

SERVICE REPAIR

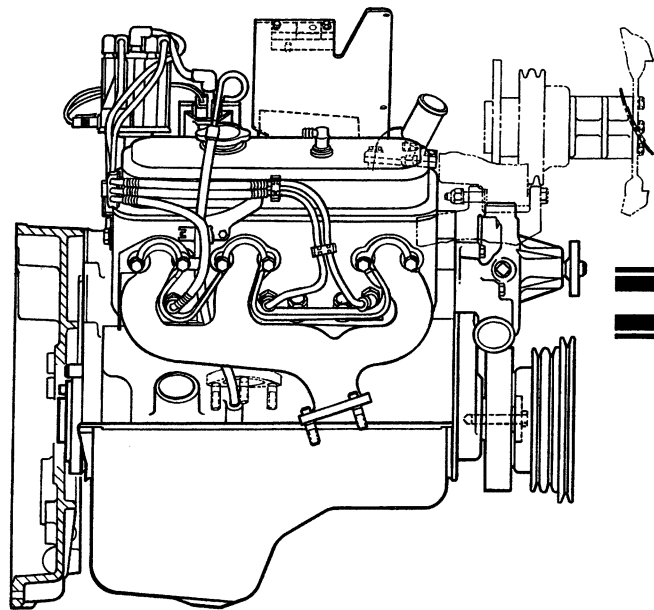
MANUAL

Hyster D004 (S70XL, S80XL, S100XL, S110XL,
S120XL, S120XLS) Forklift

HYSTER

GM ENGINES

4.3 litre V-6
5.7 litre V-8



HYSTER

SAFETY PRECAUTIONS

MAINTENANCE AND REPAIR

- When lifting parts or assemblies, make sure that all slings, chains or cables are correctly fastened and that the load being lifted is balanced. Make sure that 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 and working area clean and in order.
- 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 that all nuts, bolts, snap rings and other fastening devices are removed before using force to remove parts.
- Always fasten a **DO NOT OPERATE** sign to the controls of the unit when making repairs or if the unit needs repairs.
- Make sure you follow the **DANGER, WARNING** and **CAUTION** notes in the instructions.
- Gasoline, Liquid Petroleum Gas (LPG), and Diesel are flammable fuels. Make sure that you 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 has ventilation.

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manual**

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This section is for the following models:

H3.50-5.00XL (H70-110XL), S3.50-5.50XL (S70-120XL)
H6.00-7.00XL (H135-155XL), S6.00-7.00XL (S135-155XL),
H150-275H, P150-200B, M200-400H

GM 4.3 LITRE V-6 AND 5.7 LITRE V-8 ENGINES

This section has the description and the repair instructions for the GM 4.3 litre V-6 and the 5.7 Litre V-8 engines. Checks and Adjustments, Troubleshooting procedures and Specifications are also included in this section.

DESCRIPTION

The arrangement of the cylinders is in a "V" shape. The cylinder block is made of cast iron. The V-8 engine has five main bearings for the crankshaft. The V-6 engine has four main bearings.

The cylinder head is cast iron and has an intake valve and an exhaust valve for each cylinder. The valve mechanism is actuated by push rods and rocker arms from the camshaft.

The camshaft has five bearings on the V-8 and four bearings on the V-6. The camshaft is driven by a chain from the crankshaft. Hydraulic cam followers are used to actuate the push rods.

The pistons are made of cast aluminum and have two compression rings and one oil control ring.

ENGINE, REMOVAL AND INSTALLATION

The Removal and Installation procedures for the engine is in the section for THE FRAME for each model of lift truck. See the sections for the TRANSMISSION to separate the transmission from the engine.

CYLINDER HEAD

Removal And Disassembly (See FIGURE 1.)

WARNING

Disconnect the battery cables before making repairs to the engine.

1. Drain the coolant from the engine.
2. Disconnect and remove the coolant hose from the housing for the thermostat.
3. Remove the air cleaner, carburetor, distributor, intake manifold and the exhaust manifolds. Loosen the drive belts and remove the bracket for the fan mount from the cylinder heads.
4. Remove the rocker arm cover.

5. Remove the capscrews that hold the cylinder head to the block. Loosen the capscrews in the reverse order of the tightening sequence shown in FIGURE 5. Remove the cylinder head and the gasket.

6. Remove the nuts and balls for the rocker arms. Remove the rocker arms. Keep the parts for each rocker arm assembly together.

7. Use a valve spring compressor and remove the valves and springs. Put the valves in a rack so that they can be installed in their original positions.

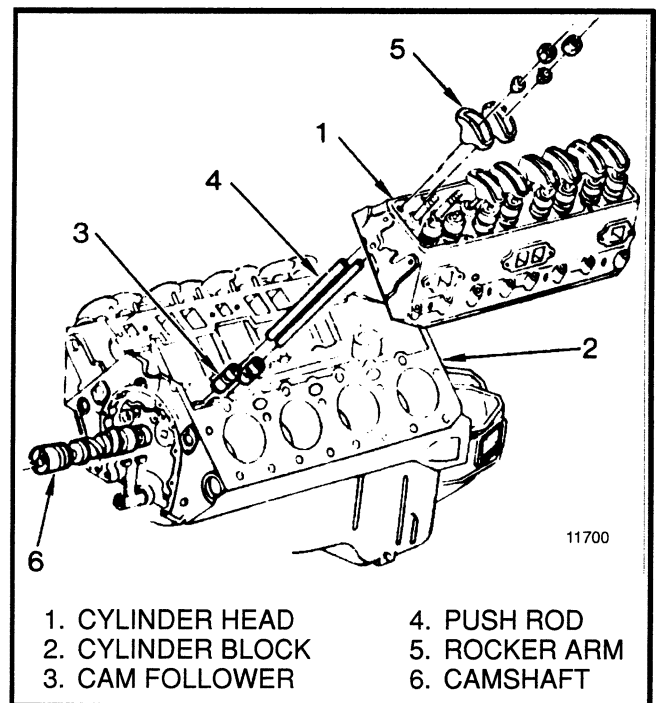


FIGURE 1. CYLINDER HEAD

Cleaning And Inspection

Clean the carbon from the ports and chambers in the cylinder head. Clean the carbon and oil from the valves, push rods and rocker arms.

Inspect the cylinder head for cracks in the ports and chambers. Inspect the valves for cracks in the heads or damaged stems.

Repairs, Valve Guides and Seats

Measure the clearance between the valve stem and the guide as shown in FIGURE 2. The maximum clearance for the intake valves is 0.094 mm (0.0037 in). The maximum clearance for the exhaust valves is 0.119 mm (0.0047 in). If the clearance is more than the maximum

amount, oversize valves must be installed. Use a reamer of the correct size when installing oversize valves. Use normal service procedures when grinding the valve seats. See the Specifications for dimensions.

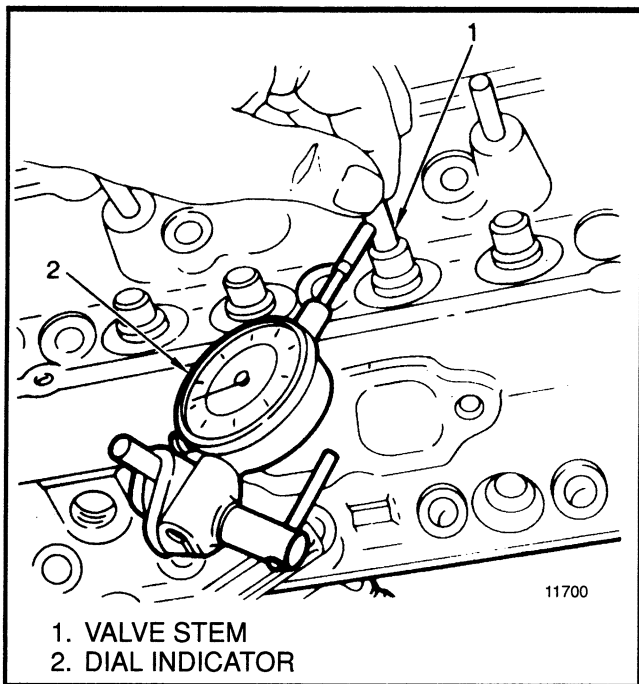


FIGURE 2. VALVE STEM CLEARANCE

Studs For The Rocker Arms

Replace a stud that has damaged threads or is loose in the cylinder head. New studs are available in the following oversizes: 0.003 inch and 0.013 inch.

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 3.

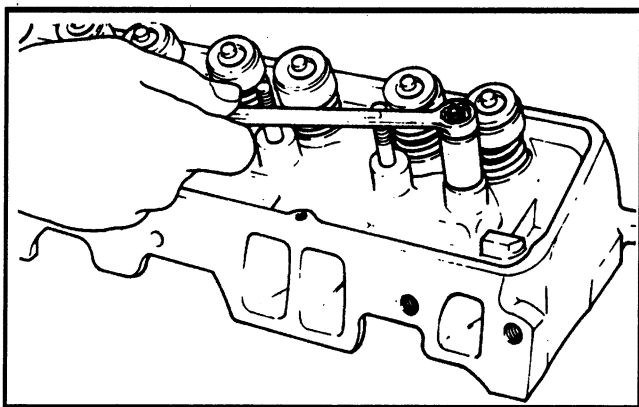


FIGURE 3. REMOVE A STUD FOR A ROCKER ARM

⚠ CAUTION

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

2. Use a reamer of the correct size for the new oversize stud. Apply SAE 90 lubricant to the new stud during installation. Install the new stud as shown in FIGURE 4.

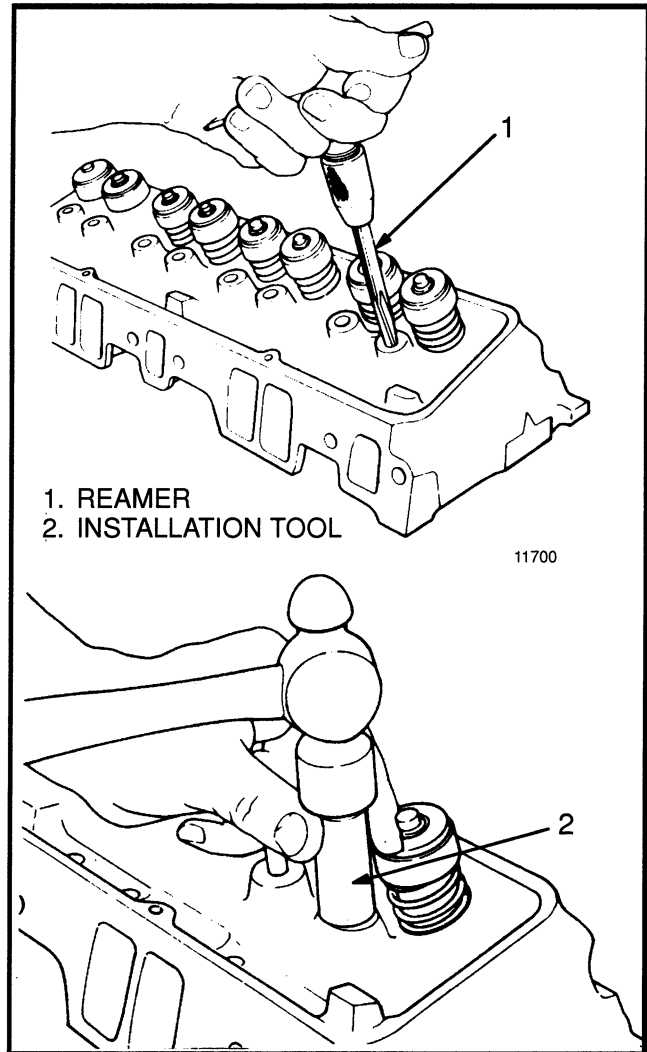


FIGURE 4. INSTALLATION OF A STUD FOR A ROCKER ARM

Valve Springs (See FIGURE 38.)

Use a special tool to check the tension of the valve springs. Compress the spring to the correct height and check the tension. See Specifications for the correct tension. Replace valve springs that are not within 44 N (10 lb_f) of specifications.

ASSEMBLY AND INSTALLATION

1. Install each valve in the correct port. Install the shim and valve springs. Compress the spring and install the oil seal in the lower groove. On the exhaust valves, install the valve rotators. Install the valve retainer cap and retainers. Measure the height of the valve spring as shown in FIGURE 38. Measure from the top of the shim to the top of the retainer cap. Install shims to get the correct height shown in Specifications. The installed height of the valve spring must not be less than the minimum height.

2. Clean the surface of the cylinder head and the top of the cylinder block. Make sure the threads in the block are clean.

3. Install the cylinder head gasket and cylinder head. If a steel gasket is used, use a sealant on both sides of the gasket. Do not use a sealant when a steel and asbestos gasket is used. Make sure the cylinder head is aligned with the pins in the block.

4. Use a sealant on the threads of the capscrews for the cylinder head. Install the capscrews and tighten them in steps until the final torque is reached. The final torque is 88 N.m (65 lb_f ft). Use the tightening sequence shown in FIGURE 5.

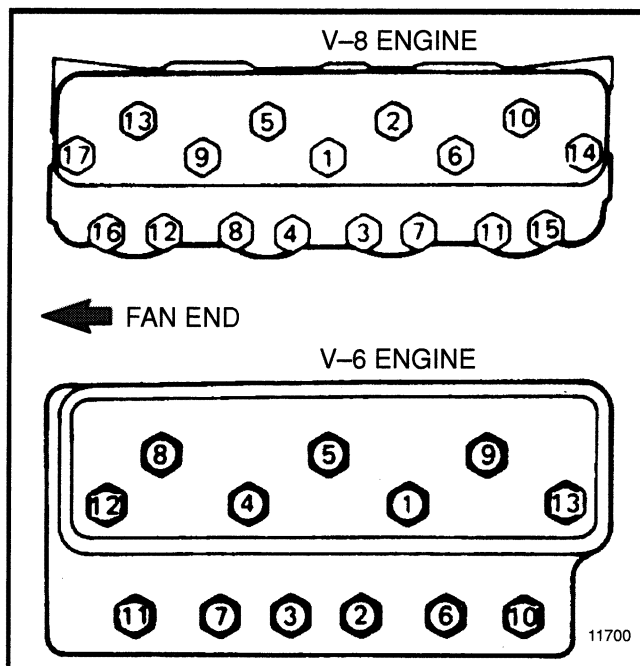


FIGURE 5. TIGHTENING SEQUENCE, CYLINDER HEAD

5. Install the intake manifold and gaskets. Tighten the capscrews in the sequence shown in FIGURE 6. On the V-6 engines, tighten the capscrews to 47 N.m (35 lb_f ft). On the V-8 engines, tighten the capscrews to 41 N.m (30 lb_f ft).

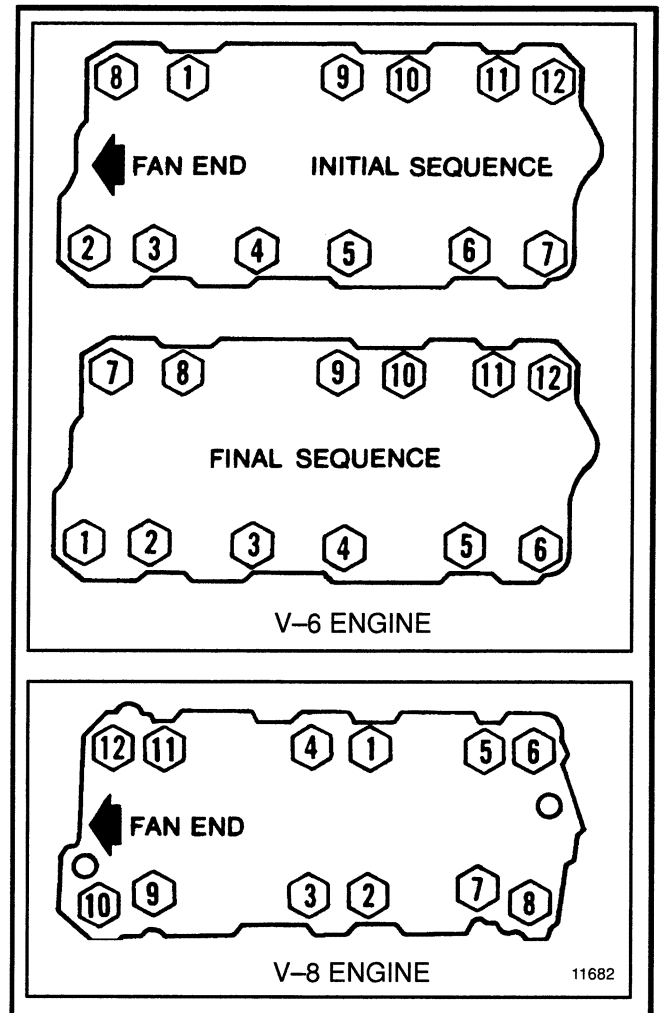


FIGURE 6. TIGHTENING SEQUENCE, INLET MANIFOLD

6. Install the push rods, making sure they are in the seat of the cam follower. Lubricate the rocker arms and rocker arm balls with a molybdenum grease. Install the rocker arms, balls and nuts. Tighten the nuts and adjust the valve clearance as described in Checks and Adjustments.

7. Use a new gasket and install each valve cover. On the V-6 engines, tighten the capscrews to 10 N.m (7 lb_f ft). On the V-8 engines, tighten the capscrews to 5 N.m (4 lb_f ft).

8. Install the exhaust manifolds. Use new gaskets when they are required. Do not use a sealant on the gaskets. On the V-8 engines, tighten all of the capscrews for the ex-

haust manifolds to 27 N.m (20 lb_f ft). On the V-6 engines, tighten the capscrews at the center port to 35 N.m (26 lb_f ft). Tighten the capscrews at the outer ports to 27 N.m (20 lb_f ft).

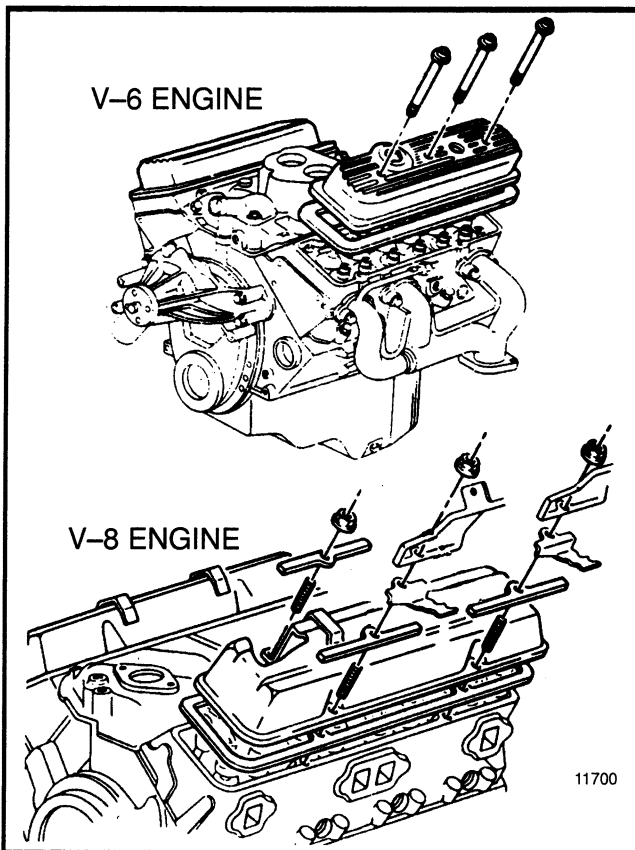


FIGURE 7. VALVE COVERS

9. Install the coolant hose to the housing for the thermostat. Fill the coolant system with coolant. See PERIODIC MAINTENANCE.

CYLINDER BLOCK, CLEANING AND INSPECTION

After the engine is disassembled, clean the cylinder block in solvent. Make sure all of the oil passages are clean. Remove the gaskets from the surface of the block.

Inspect the bores for the pistons for wear or damage. Measure the bores and check the dimensions shown in Specifications. Repair the cylinder block as necessary.

NOTE: It is important that the piston bores are prepared correctly before new piston rings are installed. Incorrect preparation can cause the parts to wear quickly.

PISTON BORE PREPARATION

Use a hone in the piston bores when installing new rings. Use the hone as follows:

1. Use a hone with a 280 grit stone. Make sure the stone is clean and will not damage the bore.
2. Move the hone quickly (approximately 60 times per minute) up and down in the bore. Make sure the hone makes a cross pattern of 45 to 60 degrees. Use the hone until the entire length of the bore has this pattern.
3. After using the hone, clean the cylinder block with hot water and detergent. Make sure all metal particles are removed from the block. Dry the bores and lubricate them with engine oil.

ENGINE MOUNTS

If the engine mount was removed from the cylinder block, tighten the capscrews for the mount as follows:

H3.50-5.00XL (H70-110XL), 31 N.m (23 lb_f ft);
H6.00-7.00XL (H135-155XL), 50 N.m (37 lb_f ft);
H150-275H, 50 N.m (37 lb_f ft).

LUBRICATION SYSTEM

Oil Pump, Removal and Disassembly (See FIGURE 8.)

1. Remove the oil sump.
2. Remove the capscrew at the mount for the pump. Remove the oil pump and shaft.
3. Remove the cover for the oil pump. Put marks on the gear teeth to show their correct location during assembly.
4. Do not remove the tube and screen assembly unless it is damaged. The tube and screen must be replaced as an assembly.

Cleaning and Inspection

Clean the parts of the oil pump in solvent and dry with compressed air. Inspect the gears, shaft and body of the pump for wear or damage. If any of the parts are worn or damaged the oil pump must be replaced. Separate parts are not available.

Oil Pump, Assembly and Installation (See FIGURE 8.)

NOTE: There are some variations in the oil pumps installed during the years of manufacture of these en-

gines, but the design is the same. The repair procedures are the same. See the **PARTS MANUAL** for each oil pump.

1. Use a sealant when replacement of the tube and screen 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 cylinder block.

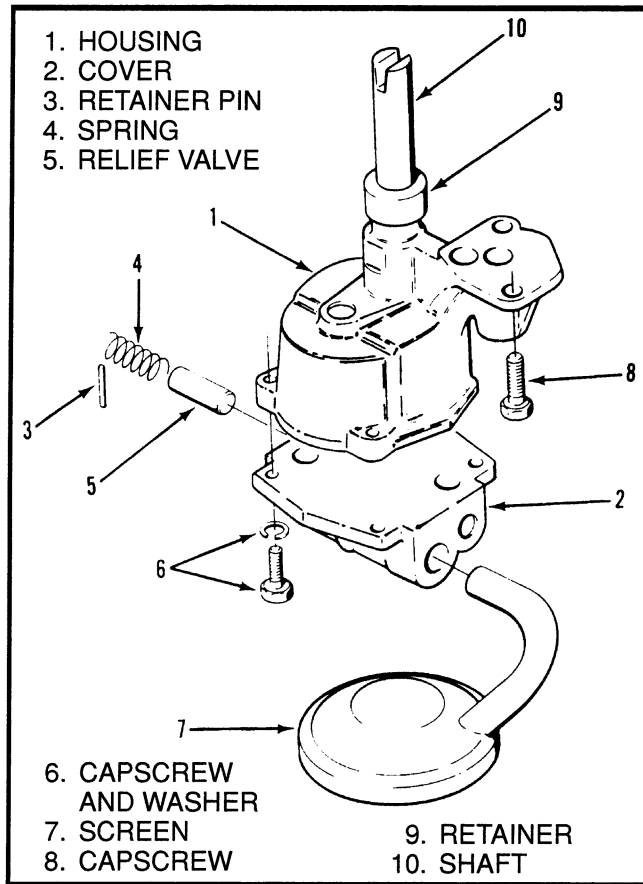


FIGURE 8. OIL PUMP

2. Install the gears in the body of the pump. Make sure to align the identification marks. Make sure that the smooth side of the idler gear is toward the cover. Install the cover for the oil pump and tighten the capscrows to 5 N.m (40 lb_f in). Turn the shaft for the oil pump and check for smooth operation.

3. Install the oil pump assembly to the engine. Make sure the shaft is aligned with the slot in the distributor shaft. Tighten the capscrow at the mount on the bearing cap to 47 N.m (35 lb_f ft).

4. Install new gasket(s) and the oil sump. Use a sealant on the gasket(s). Tighten the capscrows for the oil sump

as follows: 1/4–20 capscrows, 10 N.m (7 lb_f ft); 5/16–18 capscrows, 19 N.m (14 lb_f ft).

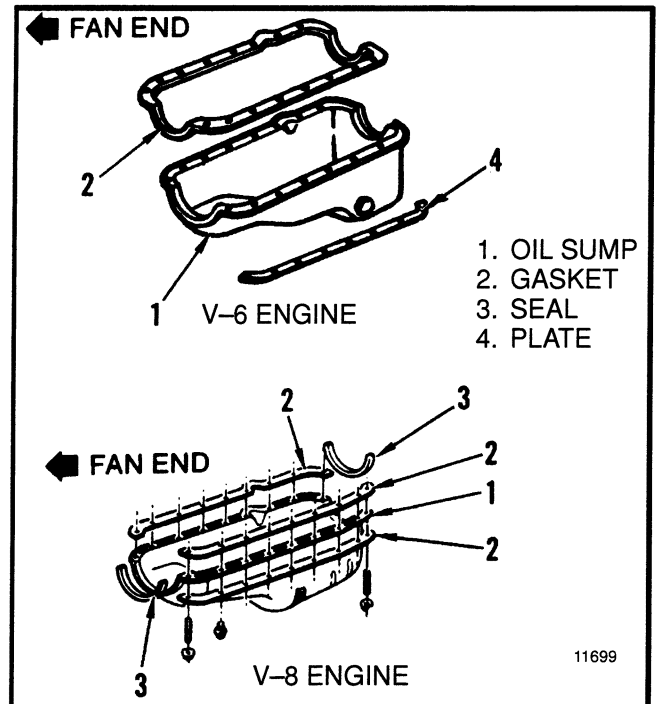


FIGURE 9. OIL SUMP

TIMING COVER, TIMING SPROCKETS, CAMSHAFT AND CAM FOLLOWERS

Timing Cover, Removal

1. Remove the fan assembly and belts. If installed, remove the drive shaft at the crankshaft pulley.

2. Remove the crankshaft pulley and vibration damper. Use a tool that pulls on the center of the vibration damper. Do not pull on the outside diameter of the vibration damper.

3. Remove the timing cover.

4. Carefully remove the oil seal from the cover.

Installation (See FIGURE 10.)

1. Install a new oil seal in the cover. Make sure the open side of the seal is toward the inside of the cover.

2. Use a sealant on the new gasket for the cover. During installation of the cover, use a special tool to align the oil seal with the crankshaft. The vibration damper will damage the oil seal if it is not installed correctly. Tighten the capscrows for the cover to 9 N.m (7 lb_f ft).

3. Use a special tool to install the vibration damper. Tighten the capscrow for the damper to 81 N.m (60 lb_f ft).

4. Install the crankshaft pulley, drive shaft, belts and fan assembly.

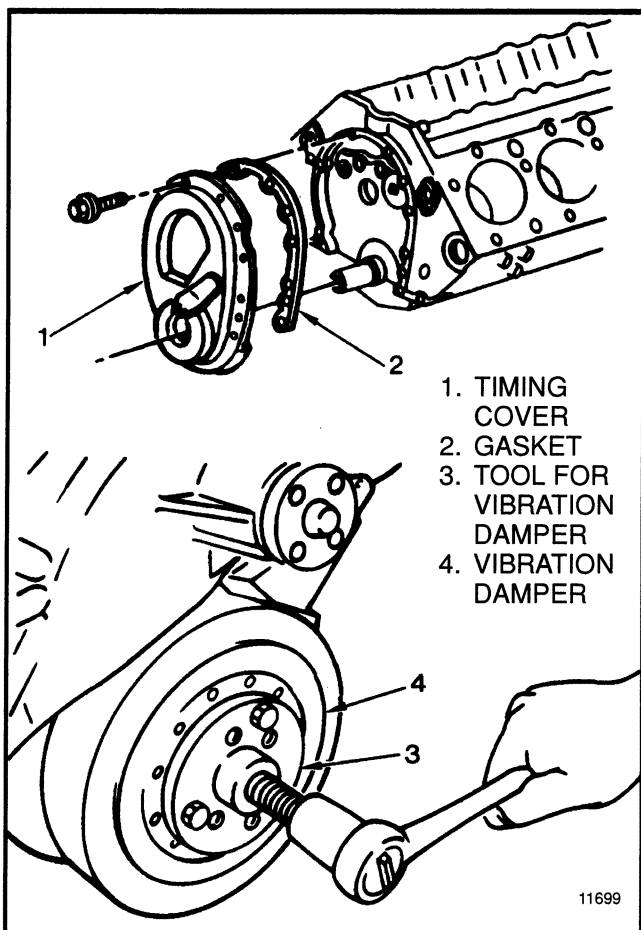


FIGURE 10. TIMING COVER

Timing Sprockets, Removal

Remove the timing cover. Remove the capscrews for the camshaft sprocket. Use a puller to remove the crankshaft sprocket. Make sure the timing chain is removed with the sprockets.

Timing Sprockets, Installation (See FIGURE 11.)

1. Install the chain on the camshaft sprocket. Install the camshaft sprocket and the crankshaft sprocket. Make sure the marks are aligned as shown in FIGURE 11. Tighten the capscrews to the camshaft sprocket to 27 N.m (20 lb_f ft).

2. Lubricate the chain and sprockets with engine oil. Install the timing cover.

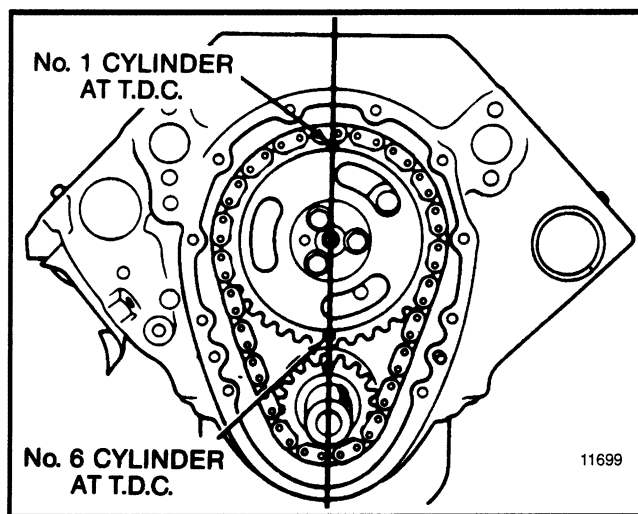


FIGURE 11. TIMING MARKS

Camshaft, Removal

1. Remove the intake manifold, push rods and cam followers. Remove the fuel pump.

2. Remove the timing cover. Align the timing marks and then remove the timing chain and sprockets.

3. Carefully remove the camshaft from the cylinder block. All of the camshaft bearings are the same size. Do not damage bearings or camshaft during removal.

4. If necessary, use a special tool as shown in FIGURE 12. to remove the camshaft bearings. Remove the front and rear bearings last.

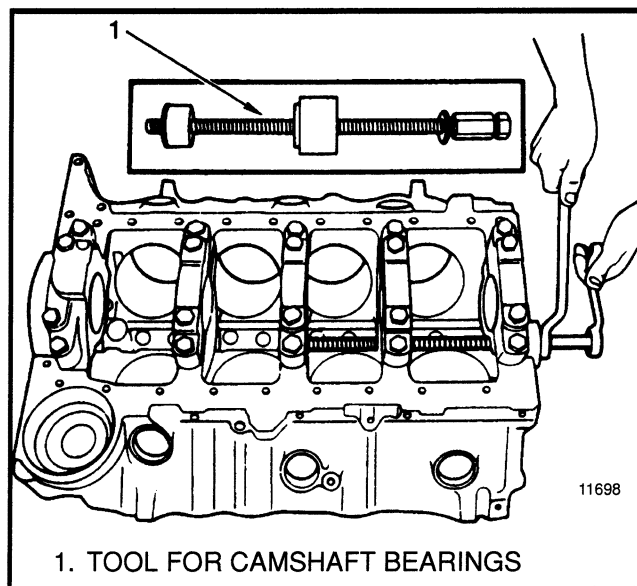


FIGURE 12. CAMSHAFT BEARINGS

Camshaft, Inspection

Measure the diameter of each bearing surface on the camshaft. Do the measurement at different positions on

the surface of the bearing to see if they are round. If the difference of the readings for each bearing is more than 0.025 mm (0.001 in), replace the camshaft.

Camshaft, Installation

1. Use a special tool as shown in FIGURE 12, to install the camshaft bearings. Install the front and rear bearings first. Make sure the oil holes in the bearings are aligned with the oil holes in the block. Use a sealant on the rear camshaft plug and install the plug in the block. Make sure the plug is even with or 0.80 mm (0.03 in) below the surface of the block.

2. Lubricate the camshaft lobes with a molybdenum lubricant. Lubricate the camshaft bearings with engine oil. Carefully install the camshaft in the cylinder block.

3. Install the timing sprockets, chain and cover as described in Timing Cover.

4. Lubricate the cam followers with a molybdenum lubricant. Install the cam followers in the block. Install the push rods and adjust the valve mechanism as described in Checks and Adjustments.

Hydraulic Valve Lifters, Removal

1. The hydraulic valve lifters normally do not need repair unless varnish or dirty engine oil has caused them to malfunction. The hydraulic valve lifters must be clean to operate correctly. If a hydraulic valve lifter must be disassembled, make sure the small parts are handled carefully to prevent loss or damage.

2. The push rods must be removed as described under "Cylinder Head, Removal". Remove the side cover from the cylinder block.

3. Remove the hydraulic valve lifters and put them in a rack so that they can be installed again in the same position in the engine.

Hydraulic Valve Lifters, Disassembly

1. See FIGURE 13. Hold the plunger (2) down with a push rod. Use the blade of a small screwdriver to remove the retainer for the push rod seat (7).

2. Remove the push rod seat (3) and the metering valve (6).

3. Remove the plunger (2), check ball assembly (5), and the plunger spring (4).

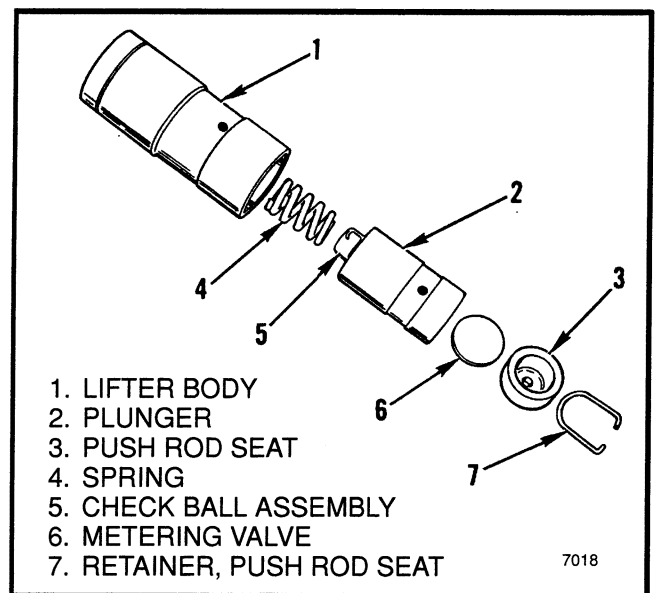


FIGURE 13. HYDRAULIC VALVE LIFTER

4. See FIGURE 14. Use a small screwdriver as a prybar to remove the check ball retainer from the plunger.

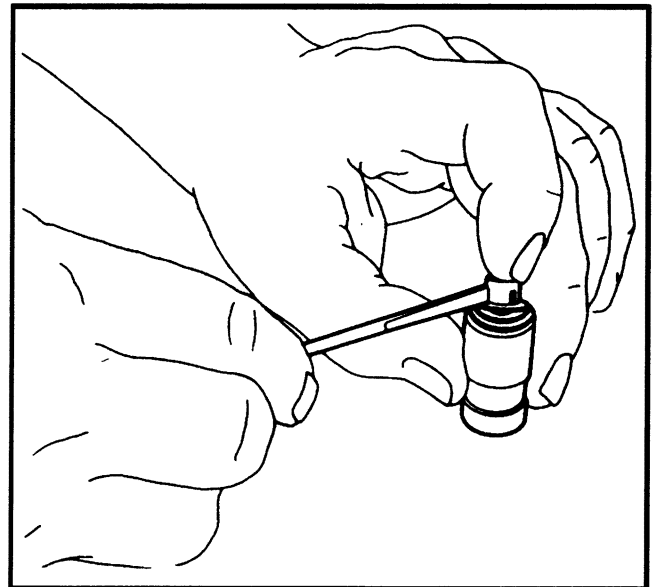


FIGURE 14. REMOVE THE CHECK BALL ASSEMBLY

Hydraulic Valve Lifters, Cleaning And Inspection

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 cylinder 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.

Hydraulic Valve Lifters, Assembly

1. Assemble the check ball assembly. Put the check ball on the small hole in the bottom of the plunger. Install the check ball spring in the seat of the check ball retainer. Put the check ball retainer over the check ball so that the check ball spring is on the check ball. Carefully press the check ball retainer into position in the plunger. See FIGURE 15.

3. See FIGURE 13. Put the plunger spring (9) over the check ball retainer (5) and slide the lifter body (1) over the spring and plunger.

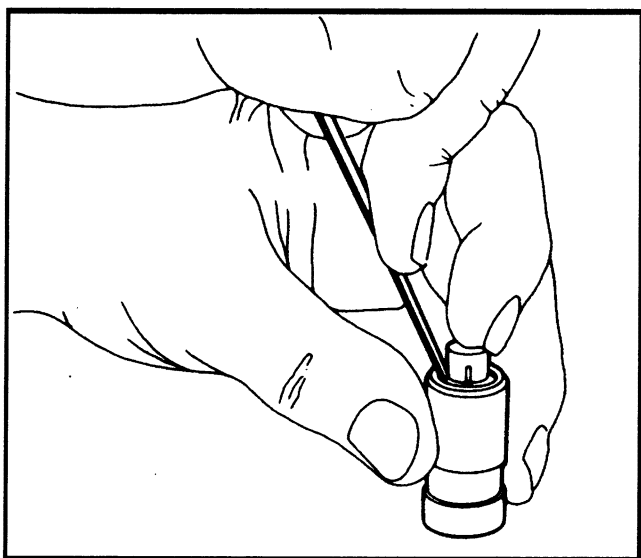


FIGURE 15. INSTALL THE CHECK BALL ASSEMBLY

4. Fill the assembly with SAE 10 engine oil. Put a 3 mm ($\frac{1}{8}$ inch) drift into the plunger and push the plunger until the holes for oil are aligned. See FIGURE 16. Now put a 1.6 mm ($\frac{1}{16}$ inch) drift through the holes to hold the plunger. Remove the 3 mm ($\frac{1}{8}$ inch) drift and fill the assembly again with SAE 10 oil.

5. Install the metering valve (3) and push rod seat (2). See FIGURE 13. Install the retainer, push rod seat (6). Push down the push rod seat to loosen the 1.6 mm ($\frac{1}{16}$ inch) drift and remove the drift. The hydraulic valve lifter is now ready for installation.

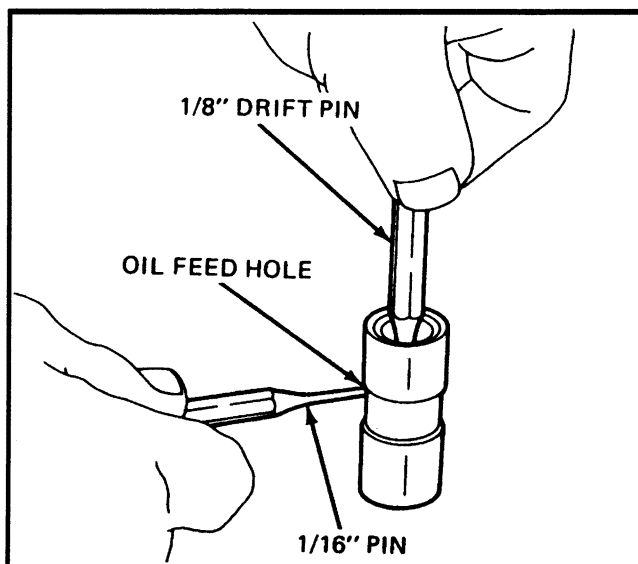


FIGURE 16. ASSEMBLY, HYDRAULIC VALVE LIFTER

CRANKSHAFT

Removal (See FIGURE 17.)

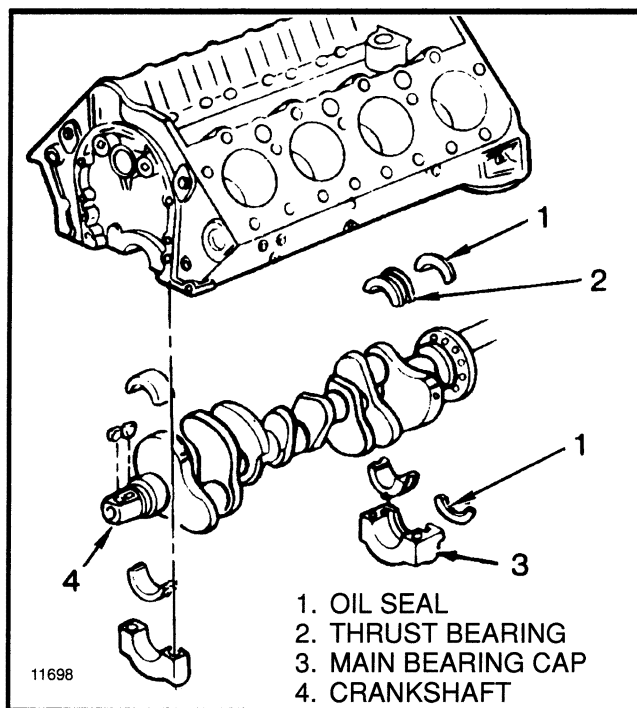


FIGURE 17. CRANKSHAFT

1. Remove the oil pan, oil pump and flywheel. On V-6 engines, remove the rear seal retainer.
2. Use a special tool to remove the vibration damper.
3. Remove the caps for the connecting rods.

4. Remove the caps for the main bearings. Make sure that there are identification marks on the caps during removal.
5. Carefully remove the crankshaft.

Inspection and Repair

1. Clean the crankshaft with solvent and dry it with compressed air.
2. Inspect the crankshaft for cracks or other damage.
3. Inspect the crankshaft for wear and damage. See FIGURE 18. Use a micrometer to measure the journals for the bearings of the crankshaft. Do the measurement at different positions to see if the surface of the bearing is round. The correct sizes are given in the ENGINE SPECIFICATIONS.

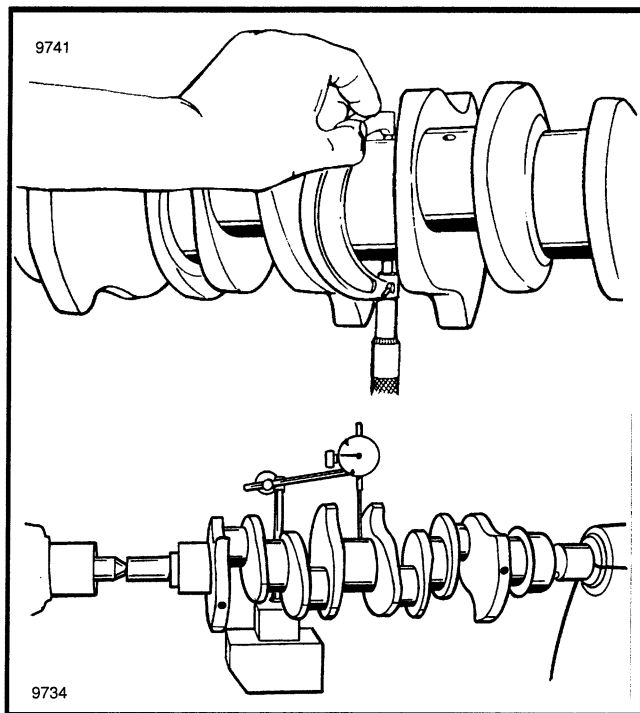


FIGURE 18. CRANKSHAFT INSPECTION

4. If the crankshaft journals must be repaired, they can be ground to the following diameters smaller (under-size) than the original size:
 - 0.25 mm (0.010 in)
 - 0.50 mm (0.020 in)

NOTES ABOUT MAIN BEARINGS: Main bearings are an insert bearing that does not use shims for adjustment. Main bearings are available in a standard size and the following undersizes: 0.001 in, 0.002 in, 0.009 in, 0.010 in, and 0.020 in. If a bearing on a journal is worn,

both the upper and lower half of the bearing must be replaced.

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 in under-size insert. This combination will decrease the clearance 0.0005 in from using a full standard bearing.

When a production crankshaft can not be fitted with this method, the main journal is then ground 0.009 in under-size. Only those main bearing journals that can not be fitted with standard, 0.001 in or 0.002 in undersize main bearing will be ground. A 0.009 in and a 0.010 in under-size bearings 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.

How To Check The Clearance Between The Main Bearings And Their Journals

1. Use PlastigageR or equivalent to check the clearance. The procedure is similar for both connecting rod bearings and main bearings. If the engine has been removed from the lift truck put 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 the specifications.
3. Check the rear main bearing first. Remove the cap for the rear main bearing. 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 21. Do not rotate the crankshaft when the Plastigage is between the main bearing and its journal.

5. Install the main bearing cap and tighten the capscrews. (See TORQUE SPECIFICATIONS FOR CAPSCREWS AND BOLTS.) 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 millimetres or thousandths of an inch. See FIGURE 22.

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 can not 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 the correct specifications.

9. Turn the crankshaft to make sure it rotates smoothly.

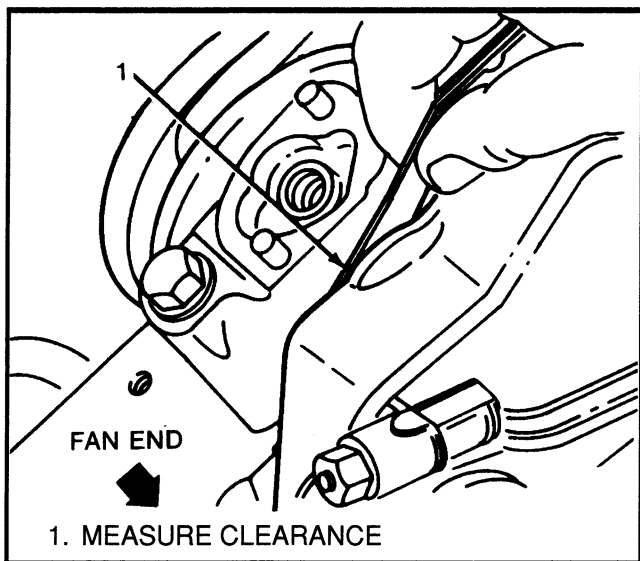


FIGURE 19. MEASURE THE AXIAL CLEARANCE OF THE CRANKSHAFT

10. Check the axial clearance between the rear main bearing and the thrust surface. Push the crankshaft forward. See FIGURE 19. Measure the clearance between the crankshaft and the thrust surface of the rear bearing. The correct clearance is 0.05 to 0.15 mm (0.002 to 0.006 inch).

Installation

1. On engines with a two-piece rear seal, install the seal halves so that the lips are towards the fan end of the engine. Apply engine oil to the seal during installation. Do not get any oil on the ends of the seal.

NOTE: With the use of special tools, the main bearings and the rear crankshaft seal (two-piece) can be replaced without removing the crankshaft.

2. Install the main bearings in the cylinder block and the bearing caps. Lubricate the bearings with engine oil and carefully install the crankshaft in the cylinder block.

3. Install the bearing caps. Make sure the arrows on the bearing caps are towards the front (fan end) of the engine. Push the crankshaft forward and measure the clearance at the front side of the rear main bearing. The correct clearance is 0.05–0.15 mm (0.002–0.006 in). (See FIGURE 19.)

4. On the V-6 engine, tighten the capscrews for the bearing caps to 70 N.m (52 lb_f ft). On the V-8 engines, tighten the capscrews for all of the bearing caps except the rear bearing cap to 95 N.m (70 lb_f ft). Tighten the capscrews for the rear bearing cap to 14 N.m (10 lb_f ft). Move the crankshaft forward and backward to align the rear main bearing. Tighten the capscrews for all bearing caps to 95 N.m (70 lb_f ft).

5. Install the connecting rods, oil pump and oil pan. Install the flywheel and other parts.

6. On late model engines with a one-piece seal, install the seal in the retainer. Use a sealant between the seal retainer and the cylinder block, then install the seal retainer (See FIGURE 20.)

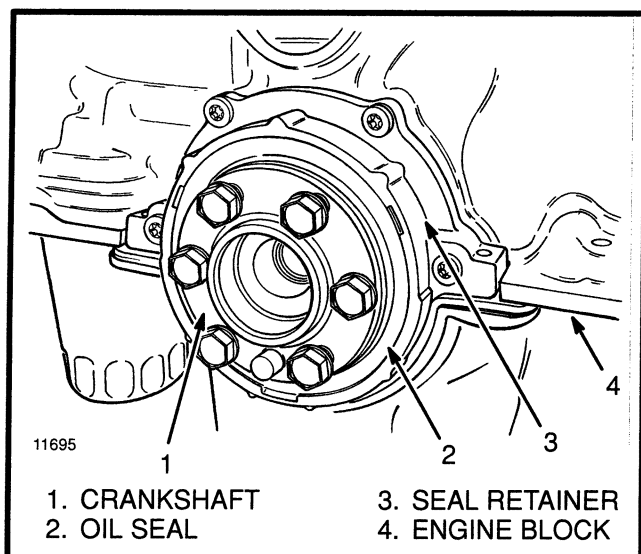


FIGURE 20. REAR SEAL

PISTON AND CONNECTING ROD ASSEMBLIES

Connecting Rod Bearings, Replacement

NOTE: Connecting rod bearings are insert bearings that do not use shims for adjustment. These bearings are available in a standard size and the following undersizes: 0.001 in, 0.002 in, 0.010 in, and 0.020 in. If a bearing on a journal is worn, both the upper and lower half of the bearing must be replaced.

1. Remove the oil sump and the oil pump.
2. Before the cap for the connecting rod is removed, mark the connecting rod and cap with the cylinder number so that the parts will be installed again in their original positions. Remove the cap for the connecting rod bearing and the lower bearing half.
3. Push the connecting rod away from the crankshaft and remove the upper bearing half. Wipe the oil from the bearing halves and the bearing journal.
4. Use a micrometer to measure the bearing journal. The bearing journal must be within the following specifications:

Out-of-round 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 can not be repaired so that the bearing journal is a correct under-

size, the crankshaft must be replaced. See the ENGINE SPECIFICATIONS, Crankshaft.

5. 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:

- a. Put a piece of Plastigage across the full width of the bearing journal as shown in FIGURE 21. Do not rotate the crankshaft when the Plastigage is between the bearing and its journal.

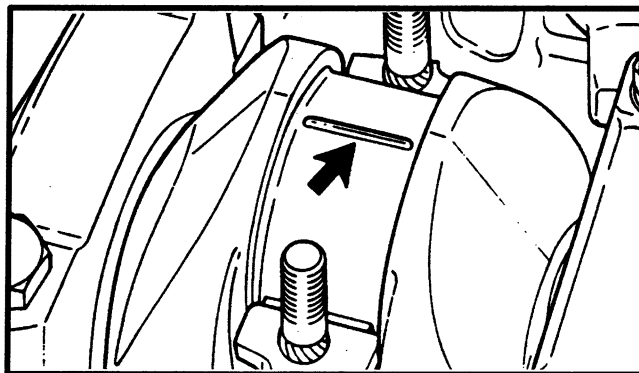


FIGURE 21. PLASTIGAGE® ON A BEARING JOURNAL

- b. Remove the 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 millimetres or thousandths of an inch. See FIGURE 22.

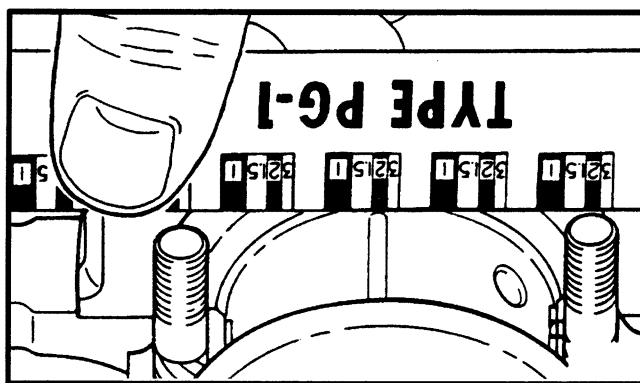


FIGURE 22. MEASURE THE PLASTIGAGE® ON A BEARING JOURNAL

- c. If the clearance is greater than the specifications, select a new undersize bearing set and install it. Measure the clearance again. If the clearance can not 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.

- d. 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. (See **TORQUE SPECIFICATIONS FOR CAPSCREWS AND BOLTS.**)

6. When all of the rod bearings have been replaced, use the following procedure to check the side clearances between the connecting rods and the crankshaft:

- a. Use a hammer to lightly hit the connecting rod parallel to the crankshaft journal to make sure there is a clearance.
- b. Measure the clearance between the caps for the connecting rods and the crankshaft. See **FIGURE 23.**

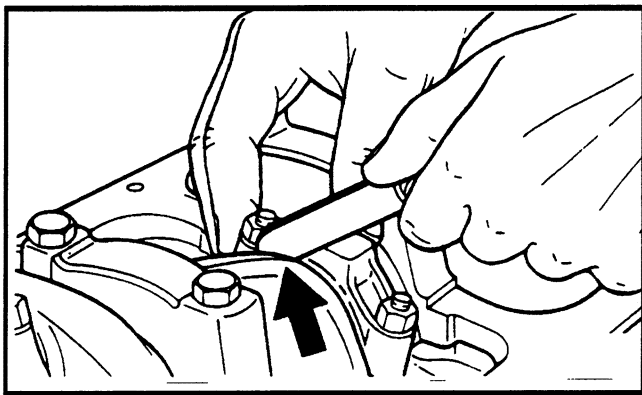


FIGURE 23. MEASURE THE SIDE CLEARANCE, CONNECTING RODS

Piston And Connecting Rod Assemblies, Removal

1. Remove the oil sump and the oil pump.
2. Remove the cylinder head as described in **Cylinder Head, Removal.**
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. Turn the crankshaft to lower the piston to the bottom of the stroke in its cylinder. Put a cloth on top of the piston for a collector of metal particles. Remove the ridge at the top of the cylinder.
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 connecting 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 connecting rod and piston from the cylinder. Temporarily install the bearing cap on the connecting rod to keep the parts together.

Disassembly

⚠ 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 piston pins from the piston. See **FIGURE 24.**

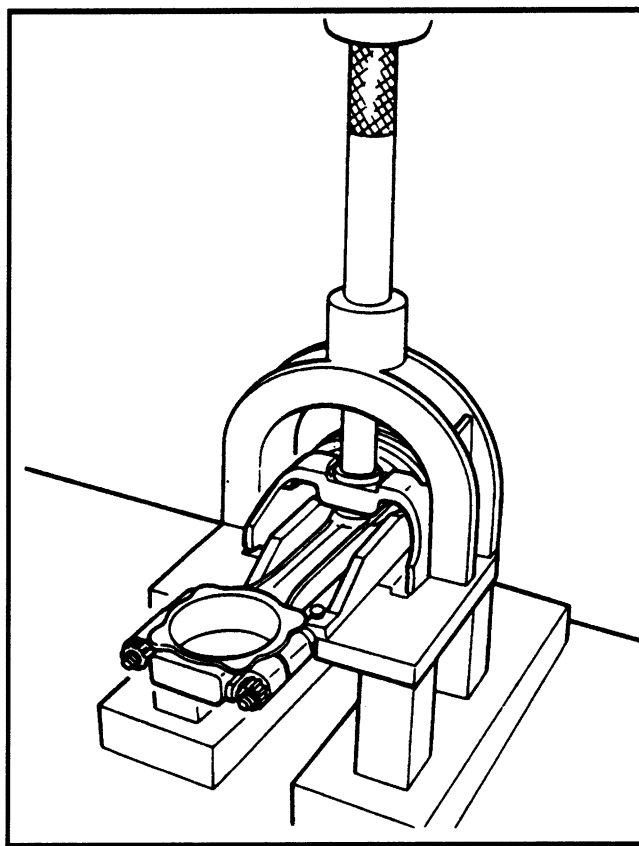


FIGURE 24. PISTON PIN REMOVAL

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

Piston, Cleaning And Inspection

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 piston pin in the piston. The normal clearance is shown in the ENGINE SPECIFICATIONS. The piston pin will normally fall from the hole in the piston by its own weight. The piston pin is a press fit in the connecting rod. The piston and piston pin are a matched set and must be replaced as a unit if the clearances are greater than the specifications.

Cylinder Bores, Inspection And Repair

Inspect the cylinder bores for wear and damage. Measure the cylinder bores in several positions as shown in FIGURE 25. 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.

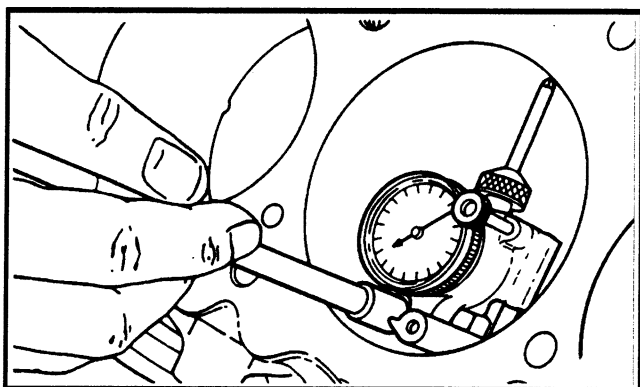


FIGURE 25. MEASURE THE CYLINDER BORE

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 26. 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. 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.

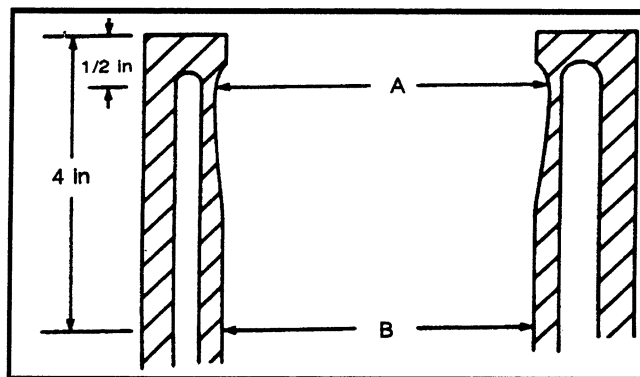


FIGURE 26. PATTERN FOR NORMAL CYLINDER WEAR

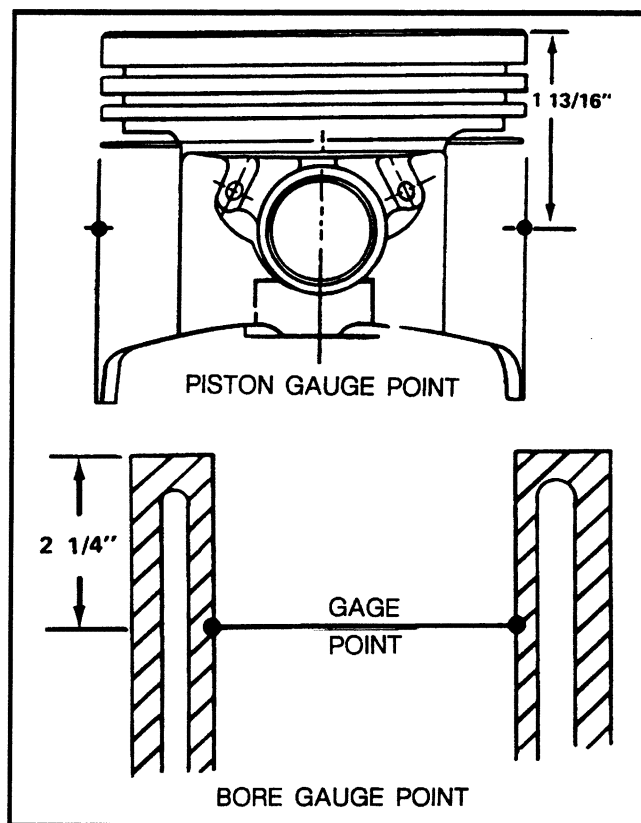


FIGURE 27. GAUGE POINTS FOR PISTON AND CYLINDER BORE

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