

Chapter Six

Multicylinder Engines

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This chapter covers the Yanmar 2GM, 2GM20, 3GM, 3GM30, 3HM and 3HM35 multicylinder, marine diesel engines.

The engine consists of a cast iron cylinder block with full-length water jackets around each cylinder. 2GM, 3GM, 3HM (including F and D series) engines have replaceable cast iron cylinder liners.

Crankshaft rotation is counterclockwise as viewed from the flywheel. On two cylinder engines, the crankshaft operates in three main bearings, with the center bearing providing the thrust surfaces. On three cylinder engines, the crankshaft operates in four main bearings, with the third bearing providing the thrust surfaces. The crankshaft gear drives the rotor-type oil pump located in the lower front of the engine block.

The camshaft is gear driven and located in the block above the crankshaft. One end of the camshaft is supported by a ball bearing (front) and the other rides directly in the block (rear).

On three cylinder engines, the camshaft is equipped with two additional bearings. In addition to operating the valves, the camshaft operates the fuel transfer pump and has an actuating lobe for the injection pump attached at the front.

Valve actuation is via mechanical lifters and pushrods acting on the rocker arms mounted in the cylinder head.

The cylinders on 2GM and 2GM20 engines are numbered from rear (flywheel) to front (timing gearcase): 1-2.

The cylinders on 3GM, 3GM30, 3HM and 3HM35 engines are numbered from rear (flywheel) to front (timing gearcase): 1-2-3. The firing order is 1-2-3.

Engine specifications (**Tables 1-3**) and tightening torques (**Table 4**) are located at the end of this chapter.

Refer to Chapter Five for diesel engine fundamentals.

NOTE

Except where specified, F and D series engines are included when a basic model number is specified. For example, if model 3GM is called out in a procedure, the procedure also applies to 3GMD and 3GMF.

ENGINE SERIAL NUMBER AND CODE

The engine serial number and model designation plate is attached to the timing gearcase (**Figure 1**). The engine serial number is also stamped on the side of the cylinder block (**Figure 2**).

Have the engine model number and serial number available when ordering parts. Record the engine model and serial numbers and store them for future reference in case the identification plate on the engine is defaced or lost.

REPLACEMENT PARTS

When installing new parts on the engine, make sure the part is designed for use on a marine engine. Automotive and marine engine parts may look similar; however, automotive parts may not be capable of operating in a harsh marine environment.

Use only Yanmar parts or parts approved for use on marine engines.

ENGINE

Precautions

Some service procedures can be performed with the engine in the boat; others require removal. The boat design and service procedure to be performed determines whether the engine must be removed.

WARNING

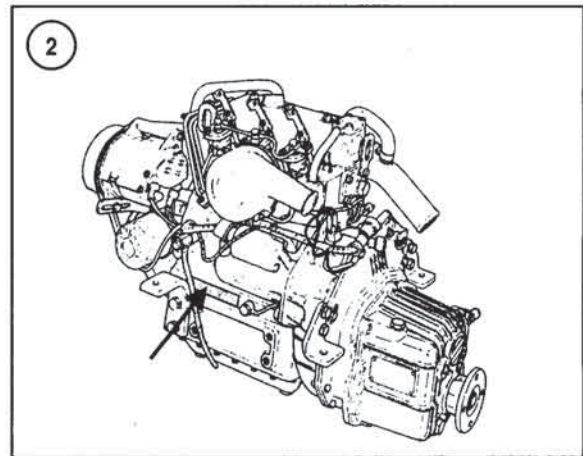
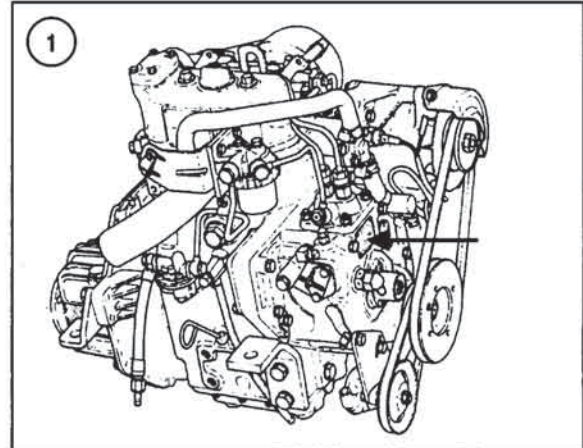
The engine is heavy, awkward to handle and has sharp edges. It may shift or drop suddenly during removal. To prevent serious injury, always observe the following precautions.

1. Never place any part of your body where a moving or falling engine may trap, cut or crush you.
2. If you must push the engine during removal, use a board or similar tool to keep your hands out of danger.
3. Be sure the hoist is designed to lift engines and has enough load capacity for the engine.
4. Be sure the hoist is securely attached to safe lifting points on the engine.
5. The engine should not be difficult to lift with a proper hoist. If it is, stop lifting, lower the engine back onto its mounts and make sure the engine has been completely separated from the vessel.

Removal/Installation

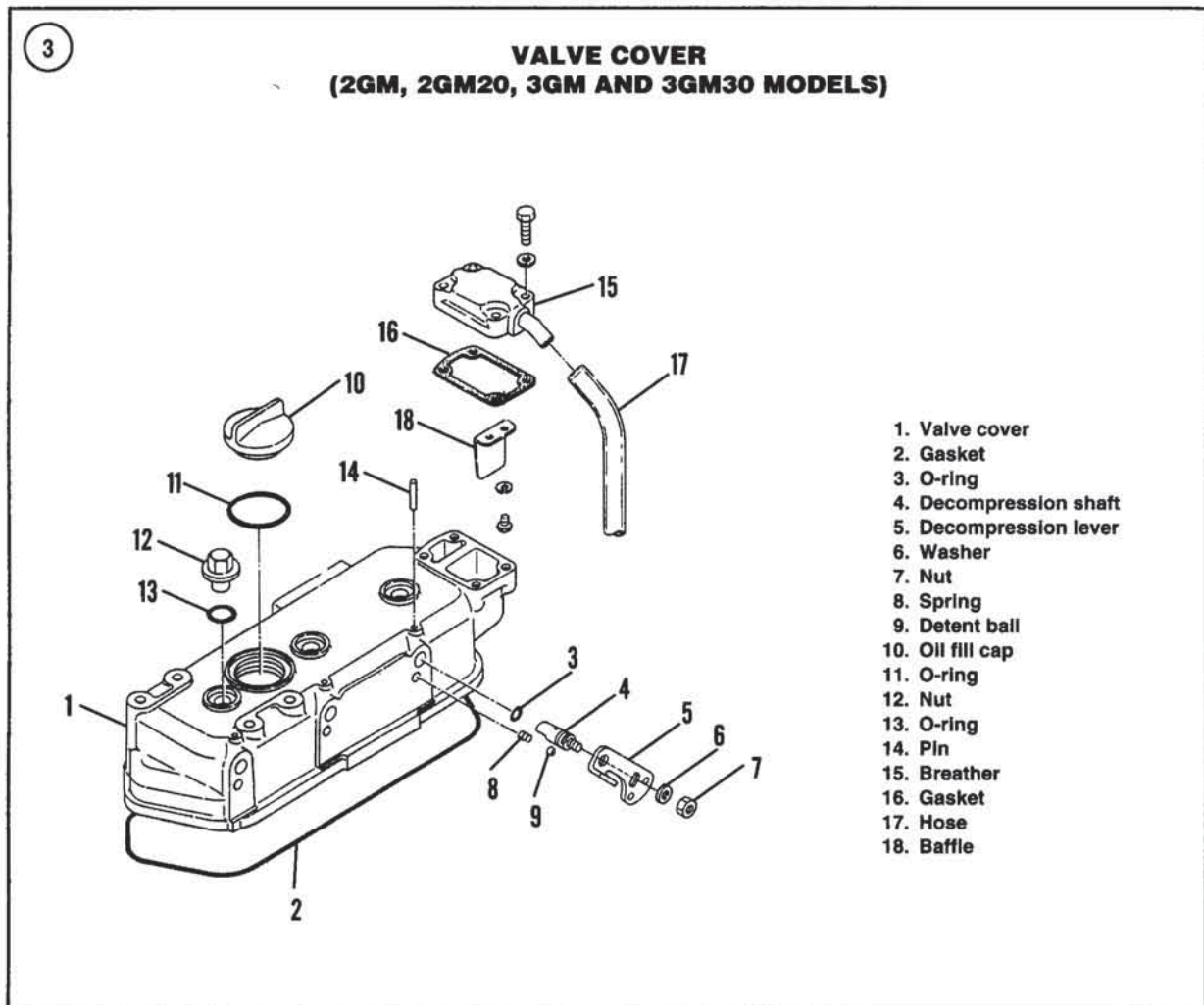
While specific procedures cannot address all engine installations, refer to the following general instructions when removing the engine.

1. Detach the negative battery cable from the negative battery terminal.
2. Close the seacock. Drain the cooling system, including



the freshwater system, if so equipped, as described in Chapter Four.

3. Disconnect the intake water hose from the seawater cooling pump.
4. Close the fuel shutoff valve and disconnect the fuel line and the fuel return line.
5. Disconnect the remote control cables.
6. Disconnect the electrical wiring harness connectors.
7. Disconnect the electrical wires from the electric starter motor and solenoid that will interfere with engine removal.
8. Detach the exhaust system.
9. Detach the driveshaft from the transmission output flange.
10. Remove the engine retaining bolts.
11. Remove the engine and transmission.
12. Remove the transmission from the engine as described in Chapter Ten or Eleven.



13. Engine installation is the reverse of removal, plus the following:

- a. Tighten the engine mounting bolts securely.
- b. Securely tighten the output flange-to-driveshaft bolts.
- c. Bleed the fuel system at the fuel filter as described under *Fuel Filter* in Chapter Three.
- d. Refill the freshwater cooling system, if so equipped, as described in Chapter Eight.

VALVE COVER

Refer to **Figure 3** and **Figure 4** for an exploded view of the valve cover assembly.

To remove the valve cover, proceed as follows:

1. Be sure the decompression lever is in the OFF position.

2. Disconnect the breather hose.

3. Unscrew the retaining nuts.

4. Remove the valve cover.

5. Remove the gasket.

6. Clean the gasket surfaces on the valve cover and cylinder head.

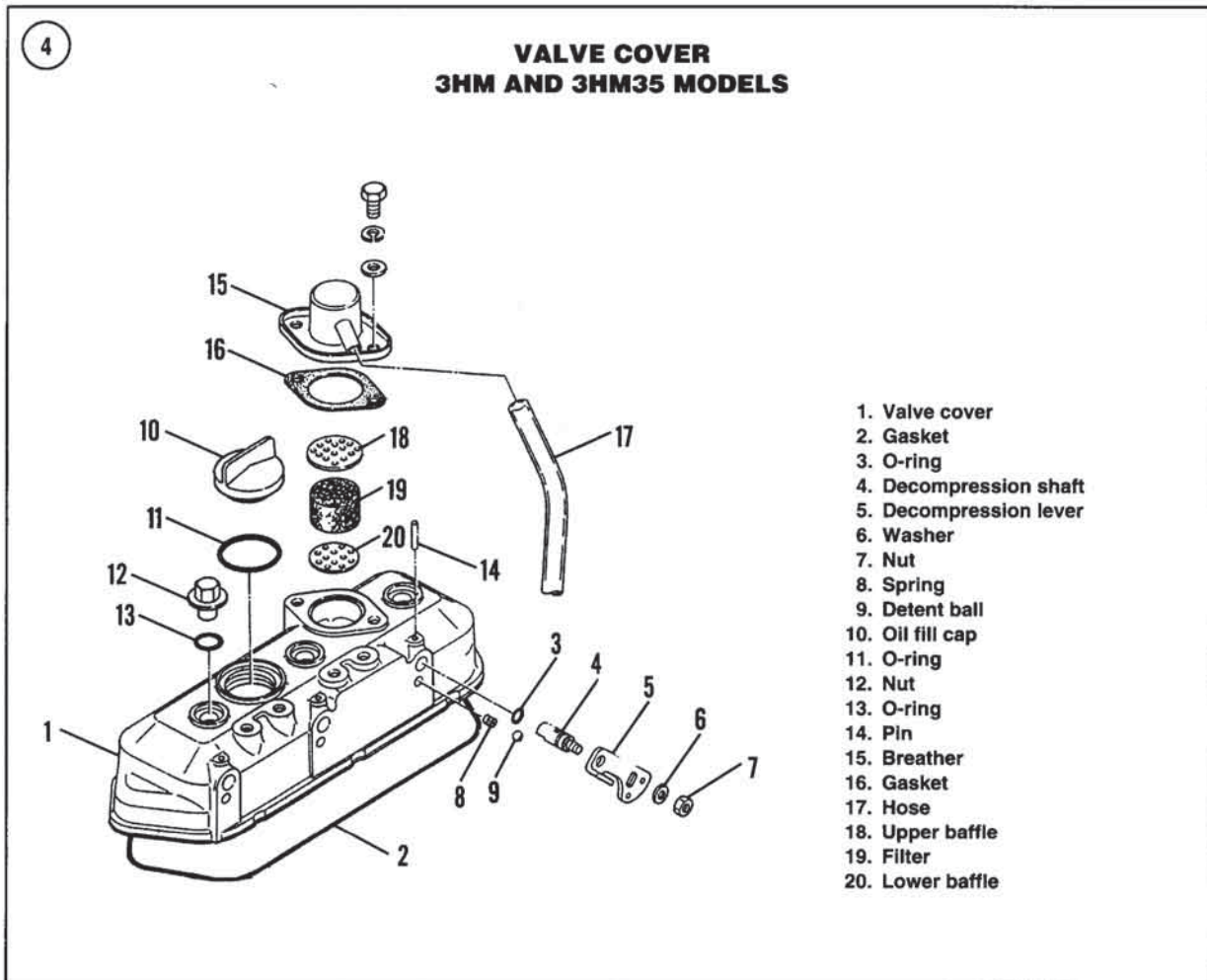
7. Reverse the removal steps to install the valve cover.

BREATHER ASSEMBLY

The crankcase breather is located in the valve cover. Refer to Chapter Three for a description of breather operation.

To service the breather, proceed as follows:

1. Remove the valve cover.
2. Remove the breather cover.



3. Clean the breather components and valve cover using solvent. Be sure the drain hole in the valve cover is open.
4. *3HM and 3HM35 models*—Replace the mesh breather element if it cannot be cleaned or if it is damaged.
5. Reassemble the breather by reversing the disassembly procedure. Note that the lower baffle (20, **Figure 4**) on 3HM and 3HM35 engines is smaller than the upper plate (18).

DECOMPRESSION MECHANISM

The decompression mechanism on the valve cover forces the exhaust valves open to reduce compression pressure in the cylinders. Reducing compression pressure enables the starter to rotate the crankshaft faster during starting. Refer to **Figure 3** and **Figure 4**.

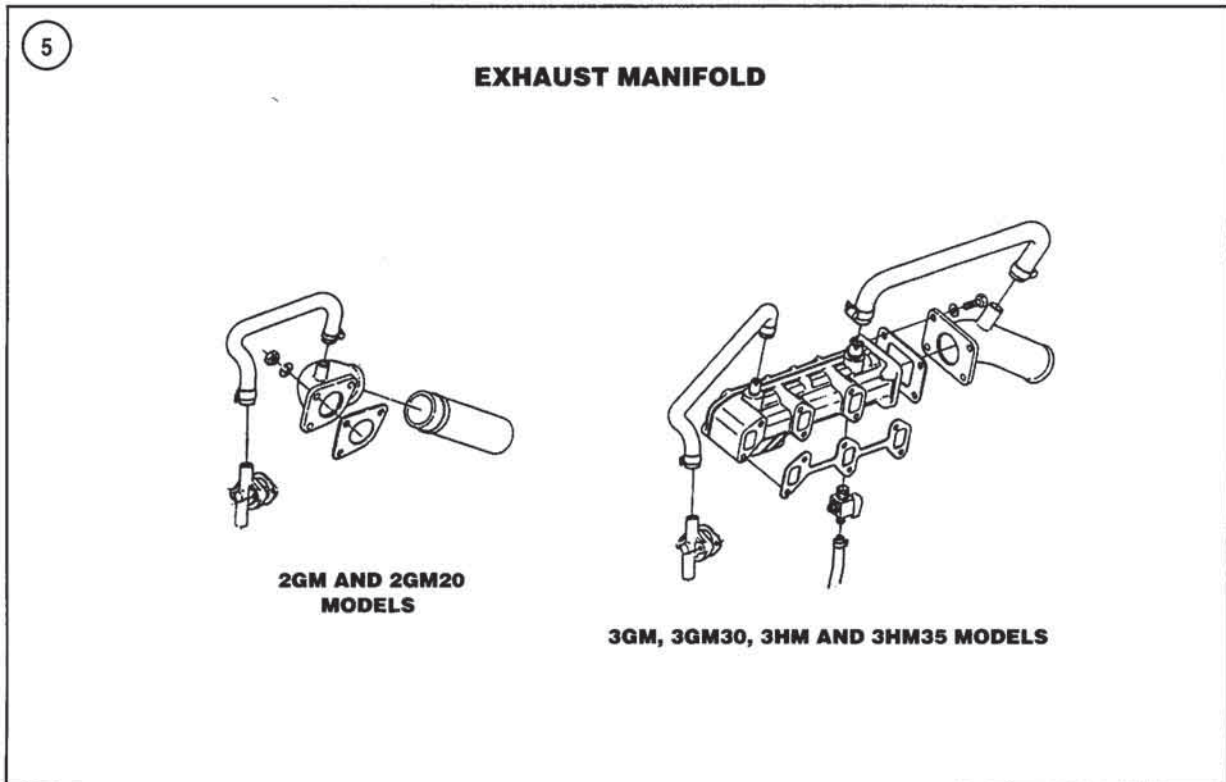
If the mechanism must be repaired, proceed as follows:

1. Remove the valve cover as previously described.
2. Using a suitable punch, drive out the retaining pin.

NOTE

The detent ball and spring will be loose when you remove the shaft assembly in Step 3.

3. Remove the shaft assembly from the valve cover.
4. Inspect the mechanism and replace the damaged parts.
5. Reverse the removal procedure to reassemble the decompression mechanism. Note the following:
 - a. Assemble the shaft and lever so the lever points up while the flat on the valve end of the shaft is down.



EXHAUST MANIFOLD

On 2GM models, the exhaust manifold is an elbow that is attached to the cylinder head (**Figure 5**). A hose from the thermostat cover directs cooling water into the exhaust elbow.

On 3GM models, the exhaust manifold contains water passages that allow water to cool the manifold. A hose from the thermostat cover directs cooling water into the exhaust manifold (**Figure 5**). A hose from the exhaust manifold directs water from the exhaust manifold into the exhaust elbow.

The exhaust manifold on 2GMF, 2GM20F, 3GMF, 3GM30F, 3HMF and 3HM35F models is combined with the coolant reservoir for the freshwater (closed) cooling system (**Figure 6**). Refer to Chapter Eight for a description of the freshwater (closed) cooling system.

Removal and Installation

2GM models

Refer to **Figure 5**.

1. Detach the exhaust hose from the exhaust elbow.

2. Loosen the hose clamps and remove the water hose from the exhaust elbow and thermostat housing.
3. Remove the exhaust elbow from the cylinder head.
4. Clean any gasket residue from the exhaust elbow and cylinder head.
5. Check the exhaust elbow for warpage, carbon buildup and corrosion.
6. Reinstall the exhaust elbow by reversing the removal procedure. Tighten the retaining nuts to the torque specified in **Table 2**.

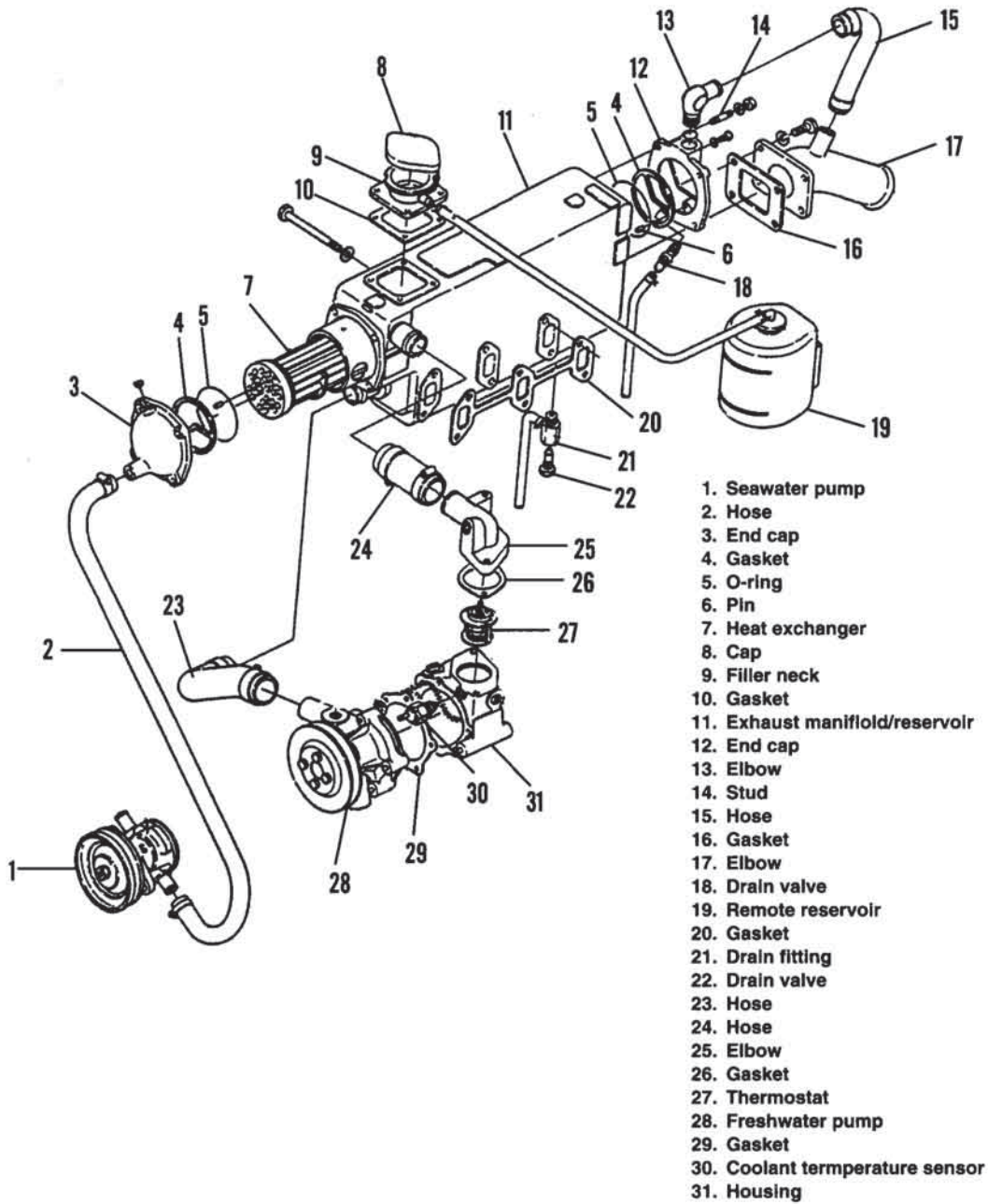
3GM, 3GM30, 3HM and 3HM35 models with seawater cooling

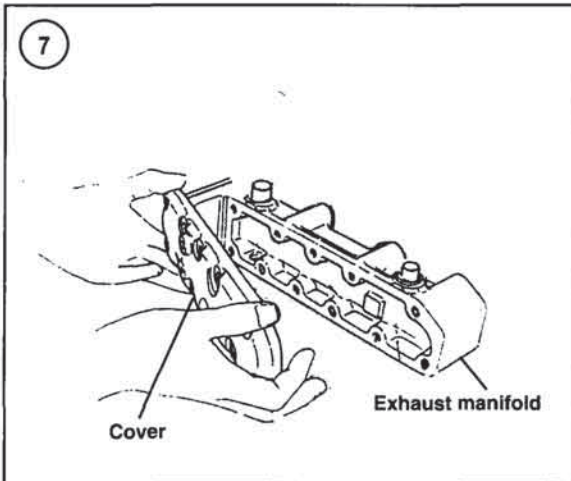
Refer to **Figure 5**.

1. Detach the exhaust hose from the exhaust elbow.
2. Loosen the hose clamps and remove the water hose from the exhaust manifold and thermostat housing.
3. Open the drain valve on the underside of the exhaust manifold.
4. Remove the exhaust manifold from the cylinder head.
5. If necessary, remove the water hose and exhaust elbow from the exhaust manifold.

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**EXHAUST MANIFOLD WITH CLOSED COOLING SYSTEM
(TYPICAL)**





6. Clean any gasket residue from the exhaust manifold and cylinder head.
7. Remove the exhaust manifold cover retaining screws and remove the manifold cover (**Figure 7**).
8. Inspect the exhaust manifold and cover for warpage, carbon buildup and corrosion.
9. Reinstall the exhaust manifold and cover by reversing the removal procedure. Tighten the retaining nuts to the torque specified in **Table 2**.

2GMF, 2GM20F, 3GMF, 3GM30F, 3HMF and 3HM35F models with freshwater (closed) cooling system

Refer to **Figure 6**.

1. Refer to Chapter Four and drain the cooling system.
2. Detach the exhaust hose from the exhaust elbow.
3. Remove the water hose from the exhaust manifold and thermostat housing.
4. Remove the water hose from the exhaust manifold and freshwater pump.
5. Disconnect the water hoses from the manifold end caps.
6. Disconnect the water hose to the overflow tank.
7. Remove the exhaust manifold from the cylinder head.
8. Clean any gasket residue from the exhaust manifold and cylinder head.
9. Check the exhaust manifold for warpage, carbon buildup and corrosion.
10. If necessary, refer to Chapter Eight to service the heat exchanger inside the exhaust manifold.
11. Reverse the removal procedure to install the exhaust manifold. Tighten the manifold bolts to the torque specified in **Table 2**. Fill the freshwater section of the closed

cooling system with coolant as described in Chapter Three.

CYLINDER HEAD

Removal

In some instances, the cylinder head may be removed for service without removing the engine. If engine removal is necessary, refer to the engine removal procedure. Refer to **Figure 8** for an exploded view of the cylinder head assembly.

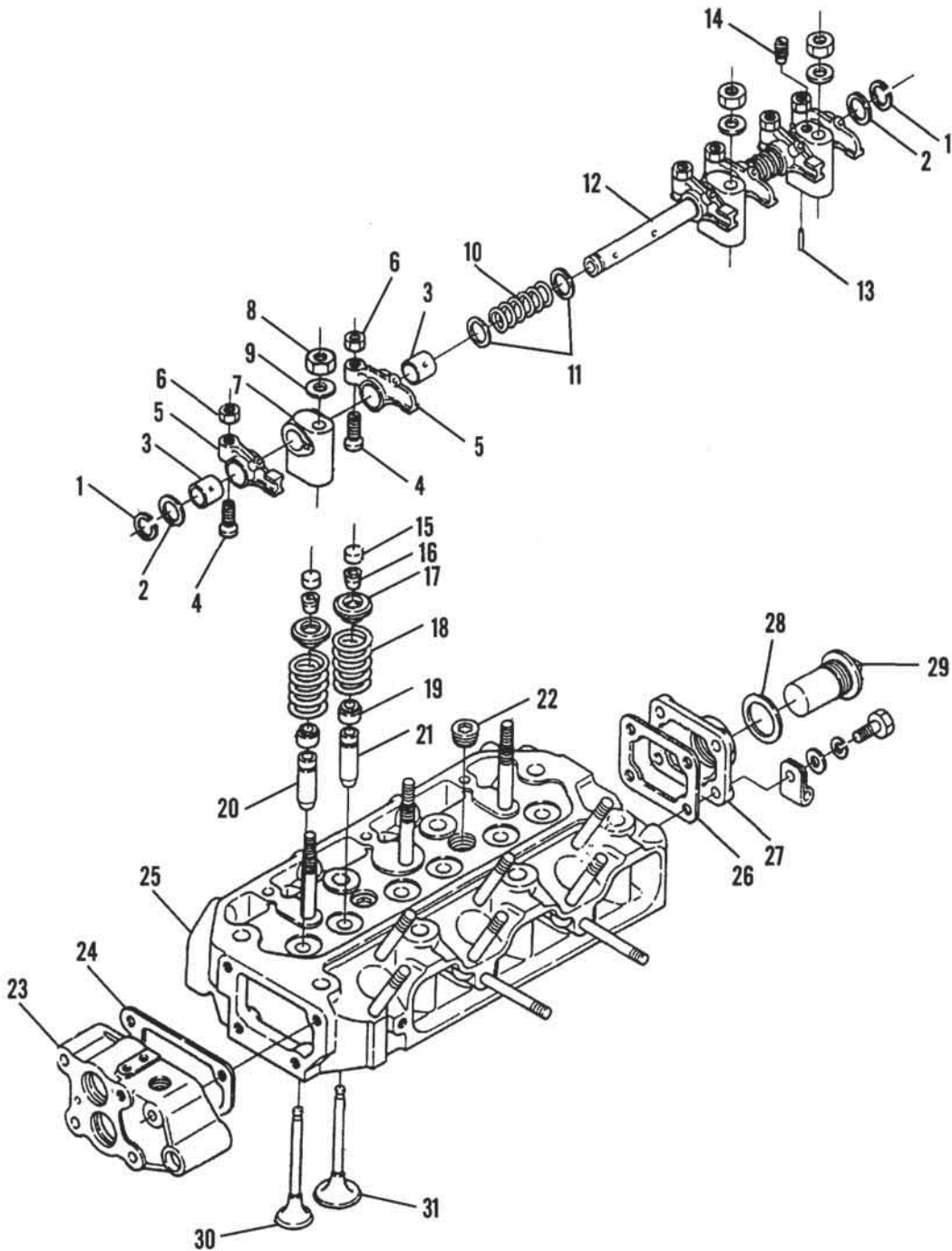
To remove the cylinder head, proceed as follows:

1. Disconnect the negative battery cable from the negative battery terminal.
2. If not previously performed, drain the cooling system as described in Chapter Four.
3. Remove the alternator as described in Chapter Eight.
4. Remove the exhaust manifold as previously described.
5. Disconnect the wire lead from the water temperature sender (**Figure 9**).
- 6A. *Engines with standard cooling*—Disconnect the lower water hose (**Figure 9**) from the thermostat housing.
- 6B. *Engines with freshwater (closed) cooling system*—Remove the freshwater pump as described in Chapter Eight.
7. Remove the air cleaner and the air cleaner base.
8. Remove the fuel injector and precombustion chamber as described in Chapter Seven.
9. Remove the valve cover as previously described.
10. Remove the nuts that retain the rocker arm stands (**Figure 10**), then remove the rocker shaft assembly.
11. Remove the push rods and mark them so they can be reinstalled in their original positions.
12. Detach the oil line fitting from the cylinder head.
13. Unscrew the smaller cylinder head retaining bolts first, then unscrew the larger bolts and nuts in a crossing pattern.
14. Remove the cylinder head and head gasket.

Inspection

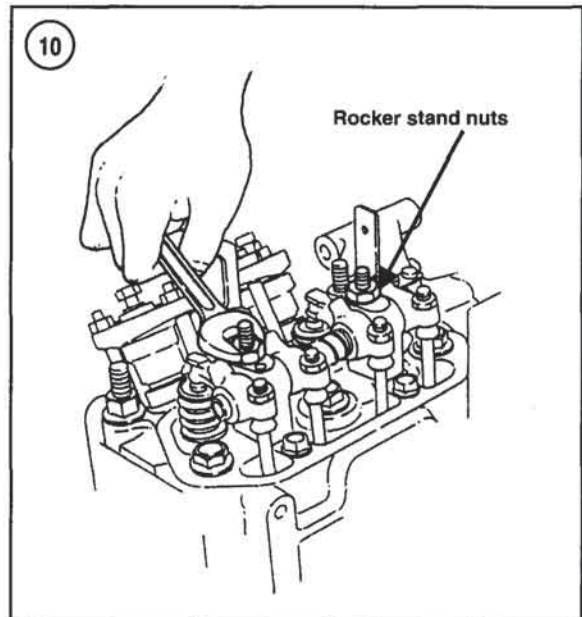
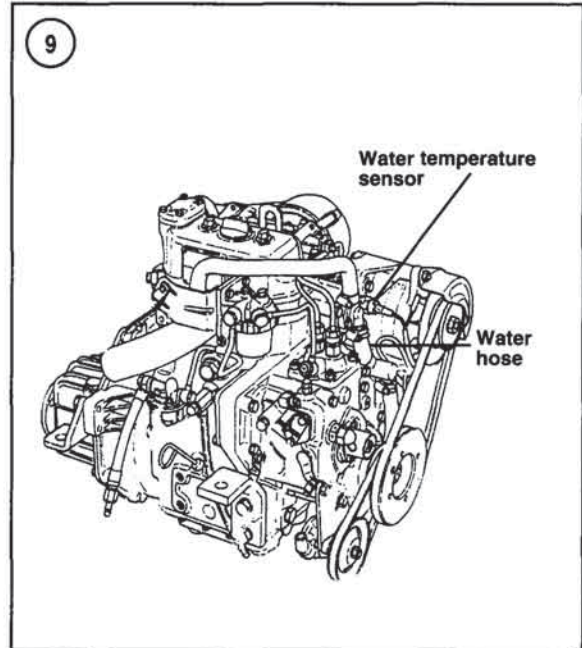
1. Refer to the *Anticorrosion Maintenance* section in Chapter Three. Remove and inspect the sacrificial anode. Install the anode in the cylinder head after completing cylinder head service.
2. If service to the valves or rocker assembly is required, refer to the *Valves* and *Rocker Assembly* sections.
3. Check the cylinder head for signs of oil or water leakage before cleaning. Look for corrosion or foreign material in the oil and water passages.

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CYLINDER HEAD

1. Snap ring
2. Washer
3. Bushing
4. Adjuster
5. Rocker arm
6. Nut
7. Rocker shaft stand
8. Nut
9. Washer
10. Spring
11. Washer
12. Rocker arm shaft
13. Pin
14. Locating screw
15. Wear cap
16. Keys
17. Valve spring retainer
18. Valve spring
19. Valve seal
20. Exhaust valve guide
21. Intake valve guide
22. Plug
23. Thermostat housing
24. Gasket
25. Cylinder head
26. Gasket
27. End cap
28. Washer
29. Sacrificial anode
30. Exhaust valve
31. Intake valve



4. Without removing the valves, remove all deposits from the combustion chamber. Use a fine wire brush dipped in solvent or make a scraper from hardwood. Be careful not to scratch or gouge the combustion chamber.

5. After all carbon is removed from the combustion chamber and ports, clean the entire head in solvent. While



cleaning, look for cracks or other visible signs of damage. Clean the passages with a stiff spiral brush, then blow them out with compressed air.

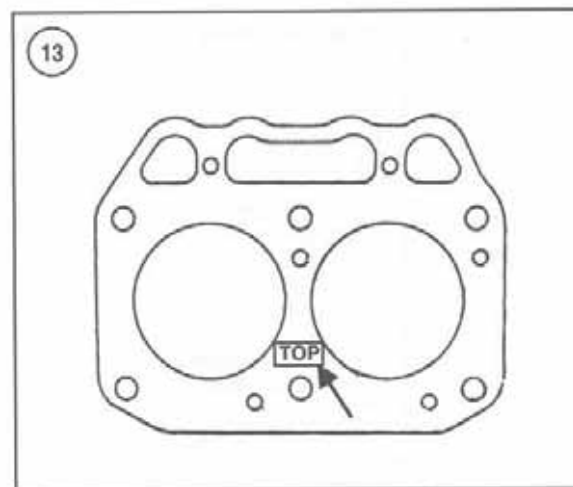
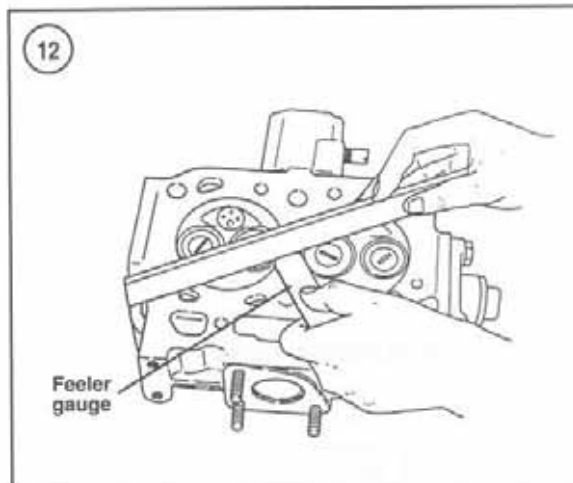
NOTE

If deposits are found in the intake or exhaust ports, remove the valves and clean the ports.

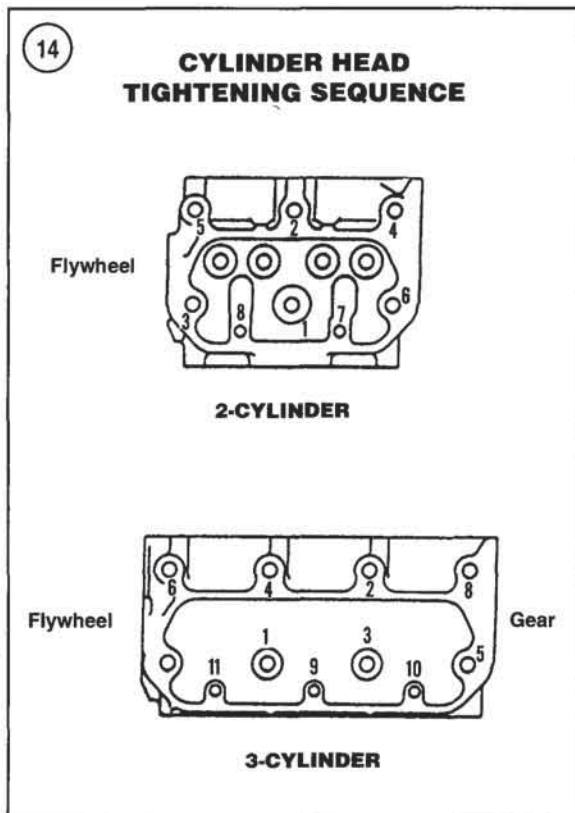
6. Clean away all carbon on the piston top.
7. Check the cylinder head studs for damage and replace them if necessary. If a stud is loose, tighten it using the following procedure:
 - a. Install two nuts on the stud as shown in **Figure 11**, typical.
 - b. Rotate the nuts so they contact each other, then hold one nut and tighten the other nut against the first nut.
 - c. Tighten the stud in the cylinder block by turning the top nut until reaching a torque of 60 N•m (44 ft.-lb.).
 - d. Hold the bottom nut, loosen the top nut, and remove both nuts.
8. Check the threaded rocker arm support stud for damaged threads. Replace if necessary.
9. Check for warpage of the cylinder head-to-block gasket surface with a straightedge and feeler gauge (**Figure 12**). Measure diagonally, as well as end to end. If the gap exceeds 0.07 mm (0.003 in.), have the head resurfaced by a machine shop.

Installation

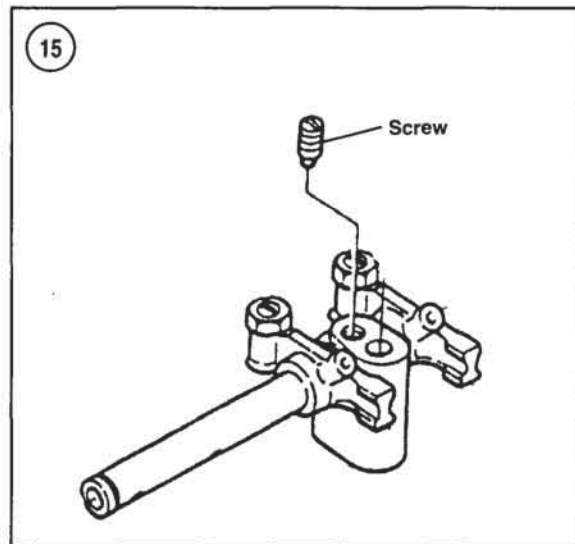
1. Make sure the cylinder head and block gasket surfaces are clean.
2. Recheck all visible oil and water passages for cleanliness.
3. Apply Three Bond 50 gasket sealer to both sides of a new cylinder head gasket.



4. Place the new head gasket over the cylinder head studs on the block. Be sure the TOP mark (**Figure 13**) on the gasket is up.
5. Carefully lower the head onto the cylinder block.
6. Apply engine oil to the threads on the cylinder head studs.
7. Install and tighten the cylinder head retaining nuts finger-tight.
8. Tighten the nuts and bolts following the sequence shown in **Figure 14** to the torque specified in **Table 4**. Tighten the nuts and bolts in three equal steps until reaching the final torque setting.
9. If removed, install the sacrificial anode into the cylinder head.
10. Attach the oil line fitting to the cylinder head.
11. Install the push rods in their original position.



12. Install the rocker assembly and the rocker arm stand retaining nuts (**Figure 10**). Tighten the nuts to 37 N•m (27 ft.-lb.).
13. Install the fuel injector and precombustion chamber as described in Chapter Seven.
14. Install the exhaust manifold.
15. Install the air cleaner base and the air cleaner.
16. Connect the wire lead to the water temperature sender (**Figure 9**).
- 17A. Engines with standard cooling—Connect the lower water hose (**Figure 9**).
- 17B. Engines with freshwater (closed) cooling system—Install the freshwater pump as described in Chapter Eight.
18. Install the alternator.
19. If the engine is installed in the boat, proceed as follows:
 - a. Attach the exhaust hose to the exhaust elbow.
 - b. On engines equipped with a closed cooling system, fill the cooling system as described in Chapter Four.
 - c. Connect the negative battery cable to the negative battery terminal.



20. Adjust the valve clearance as described in Chapter Three.
21. Reinstall the valve cover.

ROCKER SHAFT ASSEMBLY

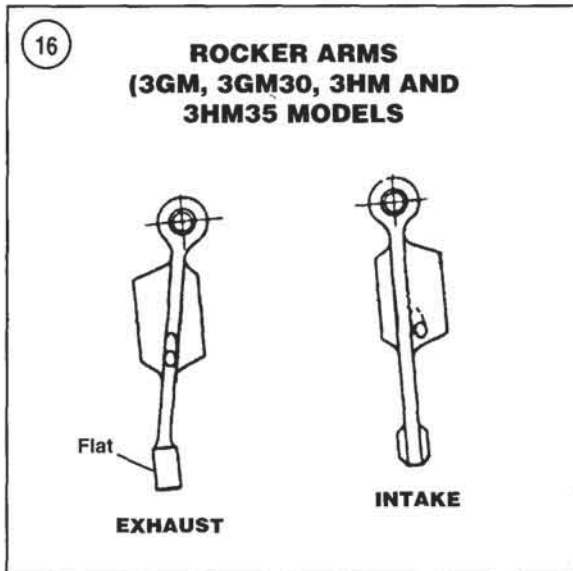
Each valve is actuated by a rocker arm that rides on a shaft (**Figure 8**). Each rocker arm is equipped with a bushing in the rocker arm bore. A snap ring at each end of the rocker arm shaft retains the rocker arms on the rocker shafts.

1. Remove the valve cover as previously described.
2. Remove the rocker arm stand retaining nuts (**Figure 10**), then remove the rocker shaft assembly.

NOTE

The rocker arms on 2GM and 2GM20 engines are identical, but rocker arms on 3GM, 3GM30, 3HM and 3HM35 engines are designed for use with the intake or exhaust valves.

3. Remove the snap rings at both ends of the rocker shaft and remove the rocker shaft components.
4. If necessary, unscrew the locating screw in the end support stand (**Figure 15**) and separate the rocker shaft from the stand.
5. Inspect each rocker arm. The pad on the rocker arm that contacts the valve stem must be smooth. Replace the rocker arm if the pad is damaged or excessively worn. Check the adjusting screw push rod seat for galling. Replace the adjusting screw if it is damaged or excessively worn.



6. Inspect and measure the inside diameter of the rocker arm bushing and the outside diameter of the rocker arm shaft. Replace the rocker arm or rocker arm shaft if the measurements exceed the specifications listed in **Tables 1-3**.

NOTE

The rocker arm and bushing are available only as a unit.

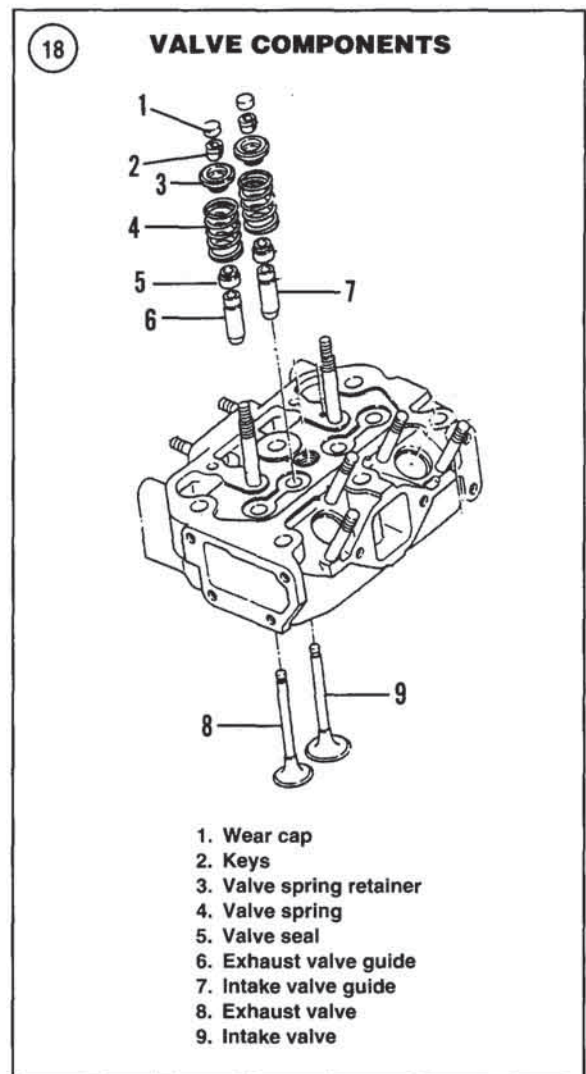
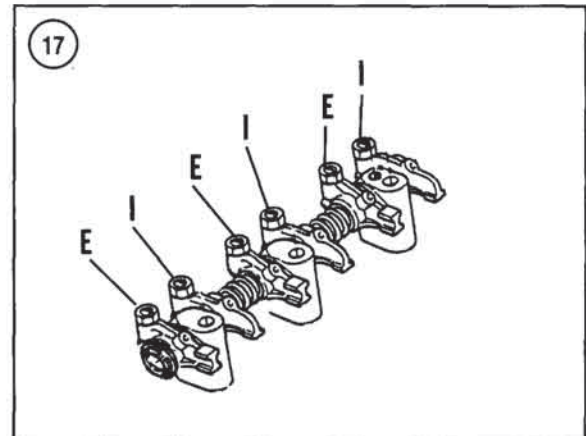
7. Reassemble and reinstall the rocker arm assembly by reversing the removal procedure. On 3GM, 3GM30, 3HM and 3HM35 engines, identify the intake and exhaust valves as shown in **Figure 16**, then position them on the shaft in the order shown in **Figure 17**.

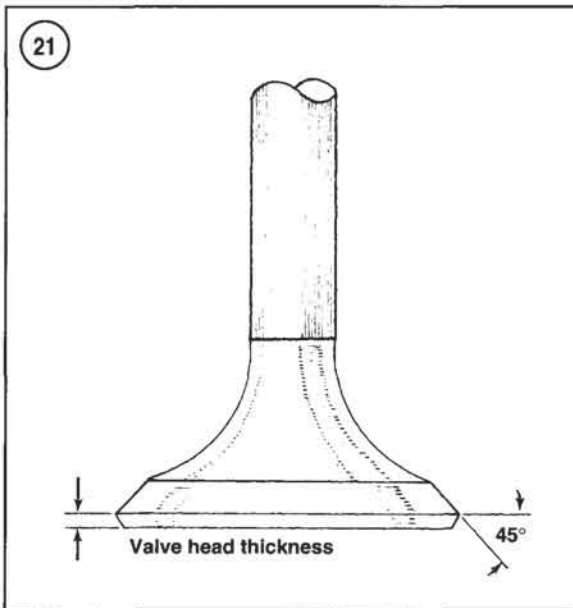
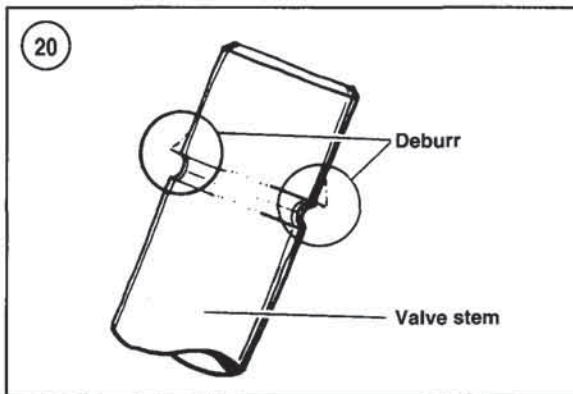
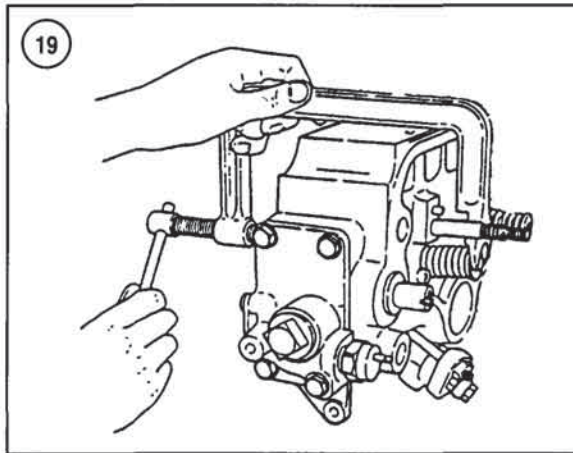
8. Adjust the valve clearance as described in Chapter Three.

VALVES AND VALVE SEATS

Servicing the valves, guides and valve seats must be done by a dealer or machine shop, as special knowledge and expensive machine tools are required.

A general practice among those who do their own service is to remove the cylinder head, perform all disassembly except valve removal and take the head to a dealer or machine shop for inspection and service. Since the cost is low relative to the required effort and equipment, this is usually the best approach, even for experienced mechanics. The following procedures are provided to acquaint the home mechanic with the procedure.





Valve Removal

Refer to **Figure 18** for this procedure.

1. Remove the cylinder head as described in this chapter.
2. Remove the rocker shaft assembly as described in this chapter.
3. Remove the wear cap (1, **Figure 18**) on the valve stem.
4. Compress the valve spring with a compressor like the one shown in **Figure 19**.
5. Remove the valve keys (2, **Figure 18**) and release the spring tension.
6. Remove the valve spring retainer and valve spring.

CAUTION

*Remove any burrs from the valve stem lock grooves (**Figure 20**) before removing the valve to prevent damage to the valve guide.*

7. Remove the valve.
8. Remove and discard the valve stem seal (5, **Figure 18**).
9. Repeat Steps 3-8 for the remaining valves.

Inspection

1. Clean the valves with a fine wire brush or buffing wheel. Discard any cracked, warped or burned valves.
2. Measure the valve stems at the top, center and bottom for wear. A machine shop can do this when the valves are ground.

NOTE

*Check the thickness of the valve edge or margin after the valves have been ground. See **Figure 21**. Any valve with a margin less than 0.75 mm (0.030 in.) should be discarded.*

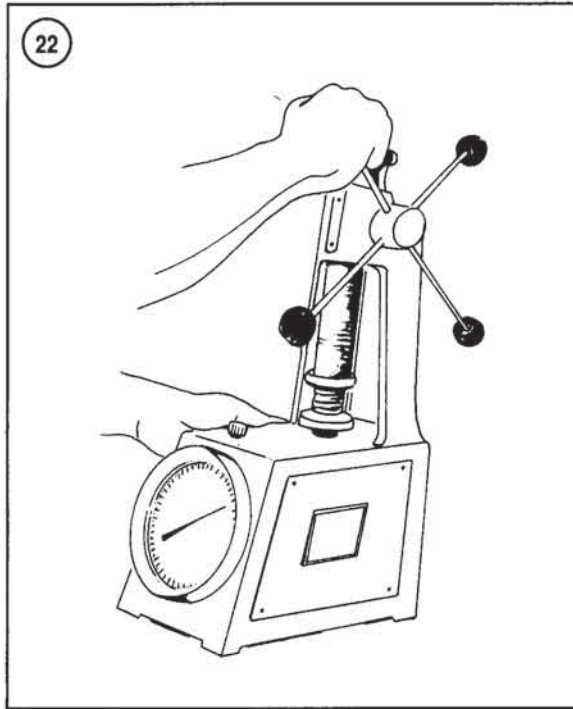
3. Remove all carbon and varnish from the valve guides with a stiff spiral wire brush.

NOTE

The next step assumes that all valve stems have been measured and are within specifications. Replace valves with worn stems before performing this step.

4. Insert each valve into the guide from which it was removed. Holding the valve just slightly off its seat, rock it back and forth in a direction parallel with the rocker arms. This is the direction in which the greatest wear normally occurs. If the valve stem rocks more than slightly, the valve guide is probably worn.
5. If there is any doubt about valve guide condition after performing Step 4, measure the valve guide. Compare the





results with specifications in **Tables 1-3**. Worn guides must be replaced.

6. Test the valve springs under load on a spring tester (**Figure 22**). Replace any spring that does not meet the specification listed in **Tables 1-3**.

7. Inspect the valve seats. If worn or burned, they must be reconditioned. This is a job for a dealer or machine shop, although the procedure is described in this chapter.

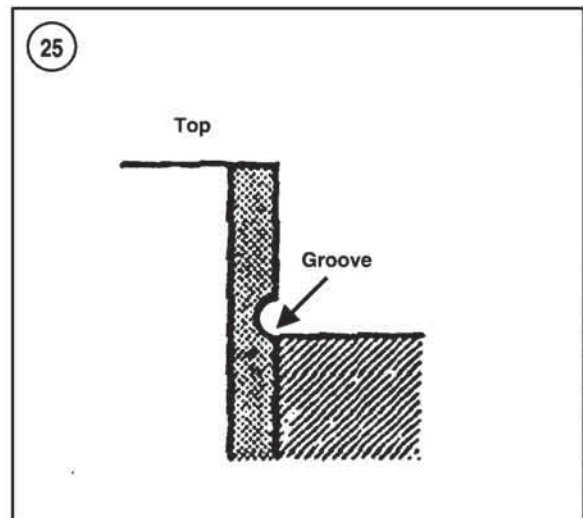
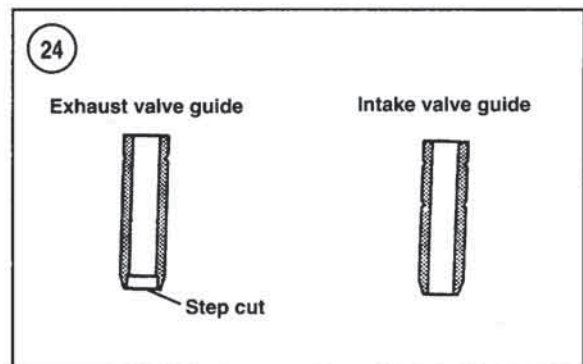
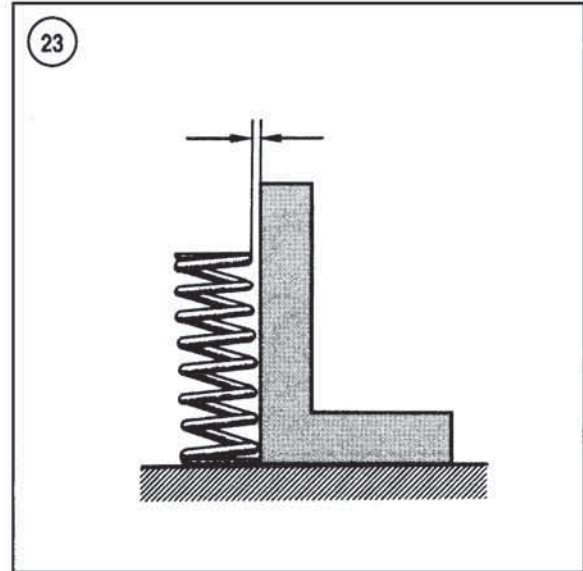
8. Check each spring on a flat surface with a steel square. See **Figure 23**. Slowly revolve the spring 360° and note the space between the top of the coil and the square. If it exceeds 1.4 mm (0.055 in.) at any point, replace the spring.

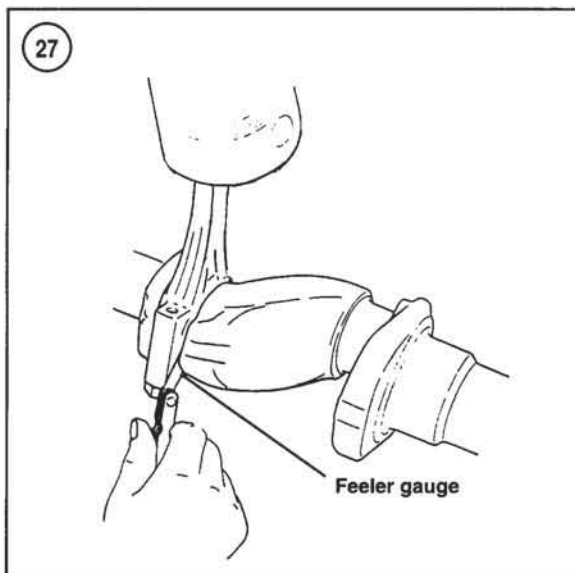
9. Check the valve guides for wear and looseness. Refer to **Tables 1-3** for valve guide specifications. A loose valve guide must be replaced.

Valve Guide Replacement

The cylinder head is equipped with replaceable valve guides. The intake and exhaust valve guides are different in shape. Refer to **Figure 24**. The intake valve guide has a straight inside bore, while the exhaust valve guide has a stepped opening at the lower end of the guide.

Take the cylinder head to a dealership or machine shop if valve guide replacement is required.

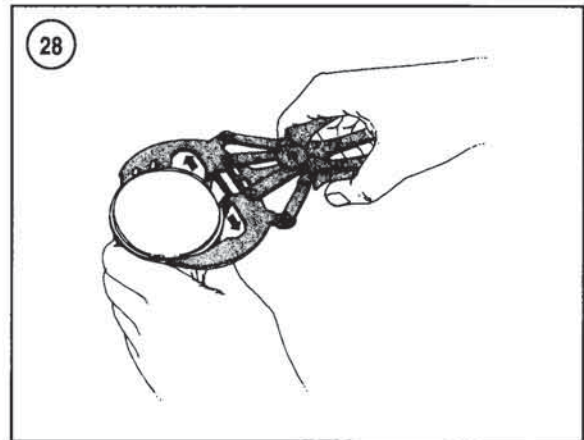




When installing the valve guides, the grooved end must be toward the top of the cylinder head. The groove must be flush with the head surface as shown in **Figure 25**.

PUSH RODS

1. Remove the rocker arms as previously described.
2. Remove the push rods and mark them so they can be reinstalled in their original positions.
3. Inspect the push rod ends for damage. Maximum allowable runout is 0.03 mm (0.0012 in.).

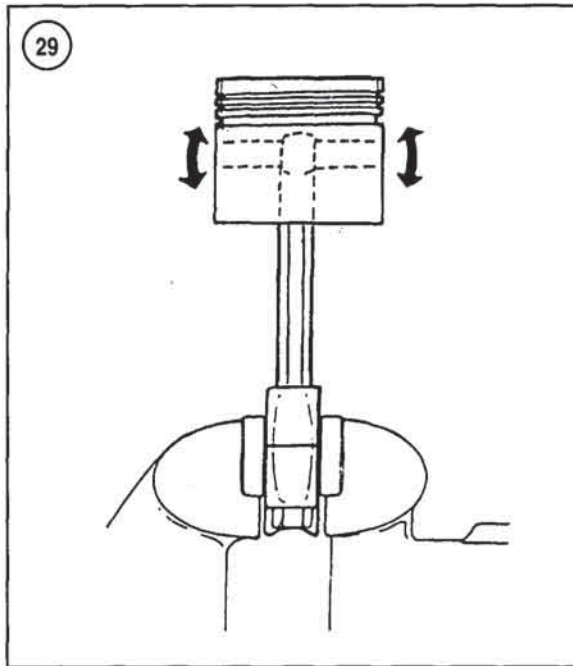


4. Reinstall the push rods by reversing the removal procedure. Adjust valve clearance as described in Chapter Three.

PISTON/CONNECTING ROD ASSEMBLY

Piston/Connecting Rod Removal

1. Remove the engine as described in this chapter.
2. Place a suitable container under the oil pan and remove the drain plug. Let the crankcase oil drain, then reinstall the drain plug.
3. Remove the cylinder head as described in this chapter.
4. Remove the oil pan.
5. On 2GM, 2GM20, 3GM and 3GM30 models—Loosen the oil pickup jam nut (**Figure 26**) and remove the oil pickup.
6. Rotate the crankshaft until the piston is at bottom dead center. Pack the cylinder bore with clean shop rags. Remove the carbon ridge at the top of the cylinder bore with a ridge reamer. These can be rented for use. Vacuum out the shavings, then remove the shop rags.
7. Rotate the crankshaft until the connecting rod is centered in the bore. Measure the clearance between the connecting rod and the crankshaft journal flange with a flat feeler gauge (**Figure 27**). If the clearance exceeds specifications (**Tables 1-3**), replace the connecting rod during re-assembly.
8. Remove the connecting rod bolts. Lift off the cap, together with the lower bearing insert.
9. Use a wooden hammer handle to push the piston and connecting rod from the bore.
10. Remove the piston rings with a ring remover (**Figure 28**).



Piston Pin Removal/Installation

The steel piston pin rides directly in the piston and in a bushing in the connecting rod. Circlips at each end retain the piston pin in the piston.

1. Before removing the piston, place the crankshaft end of the connecting rod in a vise with soft jaws. Rock the piston as shown in **Figure 29**. Any rocking motion (do not confuse with the normal sliding motion) indicates wear on the piston pin, piston pin bore or connecting rod small end bore (or combination of these).
2. Remove the clip from each side of the piston pin bore (**Figure 30**) with a small screwdriver or scribe. Hold a thumb over one edge of the clip when removing it to prevent the clip from springing out.
3. Use a wooden dowel or suitable tool and push out the piston pin. If the pin is difficult to remove, heat the piston with a hair dryer. Separate the piston from the connecting rod.

Piston/Cylinder Bore Check

Unless precision measuring equipment is available, have this procedure done by a machine shop.

1. Measure the piston diameter with a micrometer (**Figure 31**) at a right angle to the piston pin bore 9 mm (0.35 in.) from the bottom of the piston skirt.

