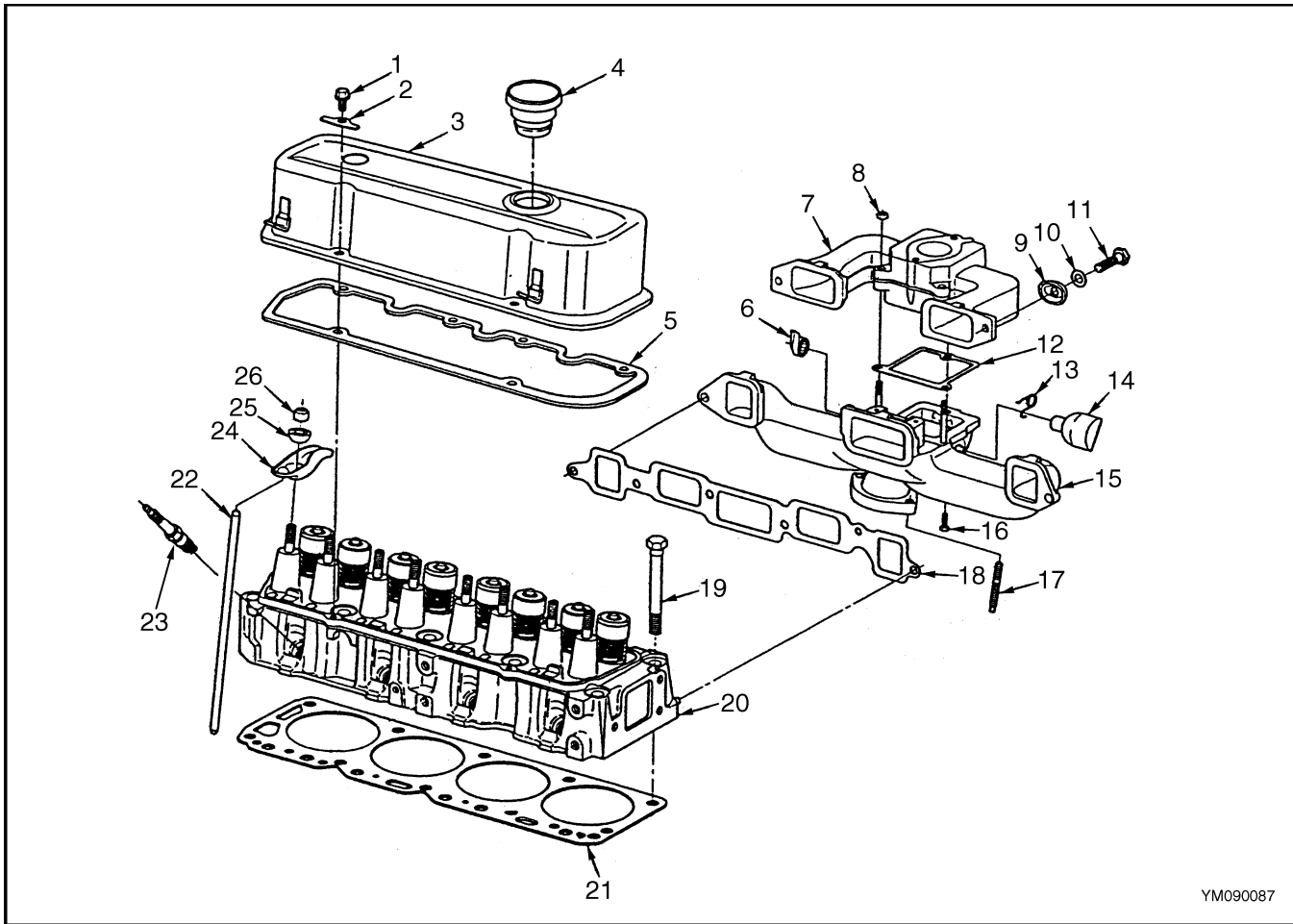
- Do not disconnect the battery when the engine is running. The voltage surge can damage the diodes and resistors.
- Do not disconnect an electric wire before the engine is stopped and the switches are OFF.
- Do not cause a short circuit by connection of the electric wires to the wrong terminals. Make 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 electronic components can be damaged.

The procedures to remove and install the engine are not included in this section. See the **Frame** section for your lift truck model for these procedures.

Cylinder Head and Valve Mechanism Repair

CYLINDER HEAD, REMOVE

1. Disconnect the battery cables at the battery.
 2. Drain cooling system. See the **Frame** section for your lift truck model for the procedures.
 3. Disconnect and remove the coolant hose from the thermostat housing.
 4. Remove or disconnect the air cleaner.
 5. Disconnect the PCV valve.
 6. Disconnect the wires and hoses fastened to brackets on the rocker arm cover.
 7. Disconnect the spark plug wires.
 8. Disconnect the linkages, fuel lines, and hoses for the fuel system.
 9. Disconnect the exhaust pipe at the exhaust manifold and remove the intake/exhaust manifolds. See Figure 5.
 10. If necessary, remove the alternator and bracket.
 11. Remove the dipstick tube for engine oil.
 12. Remove the rocker arm cover. See Figure 5.
- NOTE:** Keep rocker arm assemblies, push rods, and hydraulic valve lifters in the same order as removed.
13. Remove the rocker arms and push rods.
 14. Remove the cylinder head and gasket. See Figure 5.



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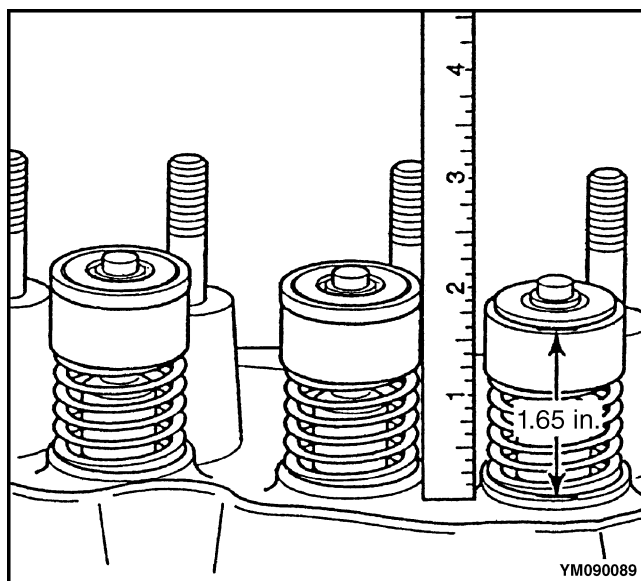
Figure 5. Cylinder Head

Legend for Figure 5

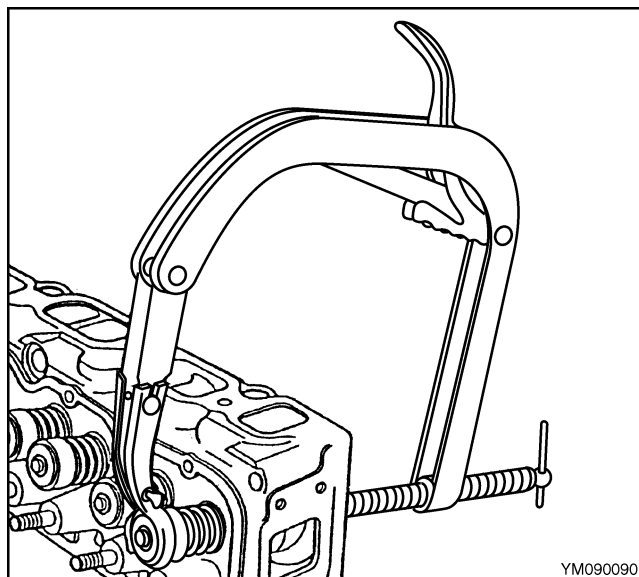
- | | |
|------------------------------------|------------------------------------|
| 1. ROCKER ARM COVER BOLT | 14. VALVE BUSHING |
| 2. ROCKER ARM COVER RETAINER | 15. EXHAUST MANIFOLD |
| 3. ROCKER ARM COVER | 16. BOLT |
| 4. OIL FILLER CAP | 17. EXHAUST MANIFOLD STUD |
| 5. ROCKER ARM COVER GASKET | 18. INTAKE/EXHAUST MANIFOLD GASKET |
| 6. VALVE THERMOSTAT | 19. CYLINDER HEAD BOLT |
| 7. INTAKE MANIFOLD | 20. CYLINDER HEAD |
| 8. NUT | 21. CYLINDER HEAD GASKET |
| 9. CLAMP | 22. VALVE PUSH ROD |
| 10. WASHER | 23. SPARK PLUG |
| 11. BOLT | 24. ROCKER ARM |
| 12. INTAKE/EXHAUST MANIFOLD GASKET | 25. ROCKER ARM BALL |
| 13. VALVE SPRING | 26. ROCKER ARM NUT |

CYLINDER HEAD, DISASSEMBLE

1. Measure the valve spring installed height using a ruler. Measure from the machined surface of the cylinder head to the top of the valve spring cap. The correct measurement is 41.91 mm (1.65 in.). See Figure 6.

**Figure 6. Valve Spring Measurement**

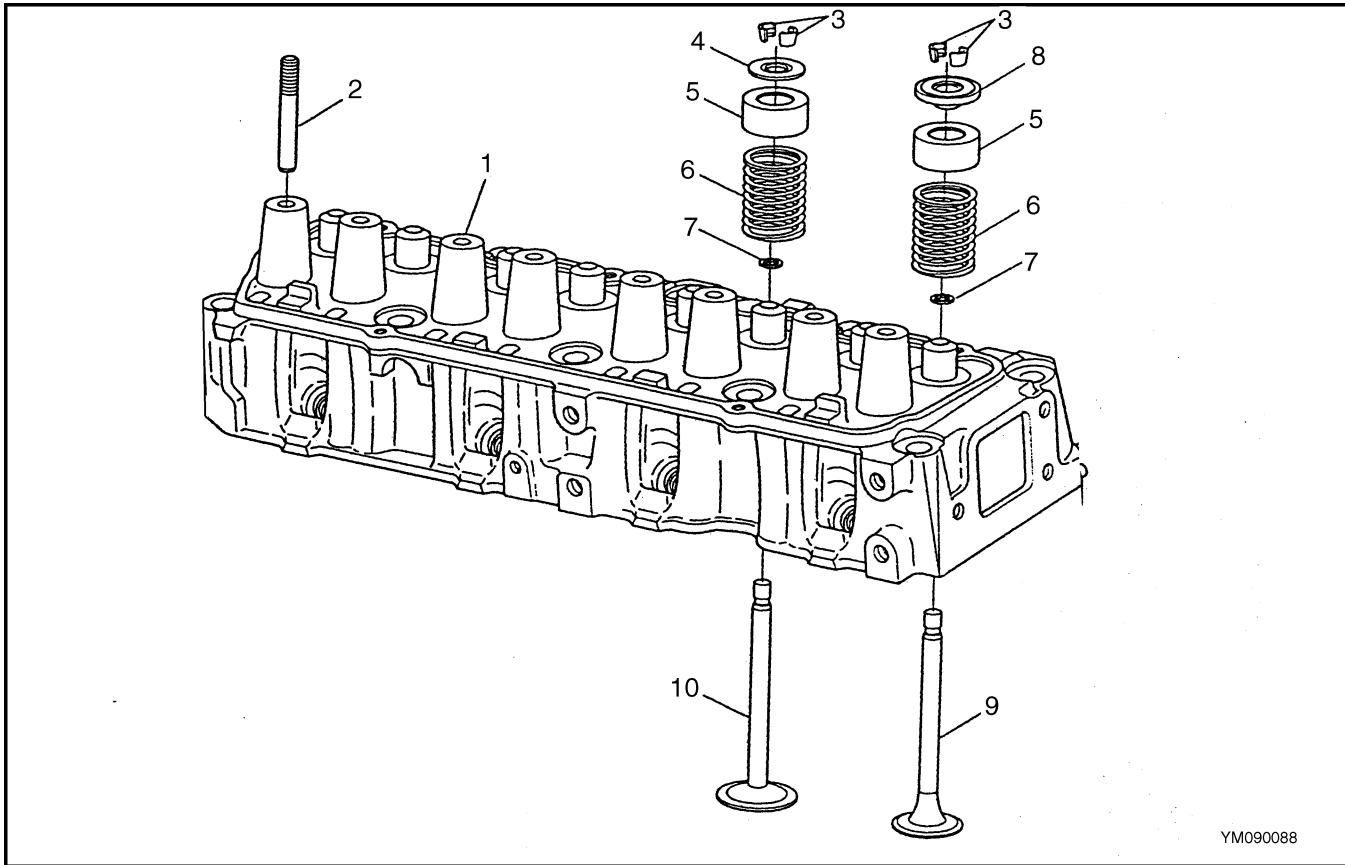
2. Use a compressor tool to compress the valve springs and remove the valve stem keys. See Figure 7.

**Figure 7. Valve Springs Removal**

3. Release the compressor tool and remove the valve spring cap, valve stem oil shield, and valve springs. Remove the valve stem oil seal and any shims from the springs. See Figure 8.

NOTE: Keep cylinder head components in order so they will be installed in the same position during assembly.

4. Remove valves from the cylinder head. Place them on a rack, in the order removed, to aid in the proper installation during assembly. See Figure 8.



- | | |
|------------------------------|-------------------------------|
| 1. CYLINDER HEAD | 6. VALVE SPRING |
| 2. VALVE ROCKER ARM STUD | 7. VALVE STEM OIL SEAL |
| 3. VALVE STEM KEY | 8. VALVE SPRING CAP (EXHAUST) |
| 4. VALVE SPRING CAP (INTAKE) | 9. EXHAUST VALVE |
| 5. VALVE STEM OIL SHIELD | 10. INTAKE VALVE |

Figure 8. Cylinder Head Disassembly

CLEAN AND INSPECT

Use a carbon-remover brush and clean the carbon from the combustion chambers and the valve ports. Be careful not to scuff the chamber. See Figure 9.

1. Clean the following areas:

- The carbon and sludge from the valve push rods and the valve rocker arms.
- The valve stems and heads. See Figure 8.
- The cylinder head and engine block gasket surfaces.
- The bolt holes and threads in the cylinder head and the engine block.

2. Inspect the following areas:

- The cylinder head for cracks in the exhaust ports and the combustion chambers.
 - The cylinder head for external cracks in the water chamber.
 - The valves for burned heads, cracked faces, or damaged stems.
 - The rocker arm bolts for wear and damage.
3. Using a valve spring tester tool, measure the valve spring pressure. The correct pressure is 444 to 490 N (100 to 110 lbf) at 40.9 mm (1.61 in.). If the valve spring pressure is less than 444 N

(100 lbf) at 40.9 mm (1.61 in.), replace the valve spring. See Figure 10.

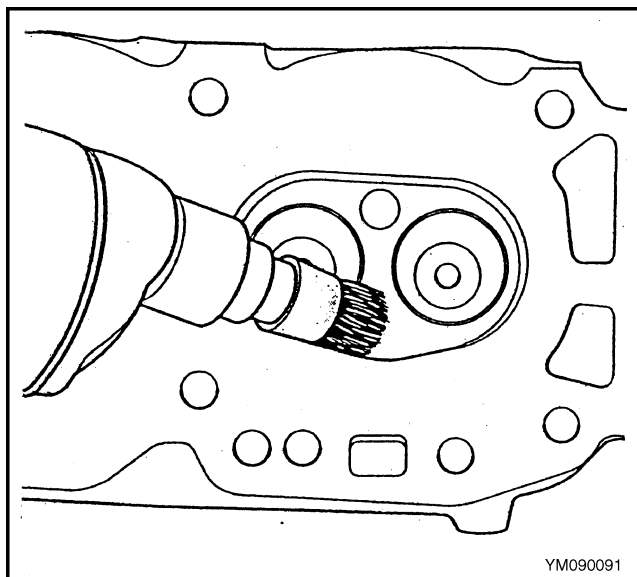


Figure 9. Clean the Cylinder Head

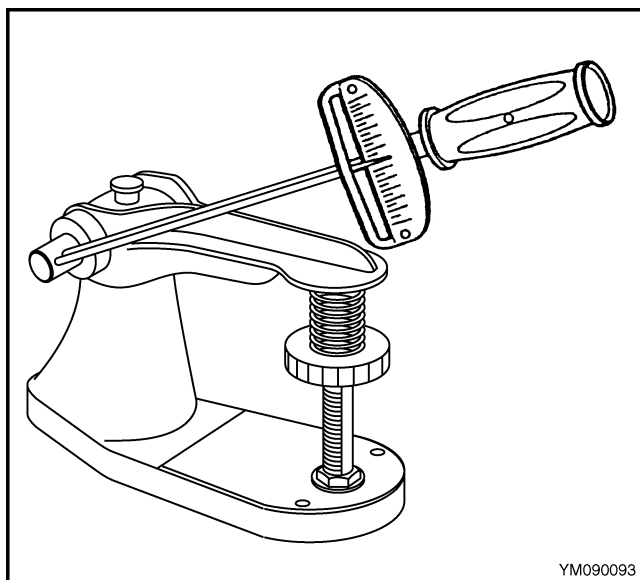


Figure 10. Measuring Valve Spring Pressure

4. Check the clearance of each valve stem in its valve guide. Use the following procedure:
 - a. Install the valve into the valve guide. Install the dial indicator onto the cylinder head as shown in Figure 11.
 - b. Position the dial indicator so that it can measure the side-to-side movement of the valve stem. The indicator stem must contact the side of the valve stem, just above the valve guide.
 - c. Lower the valve head approximately 1.6 mm (0.06 in.) off the valve seat. Move the valve stem from side to side and check the measurement on the dial indicator.
 - d. The maximum clearance between the valve stems and their valve guides is shown in the Engine Specifications section.
 - e. If the clearance between the valve stem and its valve guide is greater than the specification, a valve with an oversize stem must be installed. Use a reamer to make the bore the correct diameter for the next oversize valve. See the **Parts Manual** for oversize valves.

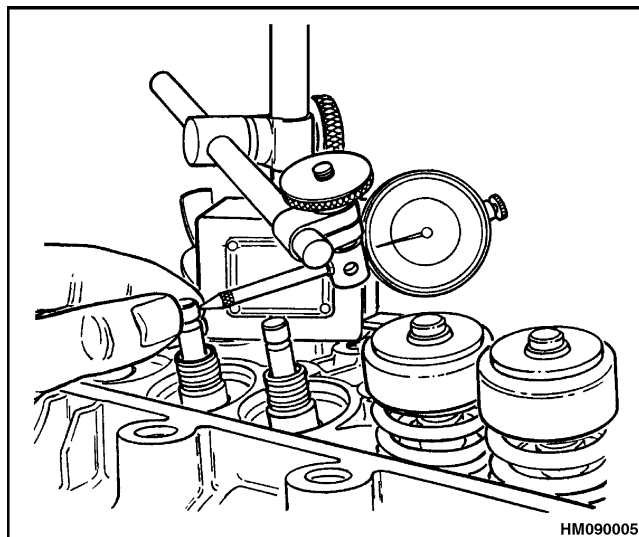


Figure 11. Valve Stem Clearance Check

5. Inspect the valve springs for squareness. See Figure 12.

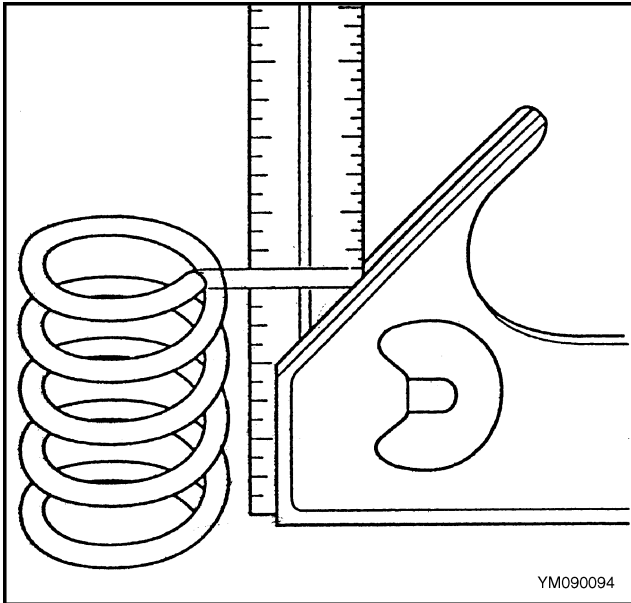


Figure 12. Valve Springs Inspect

6. Measure the valve seat runout. The valve seats should be centered to within 0.0508 mm (0.002 in.). See Figure 13.

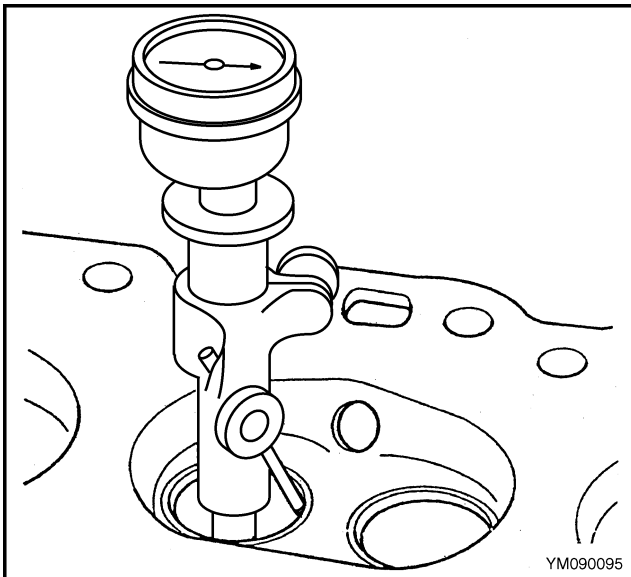


Figure 13. Valve Seat Runout Measurement

7. Inspect the cylinder head and measure it for warpage. A cylinder head with excessive warpage must be repaired or replaced. Refer to the Engine Specifications section for cylinder head dimensions. Also, see Figure 14.

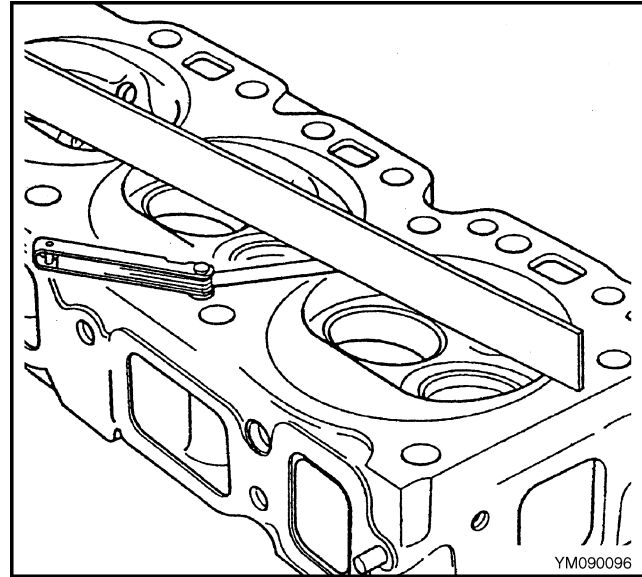


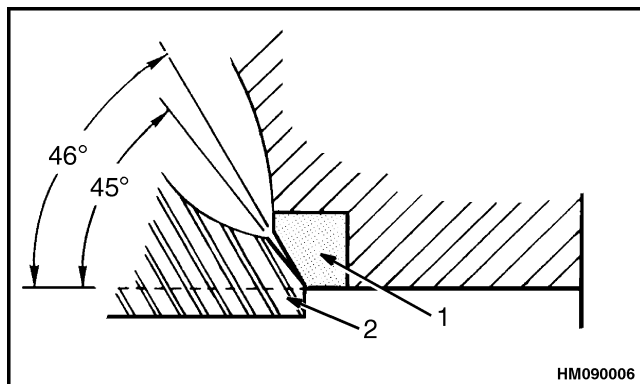
Figure 14. Cylinder Head Measurement

VALVES AND VALVE SEATS

The condition and alignment of the valves to their valve seats are important for the correct operation of the engine. Before any work is done on the valve seats, make sure the clearance of the valve stems in their valve guides is within specifications.

A correction for minimum wear and damage to the valve and seat can be done by a process called lapping. When the valve seats are lapped, keep the valve seats within the specifications. Make sure all of the lapping compound is removed from the valve and valve seat when the process is completed.

Damaged valve seats can be repaired with a cutter tool. If the valve seat cannot be repaired so that the valve depth is within specifications, the cylinder head must be replaced. The specifications for the valve seats are shown in Figure 15 and are listed in the Engine Specifications.



1. VALVE SEAT
2. MINIMUM THICKNESS OF VALVE HEAD IS 0.80 mm (0.031 in.)

Figure 15. Intake and Exhaust Valve Seat Specifications

STUDS FOR ROCKER ARMS

Replace a stud that has damaged threads or is loose in the cylinder head. Use oversized studs. See the **Parts Manual** for oversized studs.

1. Remove the old stud. Install a spacer, flat washer, and nut to the damaged stud. Use a wrench to remove the damaged stud. See Figure 16.

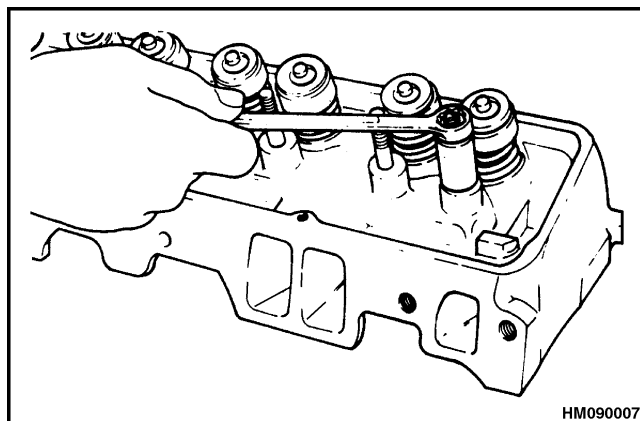


Figure 16. Rocker Stud Removal



CAUTION

Do not try to install an oversized stud without reaming the stud hole to the new size. Installation of an oversized stud without reaming the stud hole can cause cracks in the cylinder head.

2. Use a reamer of the correct size for the new oversized stud. Apply SAE 90 lubricant to the new stud during installation. See Figure 17.

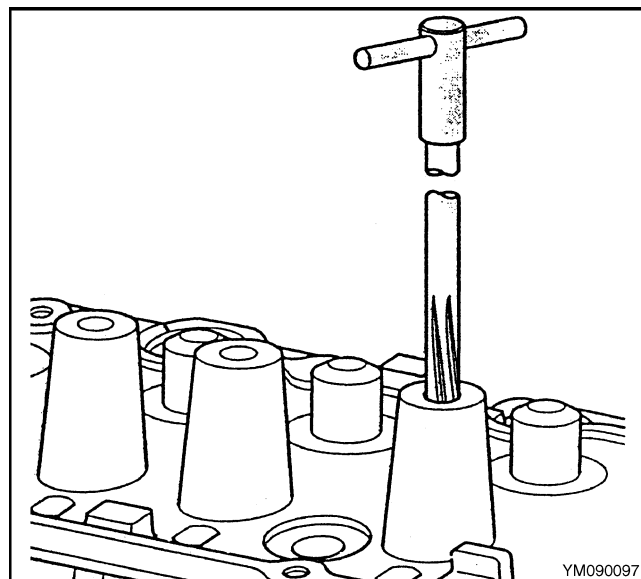


Figure 17. Ream Stud Hole

3. Install the new stud as shown in Figure 18.

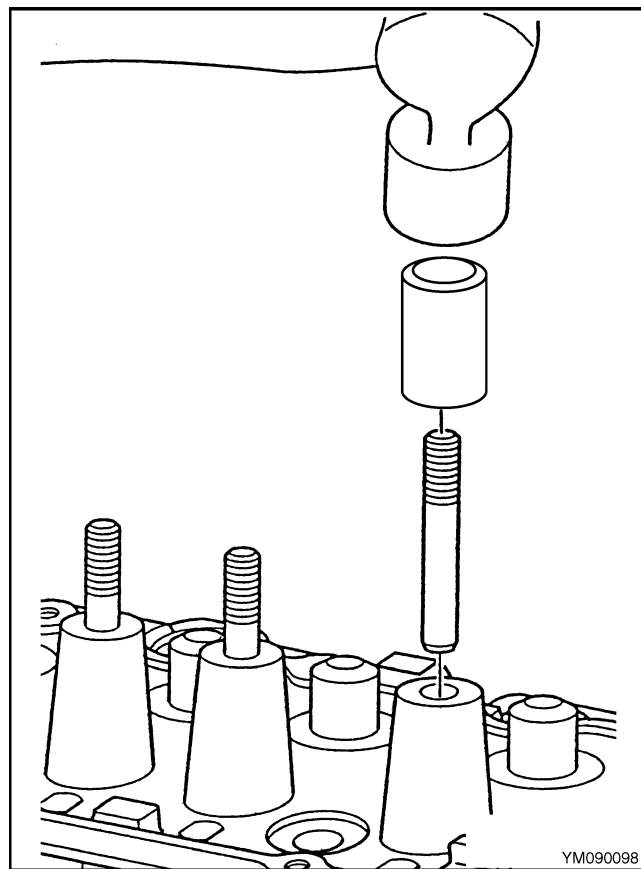


Figure 18. Stud Installation

HYDRAULIC VALVE LIFTERS

Replace

The hydraulic valve lifters normally do not need service unless they are dirty or damaged. The hydraulic valve lifters must be clean to operate correctly. If the lifters make noise or do not operate correctly, replace them. The lifters can be removed with a flexible magnet after the push rods are removed. See Figure 5.

Clean and Inspect



WARNING

Cleaning solvents can be flammable and toxic and can cause skin irritation. When using cleaning solvents, always follow the solvent manufacturer's recommended safety precautions.

Clean all parts in a cleaning solvent and inspect them carefully. If any parts are damaged or worn, the complete hydraulic valve lifter must be replaced. If the body of the hydraulic valve lifter is worn, also inspect the bore in the engine block. If the bottom of the hydraulic valve lifter is worn or damaged, inspect the camshaft lobe for wear and damage. The bottom of the lifter must be convex for correct rotation during engine operation.

CYLINDER HEAD, ASSEMBLE

1. Install the valves in their correct ports. See Figure 8. Lubricate the oil seal with clean engine oil and install the oil seal onto the valve stem.
2. Install the valve springs.
3. Install the valve stem oil shield.
4. Install the caps on the valve springs. See Figure 8.
5. Use a valve spring compressor to compress the valve springs. See Figure 7. Install the valve stem keys as described below:
 - a. Use grease to hold the keys in place while disconnecting the valve spring compressor tool.

- b. Make sure that the keys seat properly in the upper groove of the valve stem.
- c. Tap the end of the valve stem with a plastic-faced hammer to seat the keys if necessary.

CYLINDER HEAD, INSTALL

1. Clean the surface of the cylinder head and the top of the engine block. The surfaces for the gaskets must be clean. The threads for the head bolts must be clean so that the correct torque is applied during installation.
2. Install a new gasket for the cylinder head over the locating pins to the engine block. Do not use a sealant on the gasket.
3. Install the cylinder head over the locating pins on the engine block. Tighten the head bolts to 122 N•m (90 lbf ft) in the sequence shown in Figure 19.

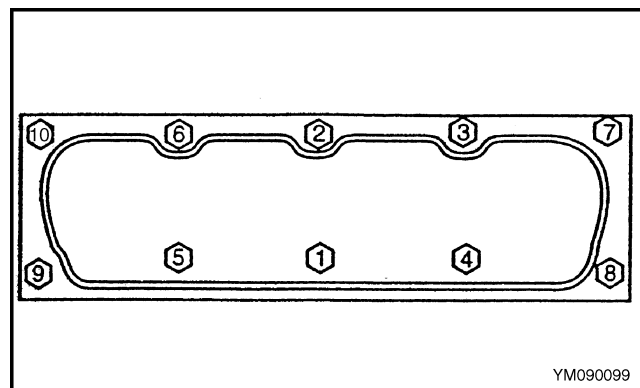
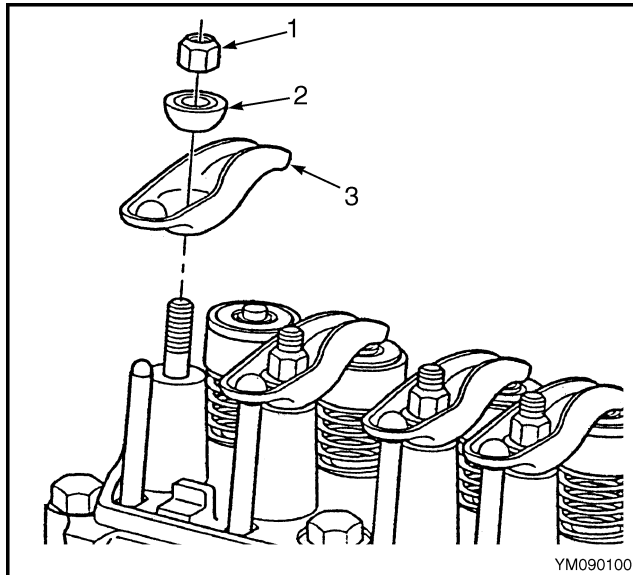


Figure 19. Cylinder Head Tightening Sequence

4. Install hydraulic valve lifters in their positions in the engine block.
5. Install the push rods in their positions in the engine. Make sure each push rod fits in its socket in its hydraulic valve lifter.
6. Lubricate the rocker arms and rocker arm balls with engine oil during installation. Install the rocker arms, rocker arm balls, and rocker arm nuts. See Figure 20. Tighten the rocker arm nuts until there is zero clearance.



- | | |
|--------------------|---------------|
| 1. ROCKER ARM NUT | 3. ROCKER ARM |
| 2. ROCKER ARM BALL | |

Figure 20. Rocker Arm Installation

7. Install the intake/exhaust manifold. Connect the exhaust pipe at the exhaust manifold.
8. Install the carburetor. Connect the carburetor linkage, fuel line, and hoses.
9. If the alternator and bracket were removed, install them.
10. Install the dipstick tube for engine oil.
11. Connect the coolant hose to the housing for the thermostat.
12. Adjust the clearance of the rocker arm assemblies as described in Valve Clearance, Adjust.
13. Install the rocker arm cover as described in Rocker Arm Cover, Install.
14. Install and connect the PCV valve.
15. If the distributor cap was removed, install it. Connect the spark plug wires. Connect the wires and hoses fastened to brackets on the rocker arm cover.
16. Install or connect the air cleaner and component parts.
17. Fill the coolant system with the correct coolant. See the **Periodic Maintenance** section for your lift truck.
18. Connect battery cable.
19. Adjust the ignition timing and carburetor as necessary. See the **Periodic Maintenance** section for your lift truck.

VALVE CLEARANCE, ADJUST

1. Remove the cover for the rocker arm assembly.
2. Turn the crankshaft until the mark on the crankshaft pulley lines up with the zero on the timing tab and the number 1 cylinder is at top dead center (TDC).
3. Place fingers on the number 1 valves as the mark approaches zero. If the valves move as the mark approaches zero, the engine is on number 4 cylinder TDC.
4. The engine should be rotated one more revolution in order to reach number 1 cylinder TDC.
5. With the engine at number 1 cylinder TDC, adjust the following valves:
 - a. Exhaust valves number 1 and 3.
 - b. Intake valves 1, 2, and 4. See Figure 21.

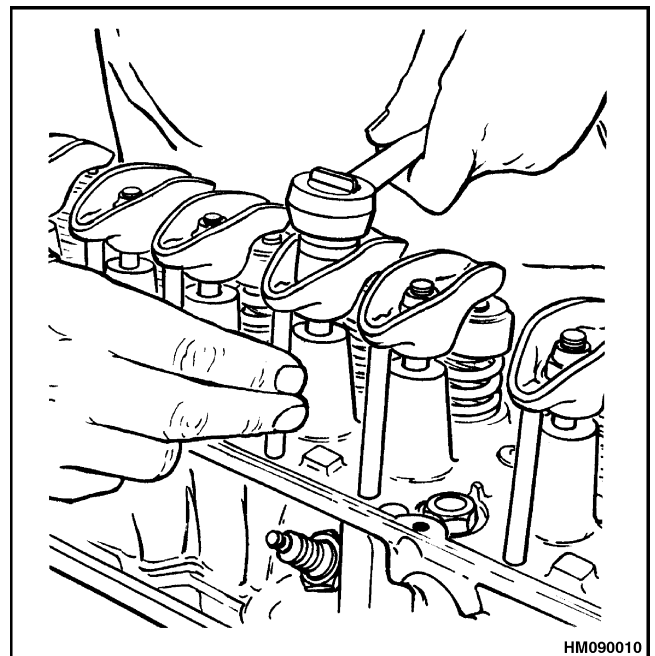
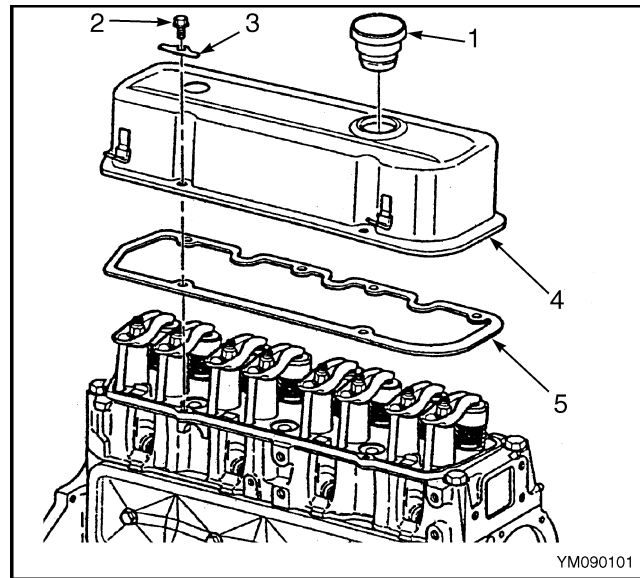


Figure 21. Valve Clearance Adjustment

6. Adjust for the correct valves as follows:
 - a. Back off the valve rocker arm nut until the lash is felt in the valve push rod.
 - b. Tighten the valve rocker arm nut until all the lash is removed.
 - c. Zero lash can be felt by moving the valve push rod up and down between your thumb and forefinger until there is no more movement.
 - d. When all the free play is gone, tighten the valve rocker arm nut one additional turn (360 degrees).
7. Turn the crankshaft one revolution until the mark on the crankshaft pulley lines up with zero on the timing tab. This is number 4 cylinder TDC.
8. With the engine at number 4 cylinder TDC, adjust the following valves:
 - a. Exhaust valves number 2 and 4.
 - b. Intake valve number 3.
9. Follow the procedures in Step 6 until all the valves are adjusted.
10. Install the distributor cap and the cover for the rocker arms. See Rocker Arm Cover, Install.

ROCKER ARM COVER, INSTALL

1. Remove all gasket material from the cylinder head and the rocker arm cover.
2. Install a new gasket onto the cylinder head rail. See Figure 22.
3. Install the rocker arm cover and tighten the rocker arm cover bolts to 4.5 N•m (40 lbf in).



- | | |
|-------------------|---------------------|
| 1. OIL FILTER CAP | 4. ROCKER ARM COVER |
| 2. COVER BOLT | 5. GASKET |
| 3. COVER RETAINER | |

Figure 22. Rocker Arm Cover Installation

Timing Gear Cover Repair

REMOVE

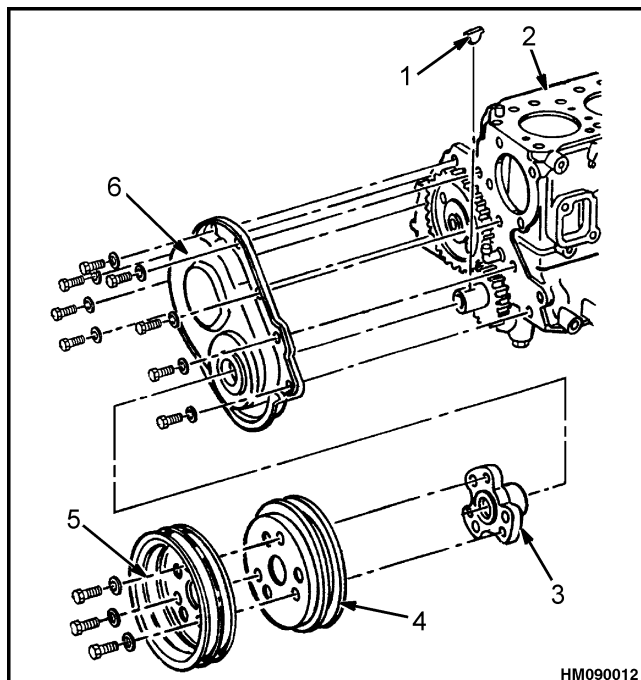
NOTE: The oil seal can be replaced without removing the timing gear cover. The crankshaft pulley and vibration damper must be removed. The oil seal can be removed with a pry bar. Work carefully so that the sheet metal of the timing gear cover is not bent or damaged during removal or installation of the oil seal. The replacement of the oil seal is easier if the timing gear cover is removed from the engine.

1. Drain the coolant from the cooling system, and remove the radiator. See **Frame** section for your lift truck model for the procedures.

2. Remove the drive belts. Remove the pulley from the vibration damper. See Figure 23.

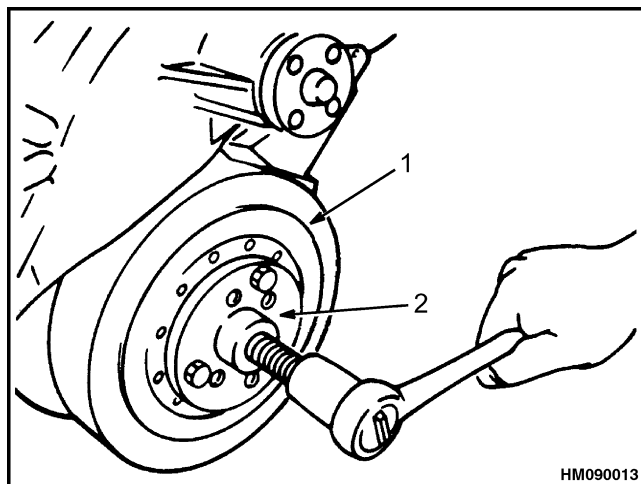
NOTE: The vibration damper is pressed onto the crankshaft. It must be pulled off with a puller.

3. Remove the vibration damper. Use a tool that pulls on the center of the vibration damper. Do not use a puller that pulls on the outside diameter of the vibration damper. See Figure 24.
4. Remove the screws that hold the oil pan to the timing gear cover. Remove the screws that hold the timing gear cover to the engine block.



- | | |
|-----------------|---------------------|
| 1. WOODRUFF KEY | 4. VIBRATION DAMPER |
| 2. ENGINE BLOCK | 5. PULLEY |
| 3. HUB | 6. TIMING COVER |

Figure 23. Timing Gear Cover and Pulleys



- | | |
|---------------------|----------------------------------|
| 1. VIBRATION DAMPER | 2. REMOVAL AND INSTALLATION TOOL |
|---------------------|----------------------------------|

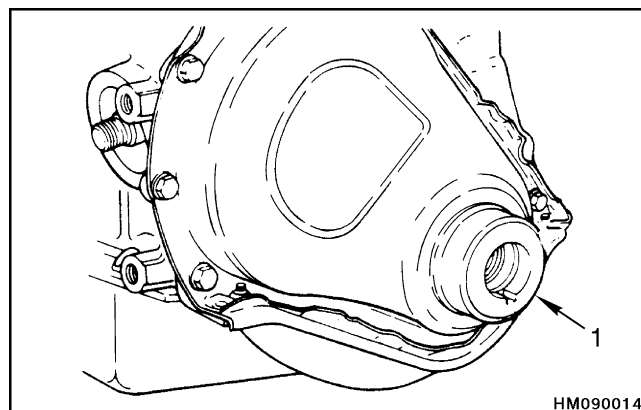
Figure 24. Vibration Damper

- Remove the timing gear cover.
- Remove the oil seal from the timing gear cover. Do not bend or damage the sheet metal of the timing gear cover when removing the oil seal.

- If necessary, remove the two Woodruff keys from the crankshaft. See Figure 23.

INSTALL

- Make sure the gasket surfaces on the engine block, timing gear cover, and oil pan are clean.
- Install a new oil seal. Carefully press the oil seal into the timing gear cover. Make sure the lip of the oil seal is toward the engine.
- If the Woodruff keys were removed, install them into the crankshaft.
- Install a new gasket between the timing gear cover and engine block. Apply a thin coat of sealant to both sides of the gasket.
- Install a centering tool in the oil seal. The oil seal must be aligned so that it is evenly in position around the hub. An oil seal that is not correctly aligned with the hub will be damaged and will leak oil. See Figure 25.



- CENTERING TOOL

Figure 25. Timing Gear Cover Centering Tool

- Install the timing gear cover. Install the two screws for the oil pan and the screws for the timing gear cover and tighten the screws with your fingers. Make sure the oil seal is correctly aligned. Tighten the screws to 10 N•m (89 lbf in).
- Remove the centering tool.
- Install the vibration damper. Use a tool that presses on the center of the vibration damper. See Figure 24. Do not use a tool that pushes on the outside diameter of the vibration damper. Make sure the hub of the vibration damper is against the crankshaft gear.

9. Install the pulley on the vibration damper. Tighten the capscrews to 44 N•m (32 lbf ft). Install the drive belts and adjust the belts as required. See the **Periodic Maintenance**

section for your lift truck model for the adjustment procedures.

10. If the cooling system is complete, fill the system with coolant and check for leaks.

Timing Wheel Repair

TIMING WHEEL, REMOVAL

1. Shut down the engine.
2. Place the number one cylinder at TDC on the compression stroke.
3. Remove serpentine belt. See **Periodic Maintenance** for your lift truck.
4. Remove three bolts, washers, and serpentine belt pulley from timing wheel.



CAUTION

When removing the timing wheel, DO NOT use a puller that pulls on the outside diameter of the timing wheel as damage can occur.

NOTE: The timing wheel is pressed onto the crankshaft. It must be pulled off with a puller.

5. Remove the timing wheel. Carefully use a puller that pulls on the center of the timing wheel. Do not use a puller that pulls on the outside diameter of the timing wheel.
6. If necessary, remove two woodruff keys from the crankshaft.

TIMING WHEEL, INSTALL

NOTE: When installing timing wheel, ensure wheel is facing correct side out.

NOTE: There is a small hole near the large gap in the teeth. This hole must be aligned with the mark on the serpentine belt pulley when installing.

1. If the woodruff keys were removed, install them into the crankshaft.

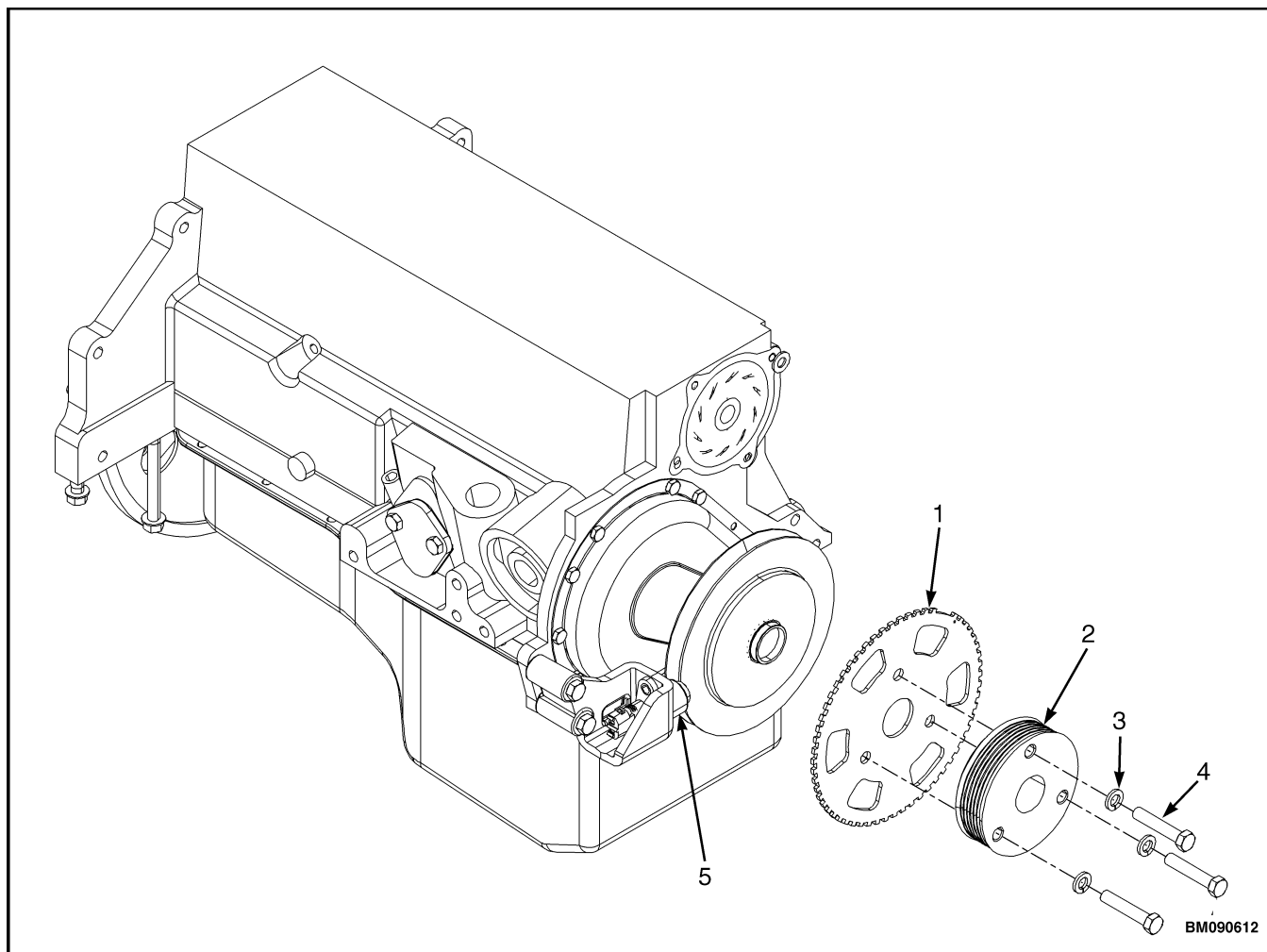


CAUTION

When replacing the timing wheel, use a rubber mallet on the center and NOT the outside diameter of the timing wheel as damage can occur.

Verify that timing wheel is against the crankshaft. Not pressing the timing wheel against the crankshaft can result in further damage to equipment.

2. Install the timing wheel. Use a rubber mallet to start tapping the timing wheel on the crankshaft. Do not use a tool that pushes on the outside diameter of the timing wheel. Make sure the hub of the timing wheel is against the crankshaft gear.
3. Drive the timing wheel onto the shaft with a series of taps. As soon as you are certain it is square, you can use the bolt and thick washer from the serpentine belt pulley to draw the timing wheel on the remaining distance. When you think the timing wheel has bottomed out on the shoulder of the crankshaft, remove the bolt and washer.
4. Install serpentine belt pulley, using three washers and capscrews. Tighten the capscrews for the serpentine belt pulley to 44 N•m (35 lbf ft). See Figure 26.



1. TIMING WHEEL
2. PULLEY, SERPENTINE BELT
3. WASHER (3 EA)

4. CAPSCREWS (3 EA)
5. SENSOR

Figure 26. Timing Wheel

AIR GAP ADJUSTMENT

1. Disconnect wire connector to the crankshaft position sensor.
2. Loosen the two crankshaft position sensor mounting bracket capscrews.

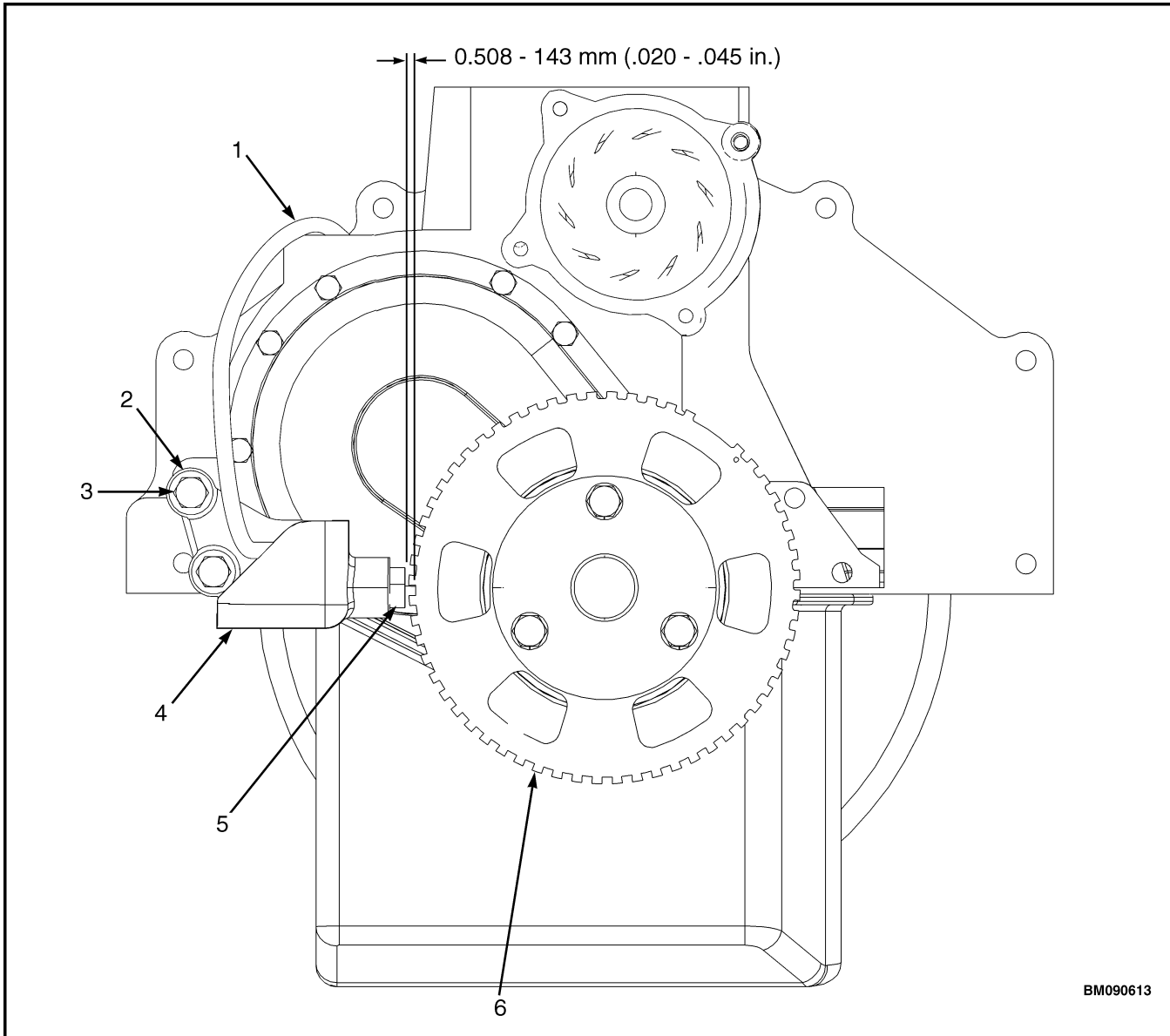
NOTE: Be sure to use a brass feeler gauge when measuring the air gap during installation.

3. Check air gap between the sensor and timing wheel and ensure clearance is to specification. Specification clearance adjustment is 0.508 - 1.143 mm (0.020 - 0.045 in.) shown in Figure 27.

4. Tighten the two crankshaft position sensor mounting bracket capscrews. Tighten the capscrews to 14 N•m (130 lbf in).
5. Check air gap and ensure clearance to specification by moving the brass feeler gauge in and out of the gap freely.

NOTE: If the feeler gauge does not move freely, repeat Step 2 through Step 5.

6. Connect crankshaft position sensor connector.
7. Start engine.
8. Perform On-Board Diagnostic system check.



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- | | |
|---|-------------------------------|
| 1. CRANKSHAFT POSITION SENSOR CONNECTOR | 4. MOUNTING BRACKET |
| 2. WASHER (2 EA) | 5. CRANKSHAFT POSITION SENSOR |
| 3. CAPSCREWS (2 EA) | 6. TIMING WHEEL |

Figure 27. Sensor to Timing Wheel Air Gap

- | | |
|---|--|
| 9. Verify there are no DTC codes present and are cleared. | 10. Verify engine is in closed loop and no MIL lights are present. |
|---|--|

Camshaft Repair

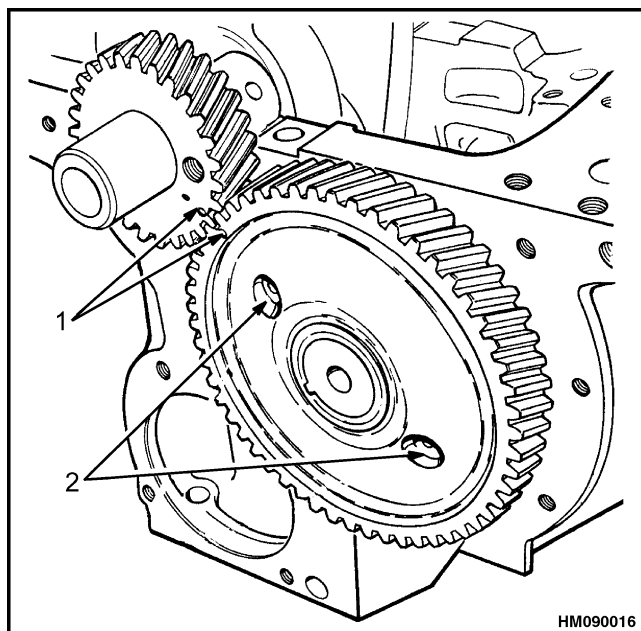
CAMSHAFT, REMOVE

NOTE: The engine is removed from the lift truck for this procedure. See the **Frame** section for your lift

truck model for the procedures to remove the engine from the lift truck.

1. Remove the drive belts, fan, and pulley.

2. Remove the timing gear cover. See the section Timing Gear Cover Repair for the procedures.
3. Remove the rocker arms and push rods as described in Cylinder Head, Remove. See Figure 5.
4. Remove the side cover for access to the hydraulic valve lifters. Remove the hydraulic valve lifters and put them on a rack so they will be installed in the same position in the engine block.
5. Align the timing marks on the timing gears as shown in Figure 28.



1. TIMING MARKS
2. CAMSHAFT RETAINER PLATE BOLTS

Figure 28. Timing Gears

6. Remove the two camshaft retainer plate bolts working through the holes in the camshaft sprocket. See Figure 28.



CAUTION

All camshaft journals are the same diameter. Care must be used in removing the camshaft to avoid damage to the bearings.

7. Remove the camshaft from the engine block. Provide enough support to the camshaft so the bearings are not damaged.

CAMSHAFT, CLEAN AND INSPECT



WARNING

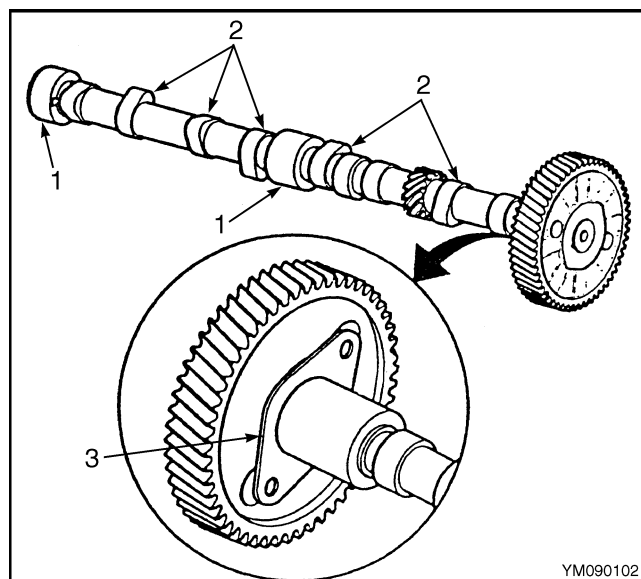
Cleaning solvents can be flammable and toxic and can cause skin irritation. When using cleaning solvents, always follow the recommendations of the manufacturer.



WARNING

Compressed air can move particles so they cause injury to the user or to other personnel. Make sure the path of the compressed air is away from all personnel. Wear protective goggles or a face shield to prevent injury to the eyes.

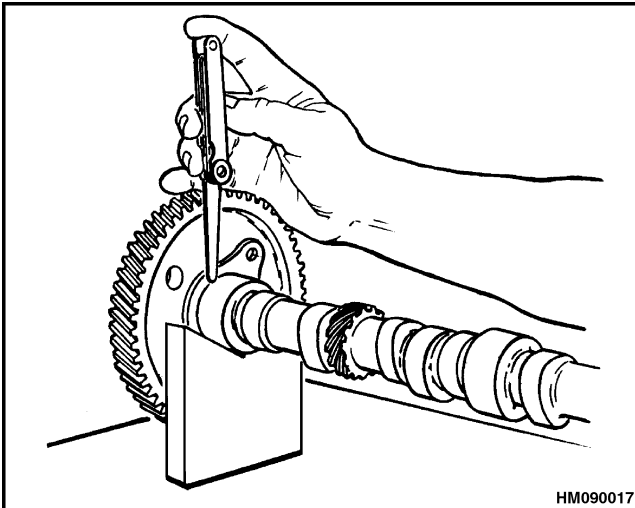
1. Clean the camshaft in solvent and dry with compressed air. Inspect the camshaft bearing journals, valve lifter lobes, and retainer plate for scratches and excessive wear. See Figure 29. See the Engine Specifications for camshaft wear data.



1. CAMSHAFT BEARING JOURNAL
2. VALVE LIFTER LOBES
3. CAMSHAFT RETAINER PLATE

Figure 29. Camshaft Inspection

2. Measure the amount of clearance between the retainer plate and the camshaft as shown in Figure 30. If the clearance is greater than 0.203 mm (0.008 in.), replace the retainer plate.



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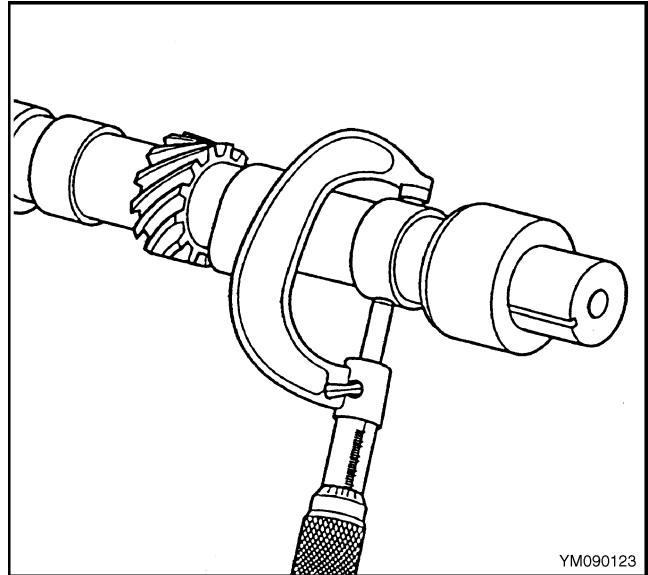
Figure 30. Retainer Plate and Camshaft Clearance Check

CAUTION

Make sure the force is applied to the hub of the camshaft gear or the camshaft gear will be damaged. Make sure the Woodruff key does not damage the retainer plate during removal or installation.

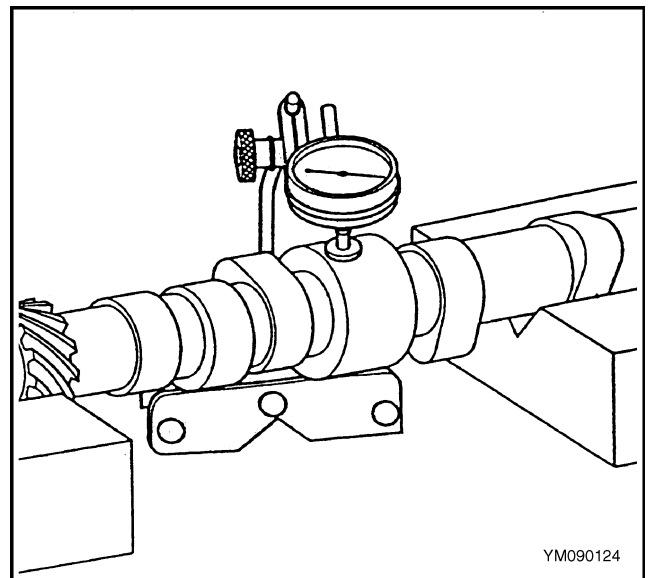
3. If the camshaft gear or the retainer plate must be replaced, the camshaft gear must be removed. A press must be used to remove and install the camshaft gear on the camshaft.
4. Using a micrometer, measure the camshaft for out-of-roundness, taper, or undersize. Refer to the Engine Specifications section. See Figure 31.
5. Place the camshaft front and rear journals on V-block for support. Use a dial indicator and measure the camshaft runout at the intermediate journal. See the Engine Specifications section for runout measurement data. See Figure 32.

6. If the camshaft measurements are not within specifications, replace the camshaft.



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Figure 31. Measuring the Camshaft

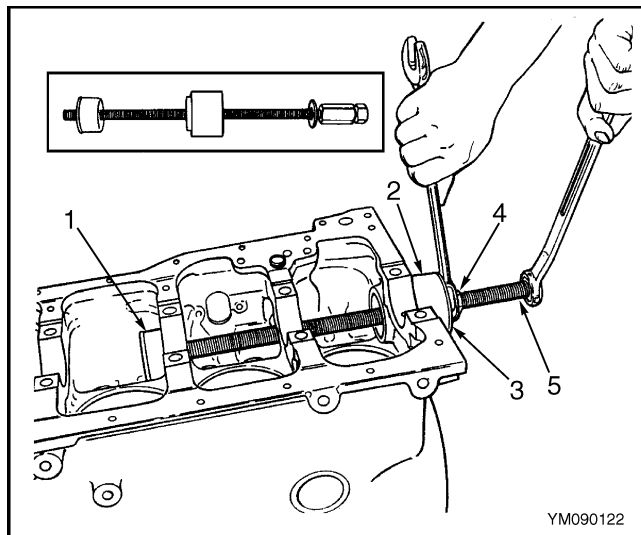


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Figure 32. Intermediate Journal Measurement

CAMSHAFT BEARINGS, REMOVE

Special tools are required to remove and install the camshaft bearings. See Figure 33. Remove the front and rear bearings last.



- | | |
|------------------|-----------------|
| 1. BEARING TOOL | 4. NUT |
| 2. PILOT | 5. PULLER SCREW |
| 3. THRUST WASHER | |

Figure 33. Camshaft Bearings Replacement

1. Remove the plug in the bore for the camshaft at the rear of the engine block. See Figure 4.
2. Using the special tool shown in Figure 33, remove the inner camshaft bearings using the procedure listed below. Repeat Step a through Step e to remove each inner camshaft bearings.
 - a. With the nut and the thrust washer installed to the end of the puller screw threads, index the pilot in the camshaft front bearing and install the puller screw through the pilot to remove the bearing.
 - b. Install the bearing tool with the shoulder toward the bearing.
 - c. Using two wrenches, hold the puller screw while you turn the nut to draw the bearing out of the bore.
 - d. When the bearing has been pulled from the bore, remove the bearing tool and the bearing from the puller screw.
 - e. Index the pilot in the rear camshaft bearing to remove the rear inner camshaft bearing.

3. Install the head of the special tool on the end of a driver. Drive the front and rear camshaft bearings out of the block bore. Drive inward, toward the center of the engine block. See Figure 34.

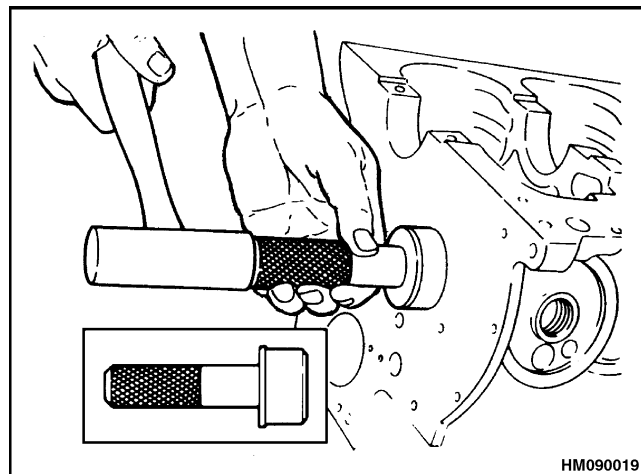


Figure 34. Camshaft Bearings Replacement

CAMSHAFT BEARINGS, CLEAN AND INSPECT

1. Inspect the camshaft bearings for proper fit in the engine block. Camshaft bearings have an interference fit to the engine block and should not be loose in their engine block bearing bores.
2. Inspect the camshaft bearings for excessive wear or damage. Bearing with excessive wear or damage must be replaced.

CAMSHAFT BEARINGS, INSTALL



CAUTION

The holes for the oil passages in the camshaft bearings must be aligned with the oil passages in the bore of the engine block. If the oil passages are not aligned correctly, the loss of lubrication will cause a failure of the camshaft bearings or other parts of the engine.

NOTE: A special tool is required to install the front and rear bearings. See Figure 34.

1. Using the special tool shown in Figure 34, align the oil holes and drive the front and rear camshaft bearings inward, toward the center of the engine block.
2. The front camshaft bearing must be 3.0 mm (0.12 in.) below the surface of the engine block

so the oil passage to the nozzle for the timing gears is open.

3. Using the special tool shown in Figure 33, install the inner camshaft bearings using the procedure listed below. Repeat Step a through Step d to install each inner camshaft bearing.
 - a. With the nut and the thrust washer installed to the end of the puller screw threads, index the pilot in the camshaft front bearing and install the puller screw through the pilot.
 - b. Index the camshaft bearing in the bore. Make sure the oil galley holes are aligned.
 - c. Install the puller screw through the bearing bore and the bearing to be installed, and assemble bearing tool to the puller screw with the shoulder toward the bearing. Make sure that enough threads are engaged. See Figure 33.
 - d. Using two wrenches, hold the puller screw while turning the nut to draw the bearing into the bore. When the bearing has been pulled into the bore, remove the bearing tool and the puller screw. Check the alignment of the bearing oil hole to the bore oil hole.
4. Install a new plug in the bore in the rear end of the engine block. The surface of the plug must be even with the surface of the engine block or not greater than 0.80 mm (0.03 in.) below the surface.

CAMSHAFT, INSTALL



CAUTION

All camshaft journals are the same diameter. Care must be used in installing the camshaft to avoid damage to the bearings.

NOTE: If a new camshaft is installed, new hydraulic valve lifters must also be installed.

1. Rotate and install the camshaft into the engine.
2. Install the two camshaft retainer plate bolts through the two holes in the camshaft sprocket (timing gear).
3. Align the camshaft and crankshaft sprocket (timing gears) alignment marks. See Figure 28. Tighten the camshaft plate retainer bolts to 9 N•m (80 lbf in).
4. Install the hydraulic valve lifters. Install the side cover for the hydraulic valve lifters. See Figure 68.
5. Install the rocker arms and push rods. See the section Cylinder Head, Install for the procedures.
6. Install the timing gear cover. See the section Timing Gear Cover Repair for the procedures.
7. Install the drive belts, fan, and pulley.

Distributor Repair

REMOVE

NOTE: This section contains only the removal and installation procedures for the distributor. The service procedures for the ignition system are found in the following sections:

- **High Energy Ignition (HEI) System, GM Engines 2200 SRM 107**
- **Microprocessor Spark Timing System (MSTS), Late Model 2200 SRM 765**



CAUTION

Carefully lift and release the lock tabs on the connectors to the distributor. The lock tabs can be easily broken if too much force is applied with a screwdriver or other tool.

Never let the TACH CONN. terminal touch a ground. The HEI module or the ignition coil will be damaged.

1. Disconnect the battery negative (ground) cable.

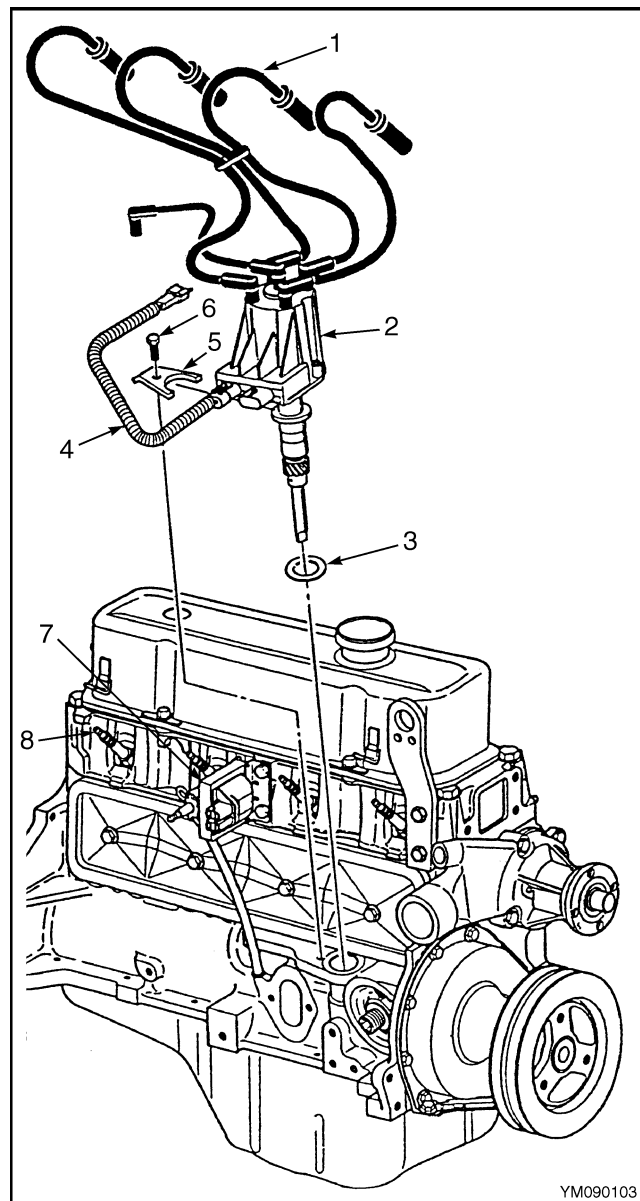
NOTE: If the spark plug wires are removed, mark them prior to removal so that they are installed in the correct sequence during the installation process.

2. If removal of the spark plug wires is not required for the repairs, leave them connected to the distributor cap.
3. Remove the two capscrews that fasten the distributor cap to the distributor. Move the distributor cap away from the work area.

4. Disconnect the distributor four-terminal connector.
5. Disconnect the ignition coil. See Figure 35.
6. Remove the bolt and clamp that hold the distributor in the engine. Make a note of the positions of the rotor to distributor housing and the distributor to the engine.
7. Slowly pull the distributor from the engine until the rotor just stops turning counterclockwise and make a note of the position of the rotor. This position must be used when the distributor is installed again.
8. If the engine has been rotated after the distributor was removed, the following procedures must be used before the distributor is installed again:
 - a. Remove the number 1 spark plug.
 - b. Put a finger over the number 1 spark plug hole and slowly rotate the engine until pressure is felt on the compression stroke.
 - c. Align the timing mark on the crankshaft pulley to 0° (TDC) on the engine timing indicator.
 - d. Turn the distributor rotor to point between the positions on the distributor cap for the number 1 and number 4 spark plug wires.
 - e. Install the distributor in the engine. The rotor and shaft will rotate a few degrees when the gear on the distributor shaft engages the drive gear on the engine cam. The timing is correct if the rotor points at the position on the distributor cap for the number 1 spark plug wire.
 - f. Go to Step 2 in the Install section and continue with the installation of the distributor.

INSTALL

1. Put the rotor and distributor in the same position as it was removed from the engine.
2. Install the distributor clamp and bolt. Hand-tighten the bolt. See Figure 35.



- | | |
|---------------------|---------------------------|
| 1. SPARK PLUG WIRES | 5. DISTRIBUTOR CLAMP |
| 2. DISTRIBUTOR | 6. DISTRIBUTOR CLAMP BOLT |
| 3. GASKET | 7. IGNITION COIL |
| 4. IGNITION HARNESS | 8. SPARK PLUG |

Figure 35. Distributor

3. Install the distributor connector(s) at the distributor.
4. Connect the ignition coil connector.

5. Install the distributor cap and the two capscrews. If the spark plug wires were removed, install them in the sequence noted during removal.
6. Connect the battery negative cable.
7. Start the engine and check the engine timing. See the **Periodic Maintenance** section for your

lift truck model for procedures on checking and adjusting the ignition timing.

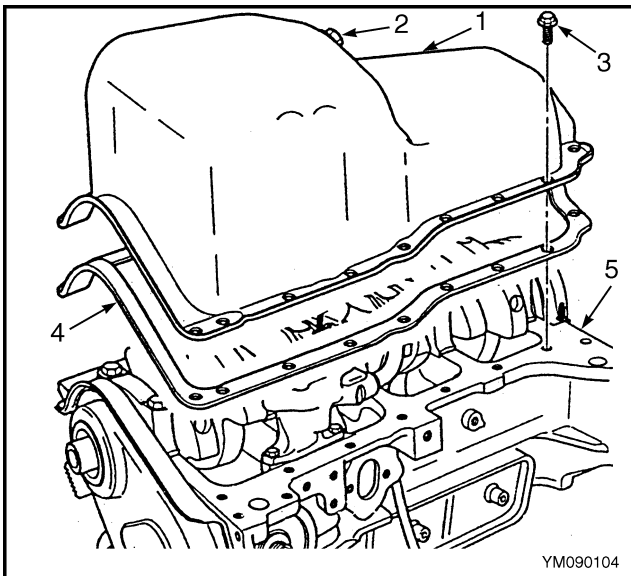
8. Tighten the bolt for the distributor clamp to 27 N•m (20 lbf ft).

Lubrication System Repair

OIL PAN

Remove

1. Disconnect the battery negative cable.
2. Remove the dipstick. Drain the engine oil.
3. Remove the starter. See the section **Starter** for your lift truck model for the removal procedures.
4. Remove the oil pan bolts and remove the oil pan. Remove and discard the gasket. See Figure 36.



- | | |
|-----------------|-----------------|
| 1. OIL PAN | 4. GASKET |
| 2. DRAIN PLUG | 5. ENGINE BLOCK |
| 3. OIL PAN BOLT | |

Figure 36. Oil Pan Removal

Install

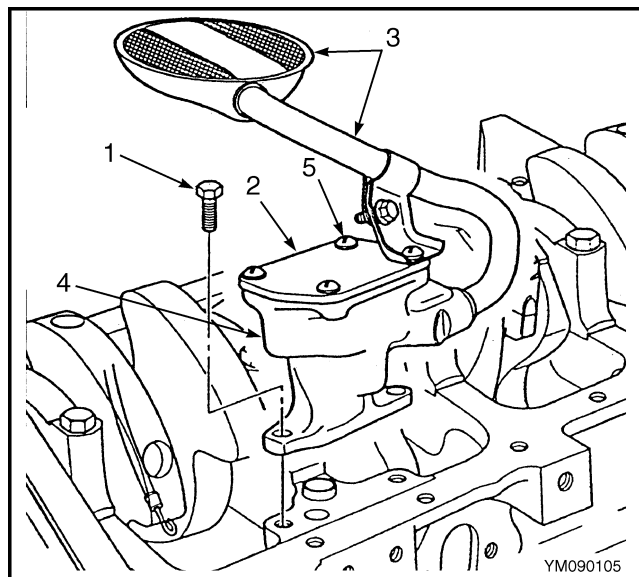
NOTE: Apply a 25 mm (1.0 in.) bead of sealant around the sealing surfaces of the oil pan.

1. Apply a small amount of sealant, 10 mm (0.394 in.) wide and 20 mm (0.787 in.) long, at the engine front cover to the engine block junction.
2. Apply a small amount of sealant, 25 mm (1.0 in.), along the crankshaft retainer assembly to the engine block junction.
3. Install new oil pan gasket. Install the oil pan. See Figure 36.
4. Install the nuts and bolts to the oil pan and tighten as follows:
 - Rear oil pan nuts to 18.6 N•m (165 lbf in)
 - Oil pan bolts to the crankcase to 9 N•m (80 lbf in)
 - Oil pan bolts to the front cover to 5 N•m (44 lbf in)
 - Oil pan studs to the oil seal retainer to 1.7 N•m (15 lbf in)
 - Oil pan drain plug to 24 N•m (18 lbf ft)

OIL PUMP

Remove

1. Remove the oil pan. See Oil Pan, Remove.
2. Remove the bolts that attach the oil pump to the engine block.
3. Remove the oil pump and gasket. Discard the gasket.



1. ATTACHMENT BOLT
2. OIL PUMP COVER
3. OIL PUMP SCREEN AND TUBE ASSEMBLY
4. OIL PUMP BODY
5. COVER ATTACHMENT SCREWS

Figure 37. Oil Pump Removal

Disassemble

Disassemble the oil pump as necessary for cleaning and inspection.

NOTE: The oil pump screen has a press fit into the pump cover. Do not remove the screen from the pipe. The pipe and screen are serviced as a complete assembly.

1. If necessary, remove the oil pump screen. See Figure 37.
2. Remove the cover bolts.
3. Remove the pump cover and gasket.

4. Make an index mark on the gears so that they can be installed again in the same position to each other. Remove the gears. See Figure 38.
5. Remove the pin, relief valve spring, and the relief valve. See Figure 38.

Clean and Inspect



WARNING

Cleaning solvents can be flammable and toxic and can cause skin irritation. When using cleaning solvents, always follow the recommendations of the manufacturer.



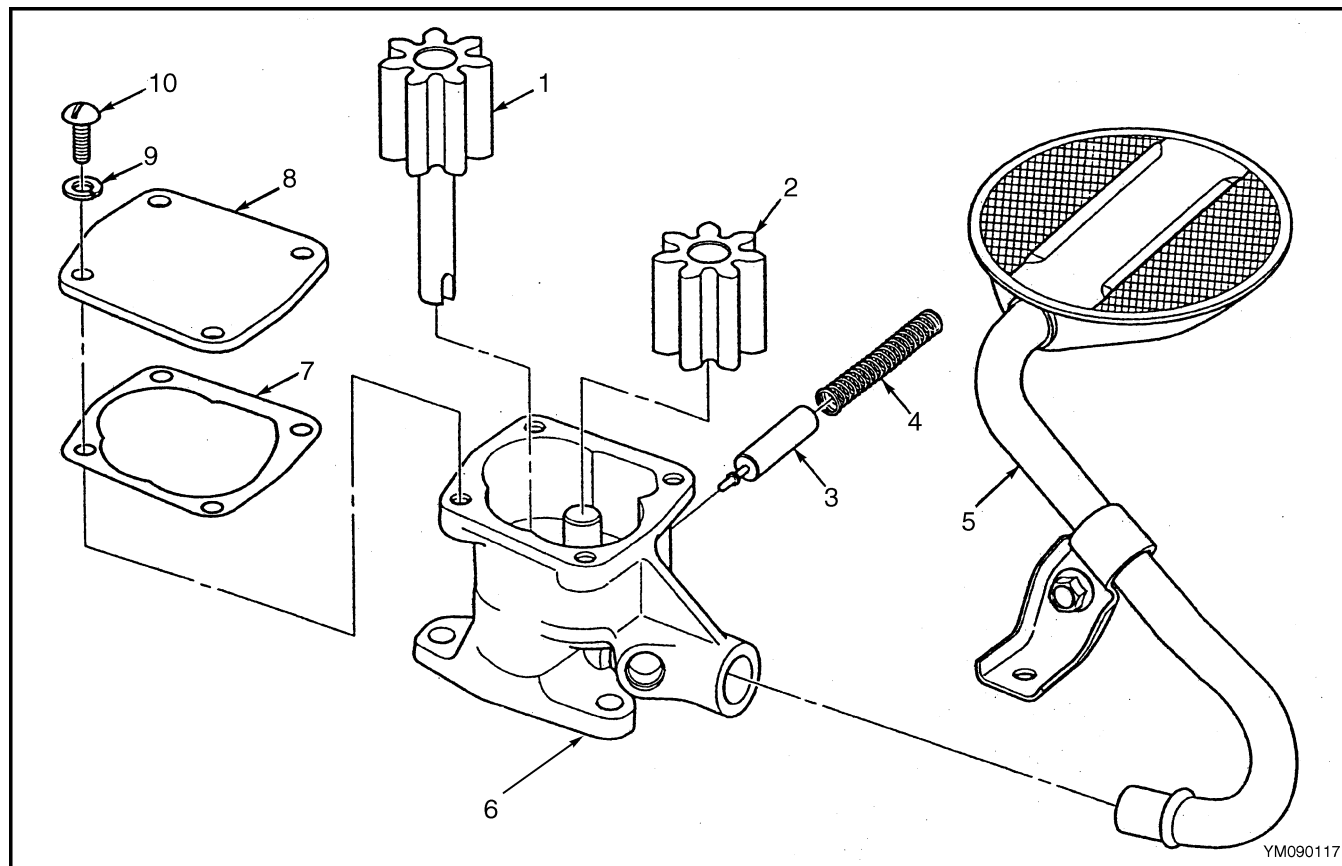
WARNING

Compressed air can move particles so that they cause injury to the user or to other personnel. Make sure that the path of the compressed air is away from all personnel. Wear protective goggles or a face shield to prevent injury to the eyes.

NOTE: The internal parts of the oil pump are not serviced separately. If the oil pump components are worn or damaged, replace the oil pump as an assembly. If the drive gear and drive shaft are worn, replace the entire oil pump.

The oil pump tube and screen are to be serviced as an assembly. Do not attempt to repair the wire mesh portion of the tube and screen assembly.

1. Clean all of the parts in cleaning solvent. Dry the parts with compressed air.
2. Inspect the gears and the pump body for wear and damage. If the parts are worn or damaged, replace the oil pump.



- | | |
|--------------------------------------|--------------------|
| 1. DRIVE GEAR | 6. OIL PUMP BODY |
| 2. DRIVEN GEAR | 7. OIL PUMP GASKET |
| 3. RELIEF VALVE | 8. OIL PUMP COVER |
| 4. RELIEF VALVE SPRING | 9. WASHER |
| 5. OIL PUMP SCREEN AND TUBE ASSEMBLY | 10. BOLT |

Figure 38. Oil Pump Disassembly

Assemble

NOTE: Use a sealant when replacement of the screen and tube assembly is necessary. Do not damage the tube during installation. Make sure that the surface of the screen assembly is parallel to the bottom surface of the engine block.

1. If the relief valve was disassembled, install the relief valve, spring, and pin. See Figure 38.
2. Install the gears in the pump body. Align the identification marks. Make sure that the smooth side of the idler gear is toward the cover.

3. Use a new gasket and install the cover. Tighten the screws to 8 N•m (71 lbf in). Turn the drive shaft with your hand to check for a smooth operation.

Install

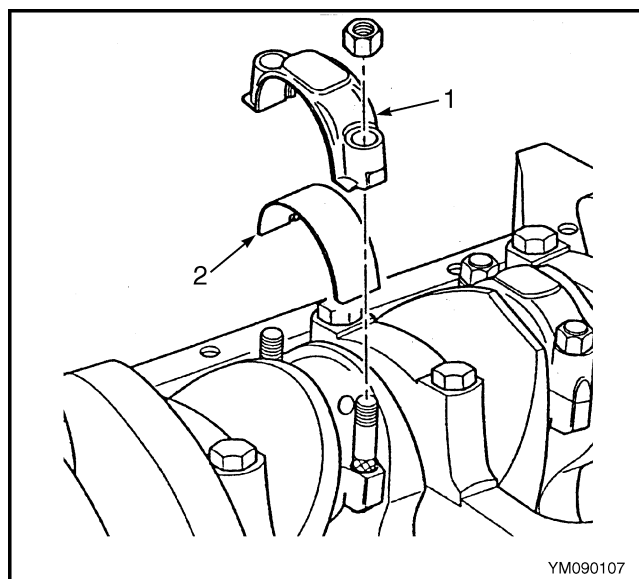
1. Install the oil pump and screen assembly. Make sure the screen is parallel to the bottom of the oil pan when the oil pump is installed.
2. Tighten the oil pump bolts to 14 N•m (124 lbf in).
3. Install the oil pan. See Oil Pan, Install.

Piston and Piston Rod Assemblies Repair

PISTON ROD BEARINGS, REPLACE

NOTE: The piston rod bearings are available in a standard size and several undersizes. See the **Parts Manual** for bearing sizes. If a bearing on a journal is worn, both the upper and lower half of the bearing must be replaced.

1. Remove the oil pan and the oil pump.
2. Before the cap for the piston rod is removed, mark the piston rod and cap with the cylinder number so that the parts will be installed in their original positions.
3. Remove the cap for the piston rod bearing and the lower bearing half. See Figure 39.



1. BEARING CAP 2. BEARING

Figure 39. Piston Rod Cap Removal

4. Push the piston rod away from the crankshaft and remove the upper bearing half. Wipe the oil from the bearing halves and the bearing journal.
5. Use a micrometer to measure the bearing journal. The bearing journal must be within the following specification:
 - Out-of-roundness less than 0.0254 mm (0.001 in.); taper less than 0.0254 mm (0.001 in.)

If the bearing journals are not within specifications, the crankshaft must be removed and the bearing journal ground to an undersize. If the bearing journal cannot be repaired so that the bearing journal is a correct undersize, the crankshaft must be replaced. See the section Engine Specifications.

6. If the bearing journal is within specifications, measure the clearance between the new bearing and the crankshaft. Use Plastigage®, or equivalent, to check the clearance as described below:
 - a. Put a piece of Plastigage across the full width of the bearing journal as shown in Figure 40. Do not rotate the crankshaft when the Plastigage is between the bearing and its journal.

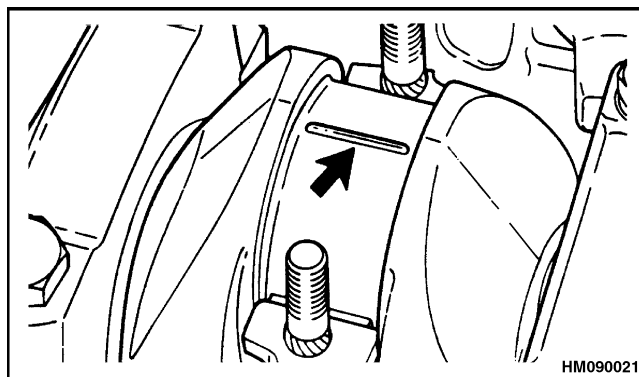


Figure 40. Bearing Journal Plastigage® Placement

- b. Install the bearing and bearing cap. Tighten the nuts to 61 N•m (45 lbf ft). See Figure 39.
- c. Remove the bearing and bearing cap. The Plastigage will be compressed and wider and will adhere to either the bearing or its journal. Use the scale on the envelope for the Plastigage to measure the width of the plastic at its widest point. The scale will indicate the clearance in millimeters or thousandths of an inch. See Figure 41.

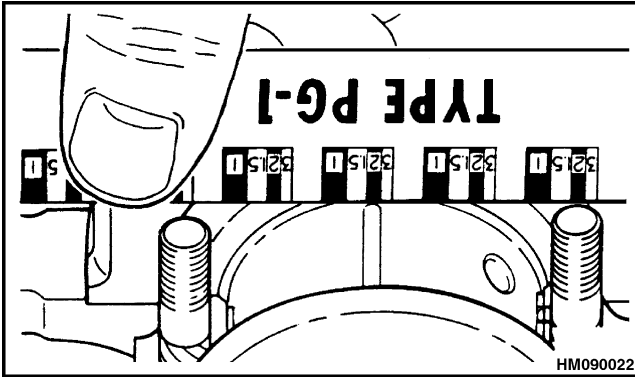


Figure 41. Bearing Journal Plastigage® Measurement

- d. If the clearance is greater than the specifications, select a new undersize bearing set and install it. Measure the clearance again. If the clearance cannot meet specifications with the available undersize bearings, the bearing journal must be ground to a new undersize. If the bearing journal is already at the maximum undersize, the crankshaft must be replaced.
 - e. If the clearance is within specifications, lubricate the bearing with engine oil and install the bearing and bearing cap. Tighten the nuts on the bearing cap to 88 N•m (65 lbf ft).
7. When all of the connecting rod bearings have been replaced, use the following procedure to check the side clearances between the piston rods and the crankshaft:
 - a. Use a hammer to lightly hit the piston rod parallel to the crankshaft journal to make sure there is a clearance.
 - b. Measure the clearance between the caps for the piston rods and the crankshaft. See Figure 42.

PISTON AND PISTON ROD ASSEMBLIES, REMOVE

1. Remove the oil pan and the oil pump.
2. Remove the cylinder head as described in Cylinder Head, Remove.

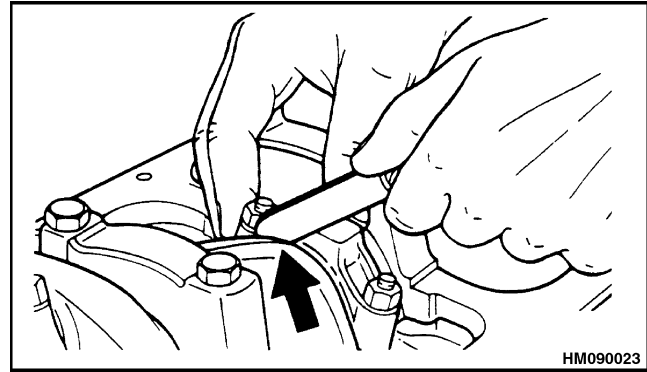


Figure 42. Piston Rods Side Clearance Measurement

3. If the engine has been in service for many hours, a ridge can be worn in the top of the cylinder. This ridge can be removed with a ridge reamer tool using the procedures described below:
 - a. Turn the crankshaft to lower the piston to the bottom of the stroke in its cylinder.
 - b. Put a cloth on top of the piston to collect metal particles.
 - c. Remove the ridge at the top of the cylinder.
 - d. Turn the crankshaft so the piston is at the top of the stroke.
 - e. Remove the cloth.
 - f. Remove the cutting debris.
4. Clean the carbon from the top of each cylinder.
5. Put an identification mark on the top of each piston.
6. Remove the caps and bearings from each piston rod. Keep the caps and bearings with their original piston assemblies. Mark the caps so that they will be installed again in their original positions. Do not mix the parts.
7. Push the piston rod and piston from the cylinder. Temporarily install the bearing cap on the piston rod to keep the parts together.

PISTON AND PISTON ROD ASSEMBLIES, DISASSEMBLE

CAUTION

The pistons are aluminum alloy and can be damaged if they are hit with a hard object. The grooves for the piston rings are machined to close tolerances. Use a tool made to clean the grooves of the piston rings. Do not use a wire brush to clean a piston.

1. Remove the piston rings from the pistons. Use a press to remove the wrist pins from the pistons. See Figure 43.

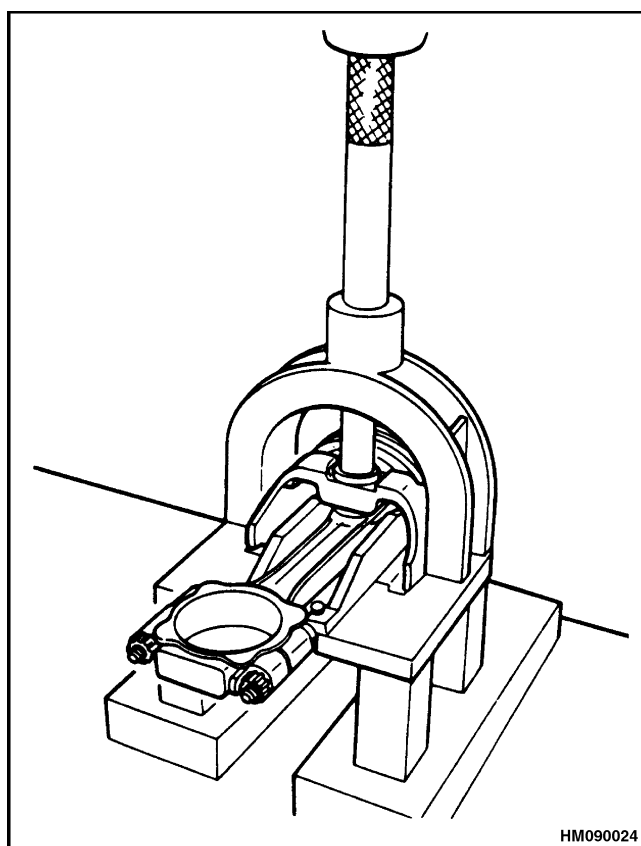


Figure 43. Wrist Pin Removal

WARNING

Cleaning solvents can be flammable and toxic and can cause skin irritation. When using cleaning solvents, always follow the recommendations of the manufacturer.

WARNING

Compressed air can move particles so that they cause injury to the user or to other personnel.

Make sure that the path of the compressed air is away from all personnel. Wear protective goggles or a face shield to prevent injury to the eyes.

2. Use solvent to clean the pistons and piston rods. Use compressed air to dry the parts. Make sure that the holes for oil passages are clean.

PISTONS, CLEAN AND INSPECT

Inspect the pistons for wear, cracks, and damage. Replace a piston that is worn or damaged.

NOTE: If the cylinder bore must be repaired, the piston must be changed to the correct oversize. Check the clearance of the piston in its cylinder after the surface of the cylinder bore has been finished with a hone.

Check the clearance of the wrist pin in the piston. The normal clearance is shown in the Engine Specifications. The wrist pin will normally fall from the hole in the piston by its own weight.

The wrist pin is a press fit in the piston rod. The piston and wrist pin are a matched set and must be replaced as a unit if the clearances are greater than the specifications.

CYLINDER BORES, INSPECT AND REPAIR

Inspect the cylinder bores for wear and damage. Measure the cylinder bores in several positions as shown in Figure 44. Measure the cylinder bore at right angles to the centerline to find any distortion from wear. A cylinder that is out of round greater than 0.05 mm (0.002 in.) must be repaired.

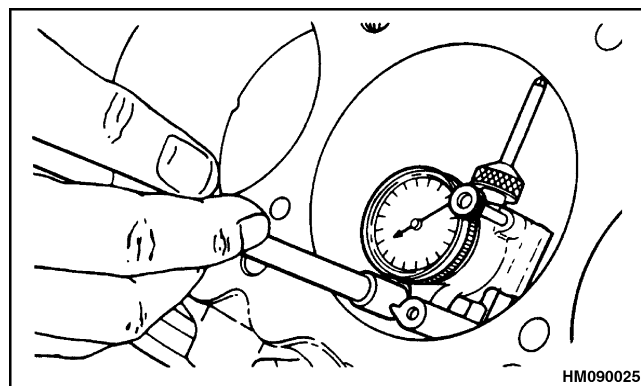


Figure 44. Cylinder Bore Measurement

Measure the cylinder bore in positions from top to bottom to find any taper from wear. A normal wear pattern for a cylinder bore is shown in Figure 45.

A cylinder that has a taper [measurement **A** that is 0.127 mm (0.005 in.) greater than measurement **B**] must have a new bore.

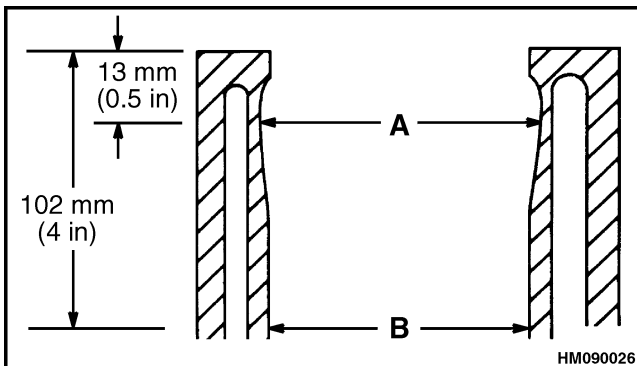


Figure 45. Normal Cylinder Wear Pattern

A tool called a hone can be used to remove a small amount of taper from a cylinder bore. Use a boring machine to repair a badly worn cylinder. The boring machine will make a more-accurate cylinder bore. The hone is then used to finish the surface of the cylinder bore.

A cylinder bore that has been repaired with a hone or a boring machine must be fitted with a piston that is the correct size. Measure the outer diameter of the piston and the inner diameter of the cylinder bore as shown in Figure 46.

Using different oversize pistons in the engine does not affect the dynamic balance of the engine. Replacement pistons from standard size to 0.030 in. oversize, normally have the same weight. The clearance specifications between a piston and its cylinder bore is shown in the Engine Specifications.

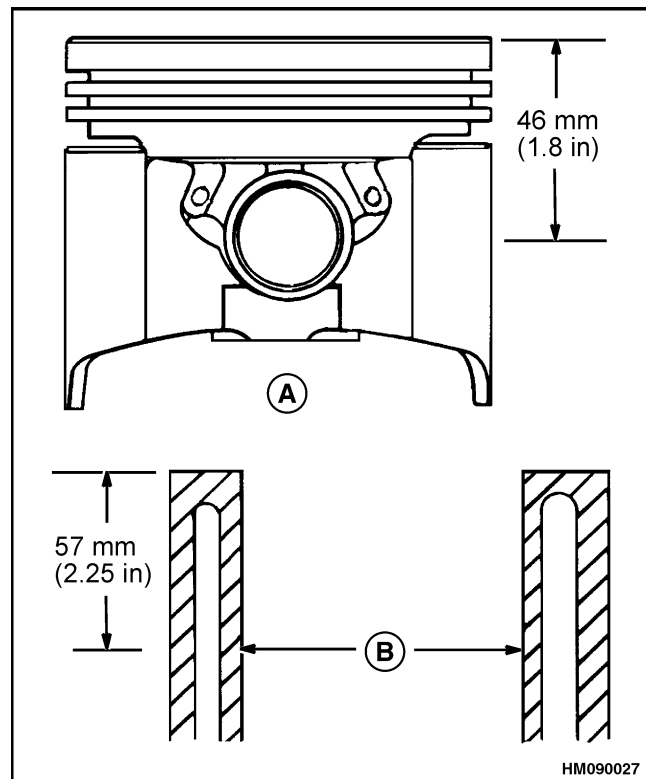
PISTON RINGS, INSPECT

NOTE: Check the clearance of the piston rings in the cylinder after the surface of the cylinder has been finished with a hone. New piston rings are available for the several piston size. See the **Parts Manual** for sizes.

The piston rings must match the size of the piston on which they are installed. Check the side clearance and the end clearance of the piston rings as described in the following paragraphs.

Each compression ring has a mark on one surface. This mark must be toward the top of the cylinder

when the piston ring is installed. The number 1 compression ring normally has a chrome or molybdenum surface.



- A. PISTON GAUGE POINT
- B. BORE GAUGE POINT

Figure 46. Piston and Cylinder Bore Gauge Points

The oil control ring has three pieces. There are two thin steel rings separated by a spacer.

1. Measure the clearance between the piston ring and the groove in the piston as shown in Figure 47. The clearances are shown in the Engine Specifications section. Replace the piston if the clearances are greater than the specifications.
2. Measure the end clearance of each piston ring as shown in Figure 48. The end clearances are shown in the Engine Specifications section. Install the piston ring into the cylinder where it will be used. Use a thickness gauge to measure the amount of end clearance. Replace the piston if the clearances are greater than the specifications.

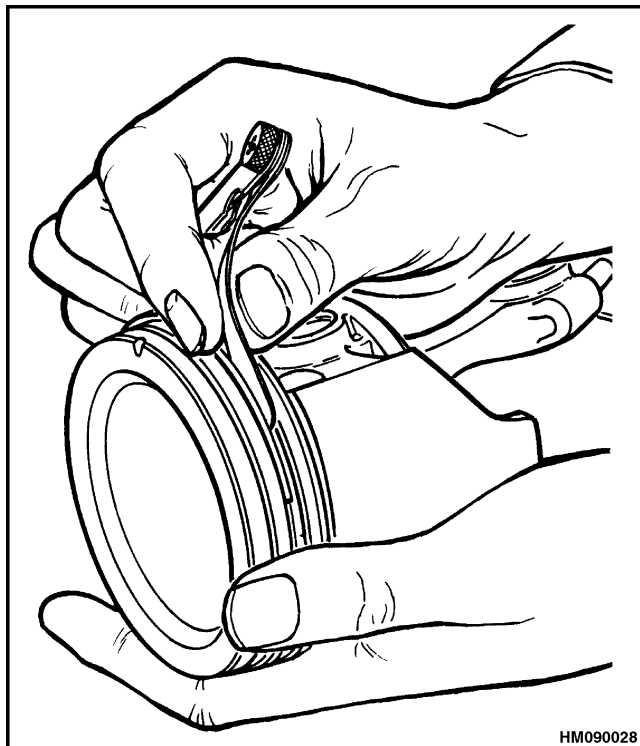


Figure 47. Piston Ring and Groove Clearance Check

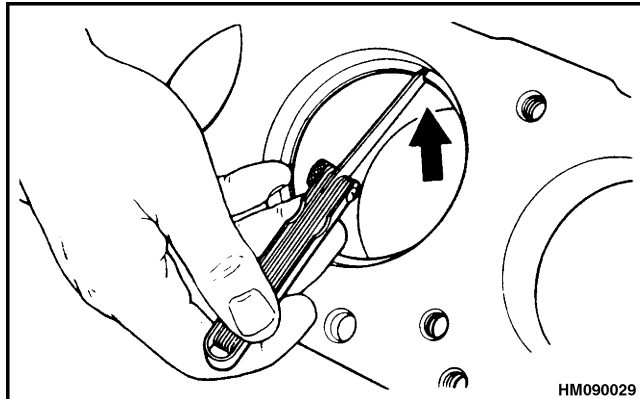


Figure 48. Piston Ring End Clearance Check

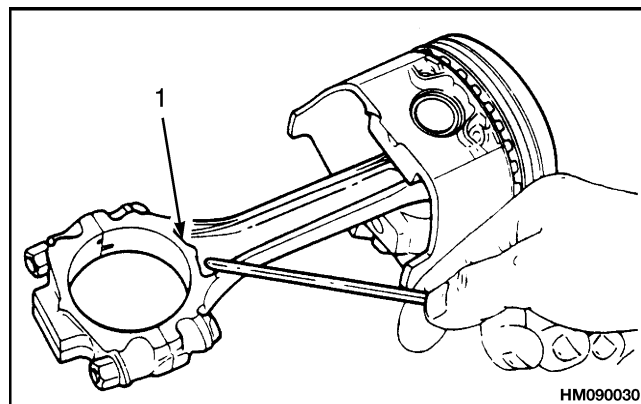
PISTON AND PISTON ROD ASSEMBLIES, ASSEMBLE

NOTE: There are notches cast in the top of all pistons to indicate the correct assembly and installation. The pistons must always be installed with this notch toward the fan end of the engine. See Figure 52.

The piston rods have a notch cast in the bearing journal as shown in Figure 49. This notch must be

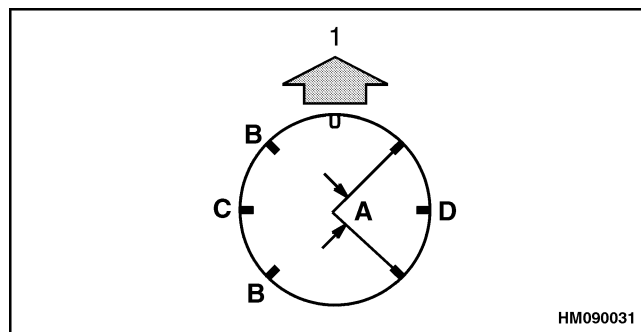
opposite the notch on the top of the piston when the piston and piston rod are assembled.

1. Assemble the piston rod to the piston. Make sure the orientation of the piston rod and piston are correct as described in the **NOTE** above. Use a press to install the wrist pin into the piston and piston rod. Lubricate the wrist pin with engine oil during installation.
2. Check the clearances of the piston rings as described in Piston Rings, Inspect. Install the piston rings on the piston as shown in Figure 50.



1. NOTCHES ON ROD OPPOSITE NOTCH IN PISTON

Figure 49. Piston Rod Identification



- A. POSITION OF GAP FOR SPACER OF OIL RING
- B. POSITION OF GAP FOR OIL RING
- C. POSITION OF GAP FOR SECOND COMPRESSION RING
- D. POSITION OF GAP FOR FIRST COMPRESSION RING

1. FAN END OF ENGINE

Figure 50. Piston Ring Arrangement

PISTON AND PISTON ROD ASSEMBLIES, INSTALL

1. Lubricate the assembly with engine oil during installation. Arrange the piston rings on the piston as shown in Figure 50. Install a ring compressor on the piston as shown in Figure 51.

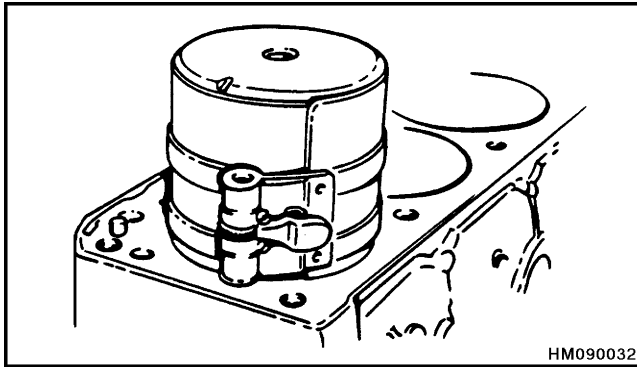
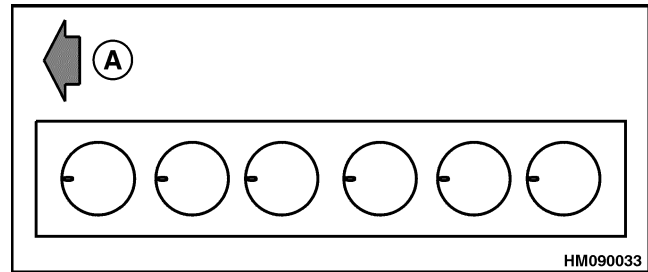


Figure 51. Ring Compressor Installation

2. Make sure that the arrow in the piston is toward the fan end of the engine as shown in Figure 52. Install the piston and piston rod assemblies in the cylinder bores.



NOTE: STAMPED ARROW MUST BE TOWARD FAN END OF ENGINE.

- A. FAN END OF ENGINE

Figure 52. Piston Position Inside Cylinder

3. Install the bearings and the caps for the piston rods. Tighten the nuts to 61 N•m (45 lbf ft). Check the side clearance of each piston rod after the bearing cap is installed. See the procedure in the paragraphs under Piston Rod Bearings, Replace.
4. Install the cylinder head as described in Cylinder Head, Install.
5. Install the oil pan and the oil pump.

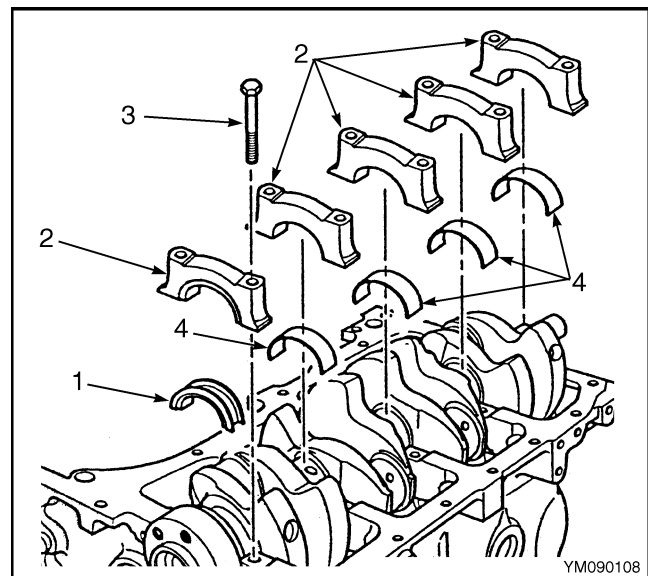
Crankshaft Repair

MAIN BEARINGS, REPLACE

NOTE: The following procedure is for replacement of the main bearings without removing the crankshaft from the engine.

NOTE: Crankshaft main bearings are a precision-insert type. Main bearing caps are machined with the engine block for proper clearance and cannot be shimmed or filed for bearing fit. If crankshaft bearing clearances are not within specifications, new bearings and/or engine block and cap repair may be required.

1. Remove the oil pan and the oil pump as described in the procedures under Lubrication System Repair.
2. Remove the cap on the main bearing that needs replacement. Remove the bearing half from the cap. See Figure 53.



- | | |
|-----------------|--------------------|
| 1. MAIN BEARING | 3. CAP BOLT |
| 2. BEARING CAPS | 4. BEARINGS (HALF) |

Figure 53. Crankshaft Bearings

3. The rear main bearing does not have an oil hole. Use the following procedure to replace the upper half of the rear main bearing:
 - a. Use a small drift punch and a hammer to remove the bearing half from the engine block.
 - b. Put some tape on a pair of pliers to make soft jaws. Use the pliers to hold the thrust surface of the bearing to the oil control ring of the crankshaft. See Figure 54. Turn the crankshaft to remove the upper bearing half.

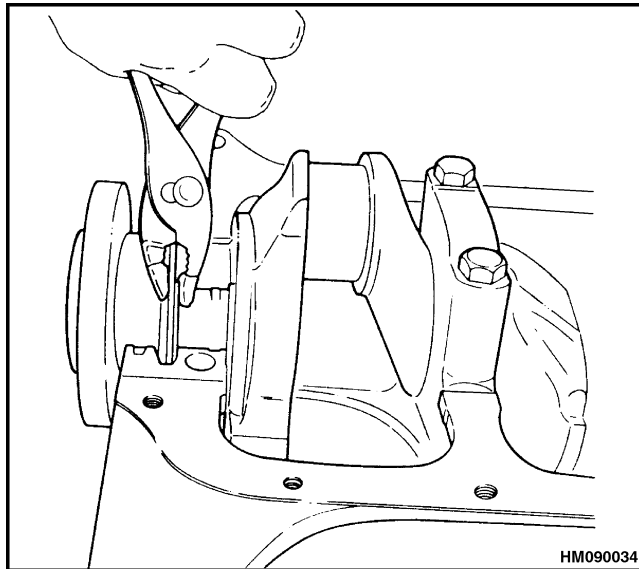


Figure 54. Rear Main Bearing Replacement

- c. Lubricate a new bearing half of the correct size with engine oil. Insert the end of the bearing without the notch between the crankshaft and the side of the engine block with the notch.
 - d. Use the pliers described in Step b to rotate the bearing half into position.
4. The other crankshaft journals have oil holes. Use the following procedure to replace the upper half of the main bearing:
 - a. Put a thin rod or a bent cotter pin through the oil hole in the crankshaft to contact the main bearing half.
 - b. Rotate the crankshaft clockwise as seen from the fan end of the engine. This movement will rotate the main bearing half from the engine block.

- c. Lubricate a new bearing half of the correct size with engine oil. Insert the end of the bearing without the notch between the crankshaft and the side of the engine block with the notch.
 - d. Rotate the main bearing half into position in the engine block.

OIL SEAL FOR REAR MAIN BEARING, REPLACE

The oil seal is a one-piece unit that can be replaced without removal of the oil pan or the crankshaft. See Figure 55. The transmission must be disconnected from the engine.

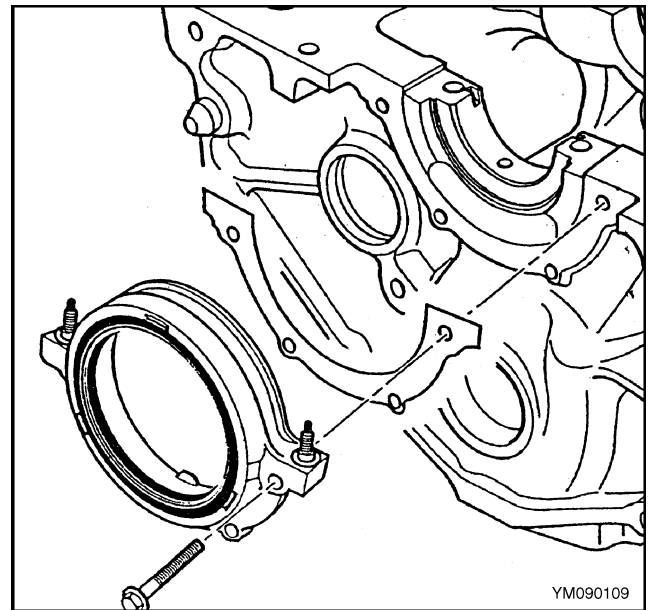


Figure 55. Oil Seal Removal

1. Remove the flywheel.
2. Remove the crankshaft rear oil seal bolts.
3. Remove the crankshaft rear oil seal housing, seal, and gasket.
4. Remove the crankshaft rear oil seal from the crankshaft rear oil seal housing. See Figure 56.
5. Clean the surface of the engine block area for the oil seal.
6. Lubricate the oil seal with clean engine oil and carefully install it. Tighten the bolts and nuts to 15 N•m (133 lbf in).

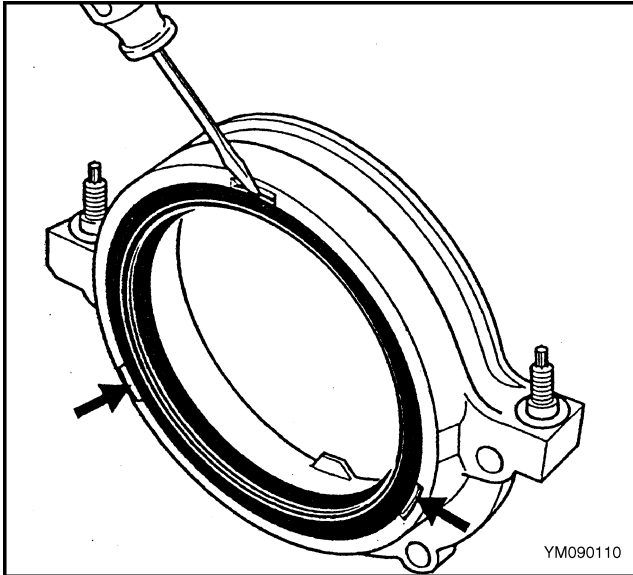


Figure 56. Oil Seal Removal

7. Install the flywheel and tighten the bolts to 88 N•m (65 lbf ft).

CRANKSHAFT, REMOVE

1. Remove the flywheel housing and the flywheel. See the removal procedures under the section Flywheel and Flywheel Housing Repair.
2. Remove the oil pan and the oil pump as described in the procedures under Lubrication System Repair.
3. Remove the crankshaft pulley or vibration dampener and timing gear cover as described in the procedures under Timing Gear Cover Repair.
4. Remove the bearing caps for the piston rods as described in the procedures under Piston and Piston Rod Assemblies Repair. If the piston and piston rod assemblies will not be removed for repair, push them to the top of their bores so that they are away from the crankshaft.
5. Remove the caps for the main bearings. Make sure that there are identification marks on the caps so that they can be installed in the same position. See Figure 53.
6. Carefully remove the crankshaft from the engine block. See Figure 57.

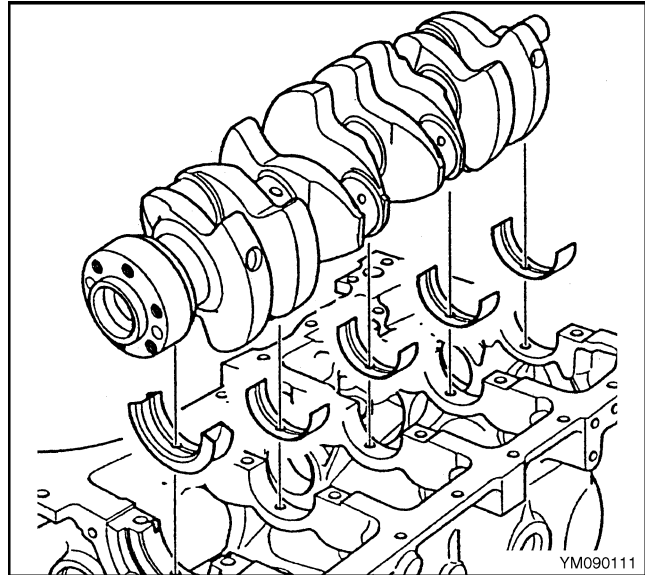


Figure 57. Crankshaft Removal

7. Remove the oil seal for the rear main bearing. Remove the main bearings from the crankcase and the main bearing caps.

INSPECT AND REPAIR

WARNING

Compressed air can move particles so that they cause injury to the user or to other personnel. Make sure that the path of the compressed air is away from all personnel. Wear protective goggles or a face shield to prevent injury to the eyes.

WARNING

Cleaning solvents can be flammable and toxic and can cause skin irritation. When using cleaning solvents, always follow the recommendations of the manufacturer.

1. Clean the crankshaft with solvent and dry it with compressed air.
2. Inspect the crankshaft for cracks, wear, and damage.
3. Use a micrometer to measure the journals for the bearings of the crankshaft. See Figure 58. Take the measurement at different positions to see if the surface of the bearing is round. The correct sizes are given in the Engine Specifications.

4. If the crankshaft journals must be repaired, they can be ground to a smaller (undersize) than the original size. See the **Parts Manual** for available bearing sizes.

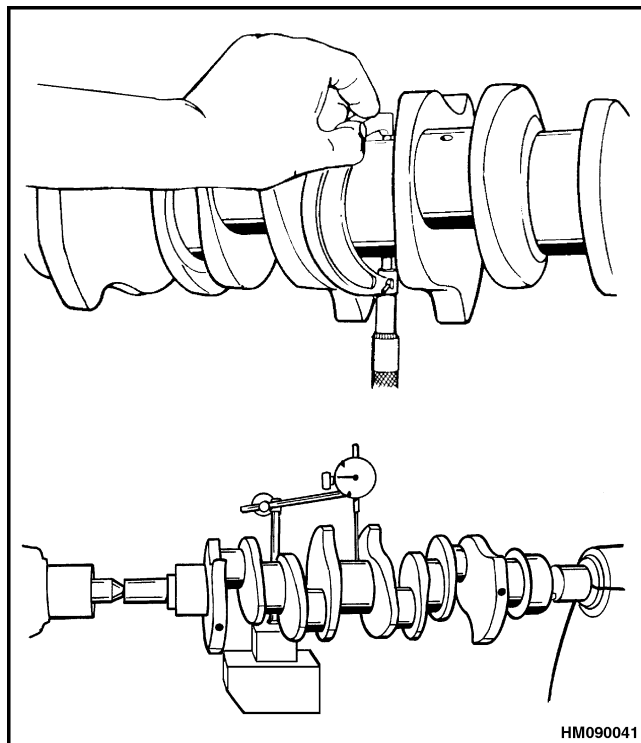


Figure 58. Crankshaft Journal Measurement

When the crankshaft is assembled by the manufacturer, the main bearings are specially selected to obtain close tolerances. For this reason, you can find one-half of a standard size insert with one-half of a 0.001-inch undersize insert. This combination will decrease the clearance 0.0005 inch from using a full standard bearing.

When a production crankshaft cannot be fitted with this method, the main journal is then ground 0.009 inch undersize. Only those main bearing journals that cannot be fitted with standard 0.001-inch or 0.002-inch undersize main bearing will be ground. A 0.009-inch and a 0.010-inch undersize bearing will be selected as described to obtain close tolerances.

A production crankshaft that has been ground will have the following identification:

- The crankshaft journal that has been ground will have a **9** marked in the metal of the crankshaft next to the journal. A spot of light green paint is also added to the crankshaft.
- The main bearing cap is also marked with green paint.

MAIN BEARING AND JOURNAL CLEARANCE, CHECK

NOTE: Crankshaft main bearings are a precision-insert type. Main bearing caps are machined with the engine block for proper clearance and cannot be shimmed or filed for bearing fit. If crankshaft bearing clearances are not within specifications, new bearings and/or engine block and cap repair may be required.

1. Use Plastigage® or equivalent to check the clearance. The procedure is similar for both piston rod bearings and main bearings. If the engine has been removed from the lift truck, position the engine so that the crankshaft is up. The weight of the crankshaft is against the upper bearing half, and the total clearance can be measured correctly. If the engine is still in the lift truck, the crankshaft must have a support to remove any additional clearance between the upper bearing half and its journal.
2. All main bearing caps must be installed and their capscrews tightened to 88 N•m (65 lbf ft).
3. Check the rear main bearing first. Remove the cap for the rear main bearing. See Figure 53. The procedure for checking the clearance of the other bearings is similar.
4. Clean the oil from the bearing half and journal to be checked. Put a piece of Plastigage across the full width of the bearing journal as shown in Figure 59. Do not rotate the crankshaft when the Plastigage is between the main bearing and its journal.

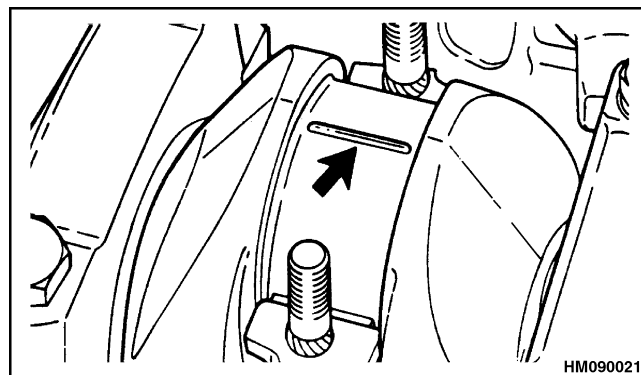


Figure 59. Bearing Journal Plastigage® Placement

5. Install the main bearing and main bearing cap and tighten the capscrews to 88 N•m (65 lbf ft). The capscrews must be tightened to their final torque, or there will be an error in the measurement.
6. Remove the main bearing cap. The Plastigage will be compressed and wider and will adhere to either the bearing or its journal. Use the scale on the envelope for the Plastigage to measure the width of the plastic at its widest point. The scale will indicate the clearance in millimeters or thousandths of an inch. See Figure 59.
7. If the clearance is greater than the specifications, select a new undersize bearing set and install it. Measure the clearance again. If the clearance cannot meet specifications with the available undersize bearings, the bearing journal must be ground to a new undersize. If the bearing journal is already at the maximum undersize, the crankshaft must be replaced.
8. If the clearance is within specifications, lubricate the bearing with engine oil and install the main bearing and bearing cap. Tighten the capscrews on the main bearing cap to 88 N•m (65 lbf ft).
9. Turn the crankshaft to make sure it rotates smoothly.

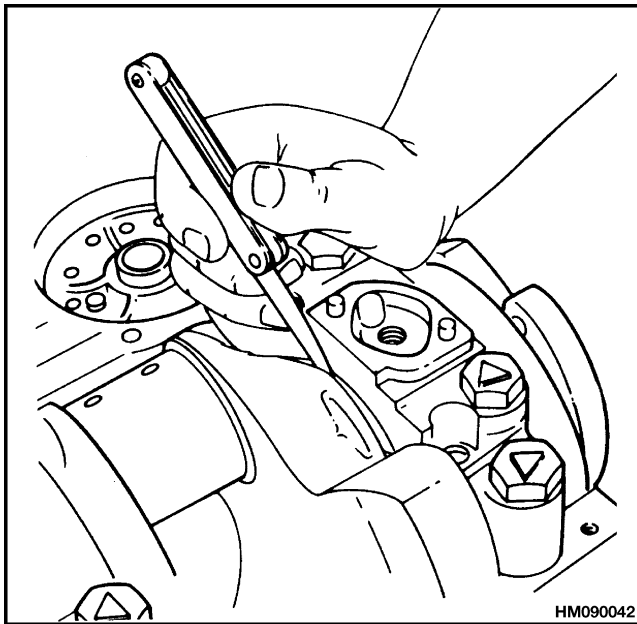


Figure 60. Crankshaft Axial Clearance Measurement

10. Check the axial clearance between the rear main bearing and the thrust surface. Push the crankshaft forward. See Figure 60. Measure the clearance between the crankshaft and the thrust surface of the rear bearing. The correct end play clearance is 0.05 to 0.15 mm (0.002 to 0.006 in.).

CRANKSHAFT, INSTALL

1. Install the oil seal for the rear main bearings. See Oil Seal for Rear Main Bearing, Replace.
2. Lubricate new main bearing halves with engine oil and install them in the bearing housing of the engine block.
3. Carefully install the crankshaft in the engine block. See Figure 57.
4. Lubricate the lower halves of the main bearings and install them in their caps. Install each main bearing cap in its position on the engine block. Make sure each main bearing cap is installed in its original position. If a main bearing cap is not installed correctly, there can be an alignment problem, which can cause rapid wear and damage to the engine.
5. Use the following procedure to install the cap for the rear main bearing:
 - a. Install the cap for the rear main bearing and tighten the capscrews to an initial torque of 14 N•m (124 lbf in). Use a hammer to hit the crankshaft lightly and move it forward against the rear main bearing. Then, use the hammer to hit the crankshaft lightly and move it backward against the rear main bearing. This procedure is to align the thrust surfaces on the rear main bearing. Tighten the capscrews for the main bearing cap to 88 N•m (65 lbf ft).
 - b. Check the clearance between the rear main bearing and the thrust surface. Push the crankshaft forward. Measure the axial clearance between the crankshaft and the thrust surface of the rear bearing. See Figure 60.
6. Check the clearance between the main bearing and its crankshaft journal. See Main Bearing and Journal Clearance, Check.

7. Install the piston assemblies as described in Piston and Piston Rod Assemblies, Install.
8. Install the oil pump and oil pan as described in the Lubrication System Repair section.

Flywheel and Flywheel Housing Repair

Some models of lift trucks have an oil clutch. Before the flywheel is removed, check for an even surface on the face of the flywheel. Fasten a dial indicator to the engine as shown in Figure 61. Turn the flywheel and check the variations indicated by the dial indicator. Make a note of the high indication and the low indication. If the difference between the indications is more than 0.20 mm (0.008 in.), replace the flywheel.

Some lift trucks have a hydraulic pump drive assembly that is part of the flywheel and flywheel housing (Figure 62). See the section **Hydraulic Pump Drive Assembly** 1900 SRM 339 for additional information on the S6.00-7.00XL (S135-155XL, S135-155XL₂, S155XLS), S3.50-5.50XM (S70-120XM), S3.50-5.00XL (S70-120XL), and H3.50-5.00XL (H70-120XL) lift trucks.

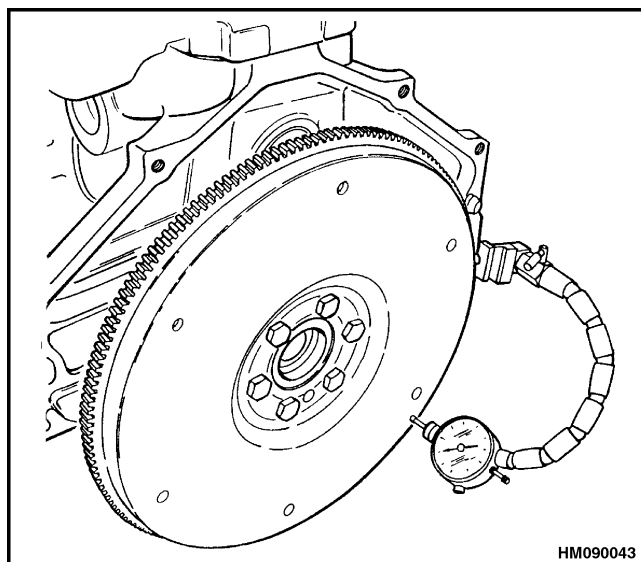
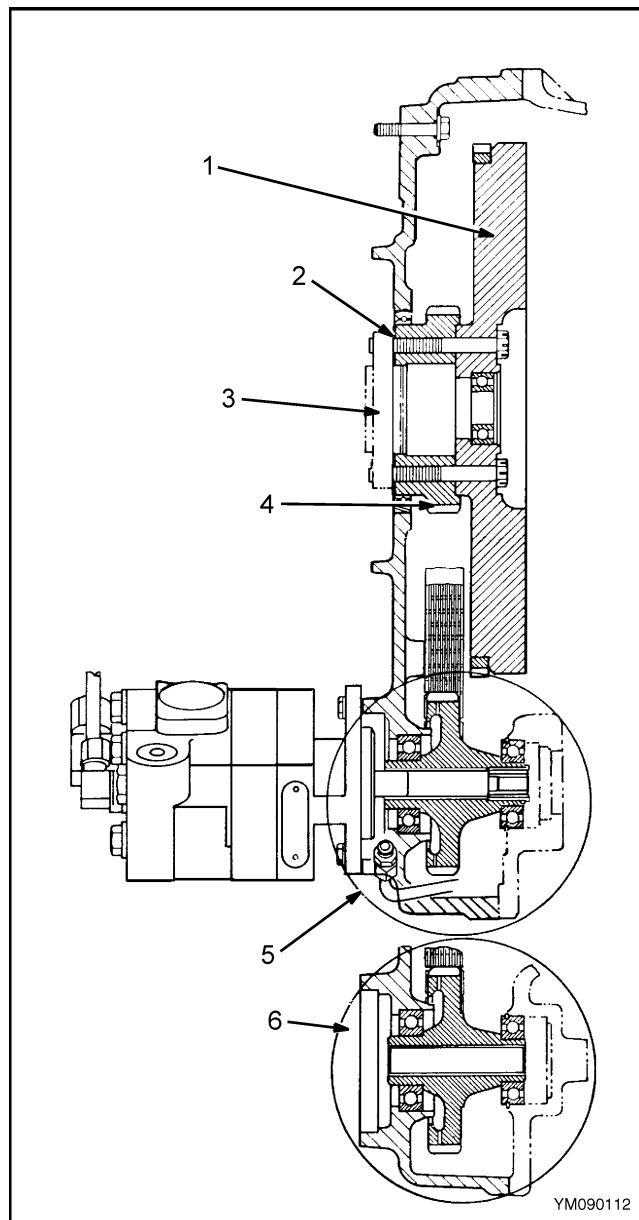


Figure 61. Flywheel Surface Check



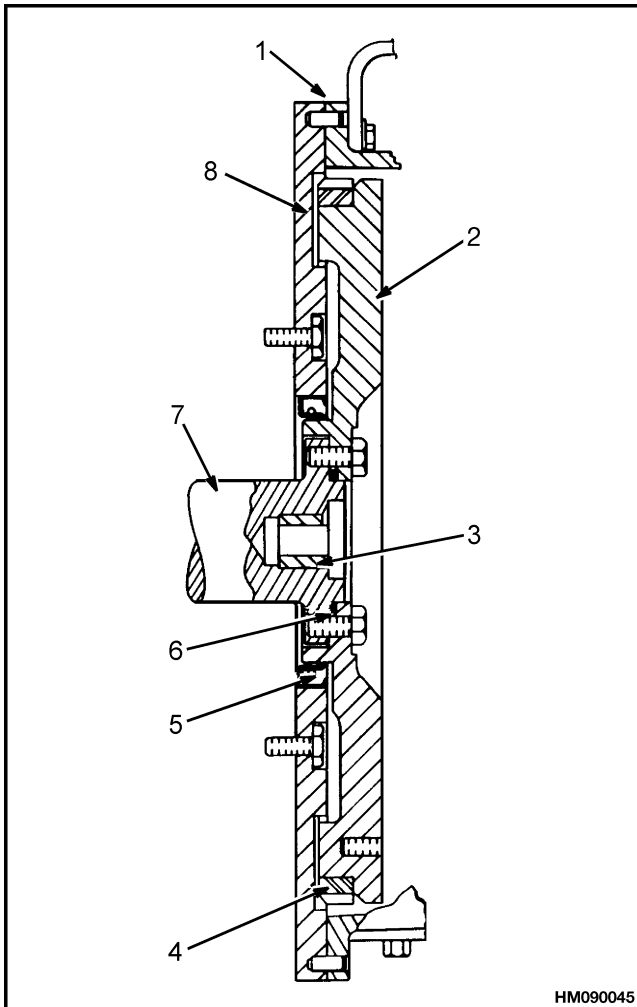
1. FLYWHEEL
2. SHIMS
3. CRANKSHAFT
4. DRIVE GEAR
5. DRIVEN GEAR ARRANGEMENT (OIL CLUTCH)
6. DRIVEN GEAR ARRANGEMENT (POWERSHIFT TRANSMISSION)

Figure 62. Hydraulic Pump Drive Assembly Flywheel Arrangement

FLYWHEEL, REMOVE

NOTE: Make a notation of the position and direction of the engine flywheel before removing it. The flywheel center alignment hole is a tapered fit to the crankshaft. The engine flywheel must be reinstalled to the original position and direction. See Figure 63.

1. Remove the engine flywheel bolts.
2. Remove the flywheel from the engine. See Figure 64.



- | | |
|--------------|------------------|
| 1. GASKET | 5. SEAL |
| 2. FLYWHEEL | 6. O-RING |
| 3. BEARING | 7. CRANKSHAFT |
| 4. RING GEAR | 8. ADAPTER PLATE |

Figure 63. Oil Clutch Flywheel Arrangement

RING GEAR, REPLACE



WARNING

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

1. Use the following procedure to remove the ring gear from the flywheel:
 - a. During removal or installation, do not heat the ring gear greater than 230°C (450°F). Heat the circumference of the ring gear evenly and carefully remove it from the flywheel with a hammer and driver.



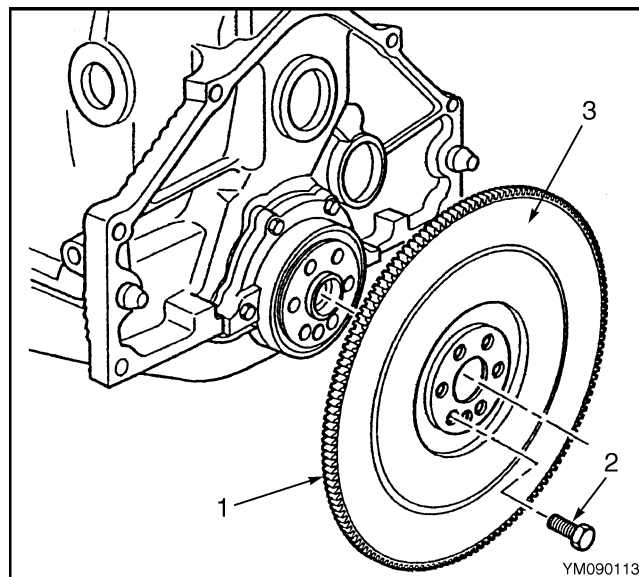
WARNING

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

- b. Heat the new ring gear to 200°C (390°F) in an oven and install the ring gear on the flywheel. Push the ring gear fully against the shoulder of the flywheel.
- c. The bearing in the flywheel can be replaced. Push the old bearing from the flywheel and push in a new bearing.

FLYWHEEL, INSTALL

1. Install the engine flywheel. See Figure 64.
2. Install the flywheel bolts and tighten them to 88 N•m (65 lbf ft).



- | | |
|--------------|-------------|
| 1. RING GEAR | 3. FLYWHEEL |
| 2. BOLT | |

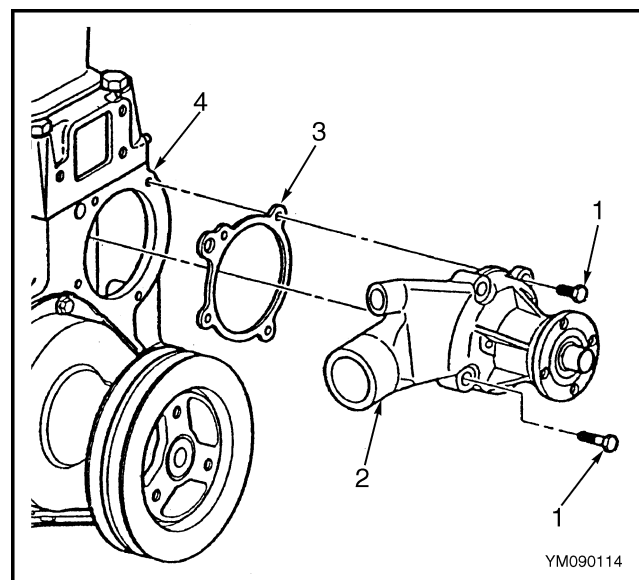
Figure 64. Flywheel Installation**Cooling System Repair****WATER PUMP****Remove**

NOTE: This section covers the removal, inspection, and installation of the water pump and the removal and installation of the thermostat. For a description of how the water pump, thermostat, and other components of the cooling system operate, see the section **Cooling System** 700 SRM 626.

1. Drain engine coolant from the cooling system.
2. Remove the water pump bolts. See Figure 65.
3. Remove the water pump and gasket. Discard the water pump gasket.

Inspect

1. Inspect the water pump for the following:
 - a. Worn or damaged gasket sealing surfaces.
 - b. Excessive side-to-side play in the pulley shaft.



- | | |
|---------------|-----------------|
| 1. BOLTS | 3. GASKET |
| 2. WATER PUMP | 4. ENGINE BLOCK |

Figure 65. Water Pump

- c. Leakage at the water inlet housing or rear cover gasket areas.
- d. Leakage at the water pump vent hole. A stain around the vent hole is acceptable. If leakage occurs at the vent hole with the engine running and the cooling system pressurized, replace the pump.

Install

1. Position the water pump and gasket to the engine block. See Figure 65.
2. Install the water pump bolts and tighten the bolts to 20 N•m (177 lbf in).

THERMOSTAT

Remove and Install



CAUTION

DO NOT operate the engine without a thermostat. The engine and cooling system can be damaged.

1. Drain the cooling system to the level of the thermostat.
2. Disconnect the hose and remove the capscrews that hold the thermostat housing parts together. Remove the top half of the thermostat housing. Remove the thermostat. See Figure 66 and Figure 1.
3. Test the operation of the thermostat. The thermostat must begin to open at 82°C (180°F) and must be completely open at 95°C (203°F).
4. Install the thermostat into the thermostat housing and install a new gasket. Install the top half of the thermostat housing and tighten the capscrews to 20 N•m (177 lbf in).
5. Connect the hose and fill the cooling system. Start the engine and check for leaks.

Alternator Repair

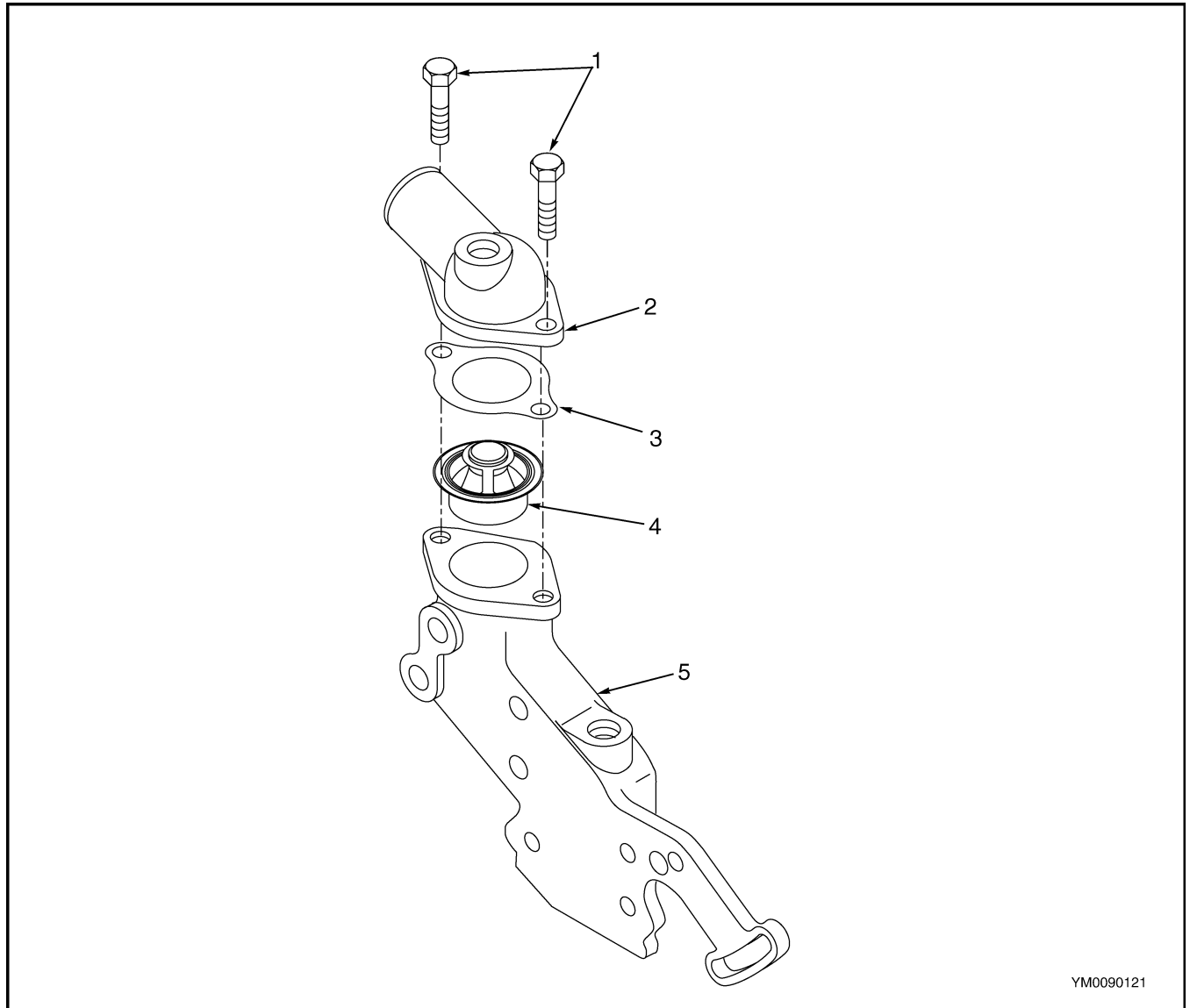
The repair procedures for the alternator used on the GM 3.0 liter engine are not covered in this section.

See the section **Alternator Repair** for your lift truck model for the procedures to repair the alternator.

Starter Repair

The procedures to repair the starter used on the GM 3.0 liter engine are not covered in this section. See

the section **Starter Repair** for your lift truck model for the repair procedures for the starter.



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|----------------------------------|-------------------------------------|
| 1. CAPSCREWS | 4. THERMOSTAT |
| 2. THERMOSTAT HOUSING (TOP HALF) | 5. THERMOSTAT HOUSING (BOTTOM HALF) |
| 3. GASKET | |

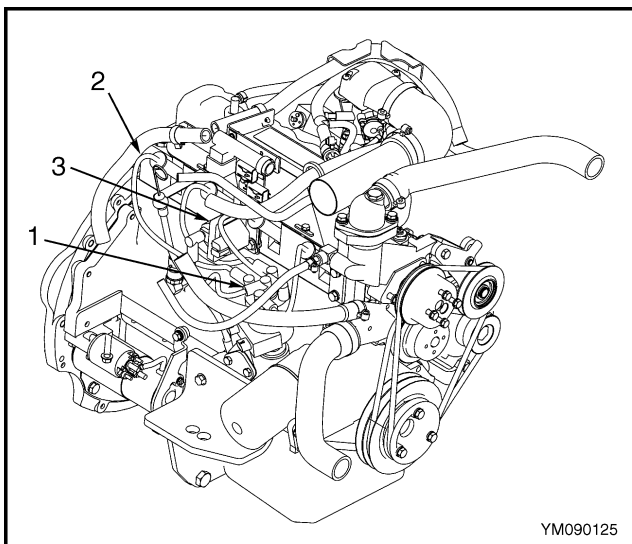
Figure 66. Thermostat Components

Checks and Adjustments

ENGINE COMPRESSION TEST

Test Procedure

1. Perform the following steps to check the cylinder compression:
 - a. Engine should be at ambient temperature.
 - b. Disconnect the two electrical connectors from the distributor. See Figure 67.
 - c. Remove the spark plugs. See Figure 67.



1. DISTRIBUTOR
2. SPARK PLUG AND WIRE
3. IGNITION COIL

Figure 67. Engine Compression Test

- d. The throttle plates should be wide open.
 - e. Make sure the battery is at or near full charge.
2. For each cylinder, crank the engine through four compression strokes.
3. The lowest cylinder reading should not be less than 70 percent of the highest.
4. The minimum pressure reading for the cylinders is 689 kPa (100 psi).

Test Results

The results of the compression test will fall into one of three categories listed below:

- **Normal** - Compression builds up quickly and evenly to the specified compression for each cylinder.
- **Piston Rings** - Compression is low on the first stroke and tends to build up on the following strokes but does not reach normal. Compression improves considerably once oil has been added.
- **Valves** - Compression is low on the first stroke and does not build up on the following strokes. Compression does not improve much after adding approximately three squirts of oil.

ENGINE NOISE DIAGNOSTIC TEST

Description

There are four steps to diagnosing engine noise. The following conditions must be determined:

- The type of noise being made
- The exact operating condition under which the noise occurs
- The rate and location of the noise
- The sounds in other engines in comparison to make sure you are not trying to correct a normal condition

Identify the type of noise (e.g., a light rattle or low rumble). Keep in mind that engine noises are generally synchronized to either engine speed (caused by the crankshaft, pistons, or piston rods) or one-half engine speed (valve train noise). Try to determine the rate at which the noise is occurring.

Test Procedure

1. Perform the following procedures with the engine running:
 - a. Try to determine if the noise is timed to the crankshaft or camshaft speed.
 - b. Use a timing light. If two knocks per flash occur, the noise is timed to the crankshaft speed. If one knock per flash occurs, the noise is timed to the camshaft.

If the noise is timed to the crankshaft speed, go to Step 2. If the noise is not timed to the crankshaft speed, go to Step 3.

2. If the noise is timed to the crankshaft speed, perform the following:
 - a. Remove the rod bearings and inspect the bearings and journals for wear.
 - b. If the parts are OK, remove the crankshaft and inspect the main bearings and journals for wear.
 - c. Replace the parts as necessary.

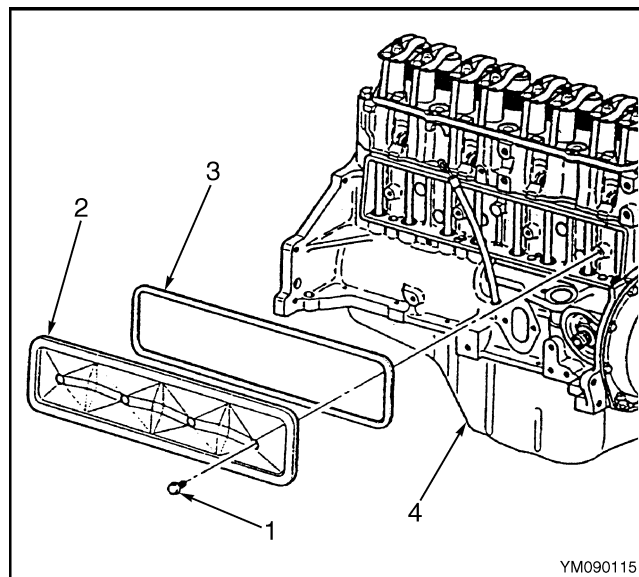
If the engine continues to knock, go to Step 3. If engine knocking has stopped, the system has been corrected.

3. Check to see if the noise is timed to the camshaft speed. If the noise is timed to the camshaft speed, go to Step 5. If the speed is not timed to the camshaft speed, go to Step 4.
4. If the engine speed is not timed to the camshaft speed, check for the following:
 - a. Inspect for loose accessory attachments. Inspect the flywheel.
 - b. Tighten or adjust as necessary.

If the engine continues to knock, go to Step 5. If the engine noise has stopped, the problem has been corrected.

5. If engine speed is timed to the camshaft speed, do the following:
 - a. Remove the push rod cover and gasket. See Figure 68.
 - b. Rotate the engine and measure the hydraulic valve lifter movement in the bore.
 - c. Compare the measurement with the specifications shown in the Engine Specifications section.

If the camshaft is within the specifications, go to Step 7. If the camshaft is not within the specifications, go to Step 6.



- | | |
|-------------------|------------|
| 1. BOLT | 3. GASKET |
| 2. PUSH ROD COVER | 4. OIL PAN |

Figure 68. Push Rod Cover Removal

6. Replace the camshaft. Refer to the section Camshaft Repair for the procedures to replace the camshaft.

If the engine continues to knock, go to Step 7. If the engine has stopped knocking, the system has been corrected.

7. If the engine continues to knock after replacing the camshaft, perform the following:
 - a. Remove the rocker arms, push rods, and hydraulic lifters. See the Cylinder Head and Valve Mechanism Repair section for the procedures.
 - b. Inspect the parts for excessive wear and damage.
 - c. Replace the parts as necessary.

Once the repairs are completed, the engine noise should be corrected, and the system should function properly.

Engine Specifications

ENGINE DATA

Number of Cylinders	4
Displacement	2965 cm ³ (181 in. ³)
Bore	101.60 mm (4.00 in.)
Stroke	91.44 mm (3.60 in.)
Compression Ratio	9.25:1
Firing Order	1-3-4-2
Idle Speed	775 to 825 rpm
Governor Speed (No Load)	2850 to 2950 rpm
Spark Plug Gap	1.1 mm (0.043 in.)

CYLINDER BORE

Bore Diameter	101.5873 to 101.6635 mm (3.9995 to 4.0025 in.)
Bore Out-of-Round Production	0.0254 mm (0.001 in.) Maximum
Bore Out-of-Round Service Limit	0.0508 mm (0.002 in.) Maximum
Bore Taper Thrust Side Production	0.0127 mm (0.0005 in.) Maximum
Bore Taper Thrust Side Service Limit	0.0254 mm (0.001 in.) Maximum
Bore Taper Relief Side Production	0.0127 mm (0.0005 in.) Maximum
Bore Taper Relief Side Service Limit	0.0254 mm (0.001 in.) Maximum
Runout - Rear Face of Block to Crankshaft Centeline	0.50 mm (0.02 in.) Maximum

PISTON

Piston-to-Bore Clearance	
Production	0.0635 to 0.0889 mm (0.0025 to 0.0035 in.)
Service Limit	0.0889 mm (0.0035 in.)

PISTON RINGS

Piston Compression Ring Groove	
Clearance Production Top	0.03048 to 0.07366 mm (0.0012 to 0.0029 in.)
Clearance Production 2nd	0.03048 to 0.07366 mm (0.0012 to 0.0029 in.)
Clearance Service Limit	0.09906 mm (0.0039 in.) Maximum
Piston Compression Ring Gap Top	
Production*	0.254 to 0.508 mm (0.01 to 0.02 in.)
*Measured in Cylinder Bore	

Service Limit*	0.88 mm (0.035 in.) Maximum
Piston Compression Ring Gap 2nd	
Production*	0.4318 to 0.635 mm (0.017 to 0.025 in.)
Service Limit*	0.88 mm (0.035 in.) Maximum
Piston Oil Ring Groove Clearance	
Production	0.0254 to 0.1524 mm (0.001 to 0.006 in.)
Service Limit	0.1778 mm (0.007 in.) Maximum
Piston Oil Ring Gap	
Production*	0.25 to 0.76 mm (0.01 to 0.03 in.)
Service Limit*	1.016 mm (0.04 in.) Maximum
*Measured in Cylinder Bore	

WRIST PIN

Diameter	23.545 to 23.548 mm (0.9270 to 0.9271 in.)
Clearance in Piston Production	0.00762 to 0.01651 mm (0.0003 to 0.00065 in.)
Clearance in Piston Service	
Limit	0.0254 mm (0.001 in.) Maximum
Fit in Piston Rod	0.02032 to 0.050292 mm (0.0008 to 0.00198 in.) Interference

CRANKSHAFT

Crankshaft Journal Diameter (All)	58.3666 to 58.4047 mm (2.2979 to 2.2994 in.)
Crankshaft Journal Taper	
Production	0.005 mm (0.0002 in.) Maximum
Service Limit	0.0254 mm (0.001 in.) Maximum
Crankshaft Journal Out-of-Round	
Production	0.005 mm (0.0002 in.) Maximum
Service Limit	0.0254 mm (0.001 in.) Maximum
Crankshaft Bearing Clearance Production	
Number 1 - Number 4	0.0254 to 0.06096 mm (0.001 to 0.0024 in.)
Number 5	0.0406 to 0.0889 mm (0.0016 to 0.0035 in.)
Crankshaft Bearing Clearance Service	
Limit Number 1 - Number 4	0.0254 to 0.0635 mm (0.001 to 0.0025 in.)
Limit Number 5	0.0381 to 0.0889 mm (0.0015 to 0.0035 in.)
Crankshaft End Play	0.05 to 0.1524 mm (0.002 to 0.006 in.)

Crankshaft Sprocket (Timing Gear)	
Runout	0.07 mm (0.003 in.) Maximum

PISTON ROD

Piston Rod Journal Diameter	53.2892 to 53.3273 mm (2.0980 to 2.0995 in.)
Piston Rod Journal Taper	
Production	0.00762 mm (0.0003 in.) Maximum
Service Limit	0.0254 mm (0.001 in.) Maximum
Piston Rod Journal Out-of-Round	
Production	0.005 mm (0.0002 in.) Maximum
Service Limit	0.0254 mm (0.001 in.) Maximum
Rod Bearing Clearance Production	0.04318 to 0.06858 mm (0.0017 to 0.0027 in.)
Rod Bearing Clearance	
Service Limit	0.0762 mm (0.003 in.) Maximum
Rod Side Clearance	0.1524 to 0.4318 mm (0.006 to 0.017 in.)

CAMSHAFT

Camshaft Journal Diameter	47.440 to 47.490 mm (1.8677 to 1.8697 in.)
Camshaft End Play	0.0762 to 0.2032 mm (0.003 to 0.008 in.)
Camshaft Sprocket (Timing Gear)	
Runout	0.1 mm (0.004 in.) Maximum
Timing Sprocket Teeth Backlash	0.10 to 0.15 mm (0.004 to 0.006 in.)
Lobe Lift Intake	6.4247 mm (0.25294 in.)
Lobe Lift Exhaust	6.4247 mm (0.25294 in.)
Lobe Lift Service Limit	±0.0254 mm (±0.001 in.) Maximum

HYDRAULIC VALVE SYSTEM

Valve Rocker Arm Ratio	1.75:1
Valve Lash	Half to One Turn Down From Zero Lash (Intake and Exhaust)
Face Angle	45 Degrees
Seat Angle	46 Degrees
Seat Runout	0.0508 mm (0.002 in.) Maximum
Seat Width Intake	1.27 to 1.778 mm (0.050 to 0.070 in.)
Seat Width Exhaust	1.524 to 2.032 mm (0.060 to 0.080 in.)
Stem Clearance Intake	

Production	0.0254 to 0.06858 mm (0.001 to 0.0027 in.)
Stem Clearance Exhaust	
Production	0.01778 to 0.06858 mm (0.0007 to 0.0027 in.)
Stem Clearance Intake Service	
Limit	0.09398 mm (0.0037 in.) Maximum
Stem Clearance Exhaust Service	
Limit	0.1193 mm (0.0047 in.) Maximum
Valve Spring Free Length	52.324 mm (2.06 in.)
Valve Spring Pressure Close	444 to 490 N (100 to 110 lbf) at 40.89 mm (1.61 in.)
Valve Spring Pressure Open	925 to 987 N (208 to 222 lbf) at 30.99 mm (1.22 in.)
Valve Spring Installed Height	
Intake	41.91 mm (1.65 in.)
Exhaust	41.91 mm (1.65 in.)
Valve Lift	
Intake	11.25 mm (0.443 in.)
Exhaust	11.25 mm (0.443 in.)

CYLINDER HEAD WARPAGE

Cylinder Head Deck - Measured Within a 152.4 mm (6.0 in.) Area	0.0762 mm (0.003 in.)
Cylinder Head Deck - Measuring the Overall Length of the Cylinder Head	0.1778 mm (0.007 in.)

LUBRICATION SYSTEM

Oil Pressure (Minimum - Hot)	124.1 kPa (18 psi) at 2000 rpm
Oil Capacity (With Oil Filter Change)	3.81 liter (4.00 qt)
Oil Pump Type	Gear Driven

COOLING SYSTEM

Thermostat	
Start to Open	82°C (180°F)
Fully Open	95°C (203°F)

Torque Specifications

Camshaft Retainer Bolts

9 N•m (80 lbf in)

Crankshaft Bearing Cap Bolts

75 to 95 N•m (55 to 70 lbf ft)

Crankshaft Rear Oil Seal Retainer Nuts

17 to 20 N•m (150 to 177 lbf in)

Cylinder Head Bolts

122 N•m (90 lbf ft)

Distributor Clamp Bolt

27 N•m (20 lbf ft)

Flywheel Bolts

88 N•m (65 lbf ft)

Front Cover Bolts

3 to 4 N•m (27 to 35 lbf in)

Ignition Coil Bracket Attaching Bolts

22 N•m (195 lbf in)

Intake to Exhaust Manifold Attaching Nuts and Bolts

27 to 34 N•m (20 to 25 lbf ft)

Intake/Exhaust Manifold to Head (2 Center)

27 to 34 N•m (20 to 25 lbf ft)

Intake/Exhaust Manifold to Head (Outer)

20 to 27 N•m (15 to 20 lbf ft)

Lift Bracket Bolts

27 to 41 N•m (20 to 30 lbf ft)

Oil Pan Nuts (Rear)

19 N•m (169 lbf in)

Oil Pan Bolts (to Crankcase)

9 N•m (80 lbf in)

Oil Pan Bolts (to Front Cover)

5 N•m (44 lbf in)

Oil Pan Drain Plug

24 N•m (18 lbf ft)

Oil Pan Studs to Oil Seal Retainer or Crankcase

2 N•m (18 lbf in)

Oil Pump Cover

8 N•m (71 lbf in)

Oil Pump to Engine Block

14 N•m (124 lbf in)

Oil Pump Pickup

7 N•m (62 lbf in)

Piston Rod Capnuts

61 N•m (45 lbf ft)

Push Rod Cover Bolts

5 N•m (44 lbf in)

Rocker Arm Cover Bolts

5 N•m (44 lbf in)

Spark Plugs

30 N•m (22 lbf ft)

Thermostat Housing Capscrews

20 N•m (177 lbf in)

Water Pump Bolts

20 N•m (177 lbf in)

Troubleshooting

PROBLEM	POSSIBLE CAUSE	PROCEDURE OR ACTION
When the ignition switch is in the START position, the starter does not operate.	The battery has a problem.	Install a new battery.
	The battery is not fully charged.	Charge the battery.
	The connections at the battery are loose or they have corrosion.	Clean and tighten the battery connections.
	The ignition switch has a problem.	Repair or install an ignition switch.
	The starter system has a problem.	Check and repair the starter circuit.
	There are damaged parts in the engine.	Repair the engine.
The engine will not start.	The fuel tank is empty.	Fill the fuel tank.
	The battery is not fully charged.	Charge the battery.
	The valves are worn or damaged.	Repair the valves.
	The piston rings are worn or have damage.	Install new piston rings.
	The ignition system has a problem.	Check and repair the ignition system.
	The fuel system has a problem.	Check and repair the fuel system.
The engine does not run smoothly.	The valve mechanism does not operate correctly.	Repair the valve mechanism.
	The head gasket has a leak.	Install a new head gasket.
	The cylinder head has cracks.	Install a new cylinder head.
	There is a leak in the intake system.	Install new gaskets at the intake manifold.
	The spark plugs have a problem.	Install new spark plugs.
	The ignition system has problems.	Repair the ignition system. See the Electrical System section for your lift truck model for the ignition system repair procedures.

PROBLEM	POSSIBLE CAUSE	PROCEDURE OR ACTION
The engine does not have enough power.	The air filter is dirty.	Clean or install a new air cleaner.
	The fuel is the wrong type.	Drain and fill fuel tank with the correct fuel type.
	The ignition timing is not correct.	Check timing.
	The valve mechanism does not operate correctly.	Repair parts of valve mechanism.
	The piston assemblies are worn or damaged.	Install new pistons.
	The spark plugs are the wrong type or they are not installed correctly.	Install new spark plugs.
	The valve timing is not correct.	Check valve mechanism.
	The exhaust system has restrictions.	Clean or repair exhaust system.
There is noise inside the engine.	The main bearings are worn or damaged.	Install new bearings.
	The bearings for the piston rods are worn or damaged.	Install new bearings.
	The pistons are worn or damaged.	Install new pistons.
	The engine is too hot.	Check the cooling system.
	There is not enough oil in the engine.	Fill the engine to the correct level.
	The flywheel is loose.	Tighten the capscrews for the flywheel.
	A piston rod is bent.	Repair the engine.
	There is a leak in the exhaust system.	Repair the exhaust system.
	A valve lifter has a problem.	Check the valve lifters.
	The valve mechanism does not operate correctly.	Repair the valve mechanism.

PROBLEM	POSSIBLE CAUSE	PROCEDURE OR ACTION
There is noise in the engine during acceleration.	The spark plugs are dirty.	Install new spark plugs.
	The spark plugs are the wrong type.	Install the correct spark plugs.
	The ignition timing is not correct.	Check the timing.
	The fuel is the wrong type.	Fill the tank with the correct fuel.
	There is too much carbon in the combustion chamber.	Clean the cylinder head and pistons.
	The engine is too hot.	Check the cooling system.
The engine gets too hot.	There is not enough coolant in the cooling system.	Fill cooling system with coolant.
	The belt for the water pump is worn or not adjusted correctly.	Adjust drive belts.
	The thermostat has damage.	Install a new thermostat.
	The cooling system has restrictions.	Clean the cooling system parts.
	The water pump has damage.	Install a new water pump.
	The radiator is dirty.	Clean the radiator.
	The exhaust system has restrictions.	Clean or replace the parts of the exhaust system.
The bearings in the engine are damaged.	There is not enough oil in the engine.	Fill engine with correct oil.
	The oil in the engine is the wrong type.	Fill engine with correct oil.
	The oil pump has damage.	Install a new oil pump.
	The piston rods have damage.	Install new piston rods.
	The camshaft is worn or damaged.	Install a new camshaft.
	The passages for oil have restrictions.	Clean oil passages.
	The bearings are not installed correctly.	Install new bearings.
	The oil in the engine is dirty.	Install a new oil filter and oil.

PROBLEM	POSSIBLE CAUSE	PROCEDURE OR ACTION
Engine makes knocking sound continuously for 2 to 3 minutes when turned off.	Engine flywheel is contacting the splash shield.	Reposition the splash shield.
	The crankshaft balancer or drive pulleys are loose or broken.	Tighten or replace as necessary.
	Excessive piston to bore clearance.	Replace the piston.
Engine makes knocking sound at startup, but sound only lasts a few seconds.	Incorrect engine oil type.	Drain and fill with the correct engine oil type. See the Periodic Maintenance section for the correct type of oil to use.
	Excessive piston-to-bore clearance.	Replace the piston.
	Excessive wrist pin-to-piston clearance.	Replace the piston.
	Excessive crankshaft end clearance.	Replace crankshaft.
	Excessive crankshaft bearing clearance.	Replace crankshaft bearings.
Engine makes knocking sound while idling (hot).	Detonation or spark knock.	Check the operation of the ignition controls or knock sensor circuit.
	Loose flywheel bolts.	Tighten bolts.
	Exhaust leak at the manifold.	Tighten the exhaust manifold bolts and/or replace the gasket.
	Excessive piston rod bearing clearance.	Replace the bearings as necessary.
	Excessive wrist pin clearance.	Replace wrist pin.
	Crankshaft thrust bearing clearance is not correct.	Replace crankshaft bearings.
	Bent piston rod.	Repair or replace piston rod.

