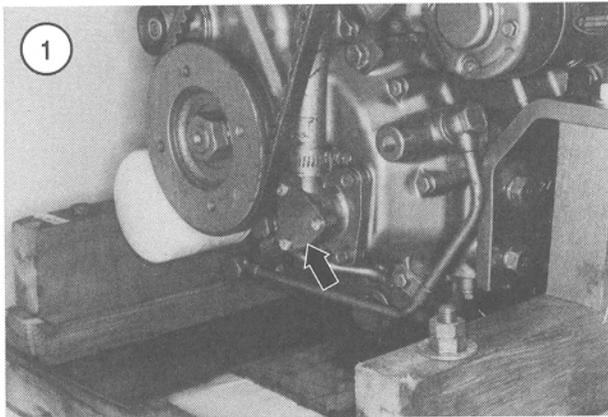


Chapter Eight

Cooling System



This chapter covers service procedures for the thermostat, engine water pump, seawater pumps, drive belts and connecting hoses in both standard and closed cooling systems.

Cooling system flushing procedures are provided in Chapter Three. Drain and refill procedures are described in Chapter Four.

Table 1 and **Table 2** are located at the end of this chapter.

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.

COOLING SYSTEMS

Seawater (Standard) Cooling System

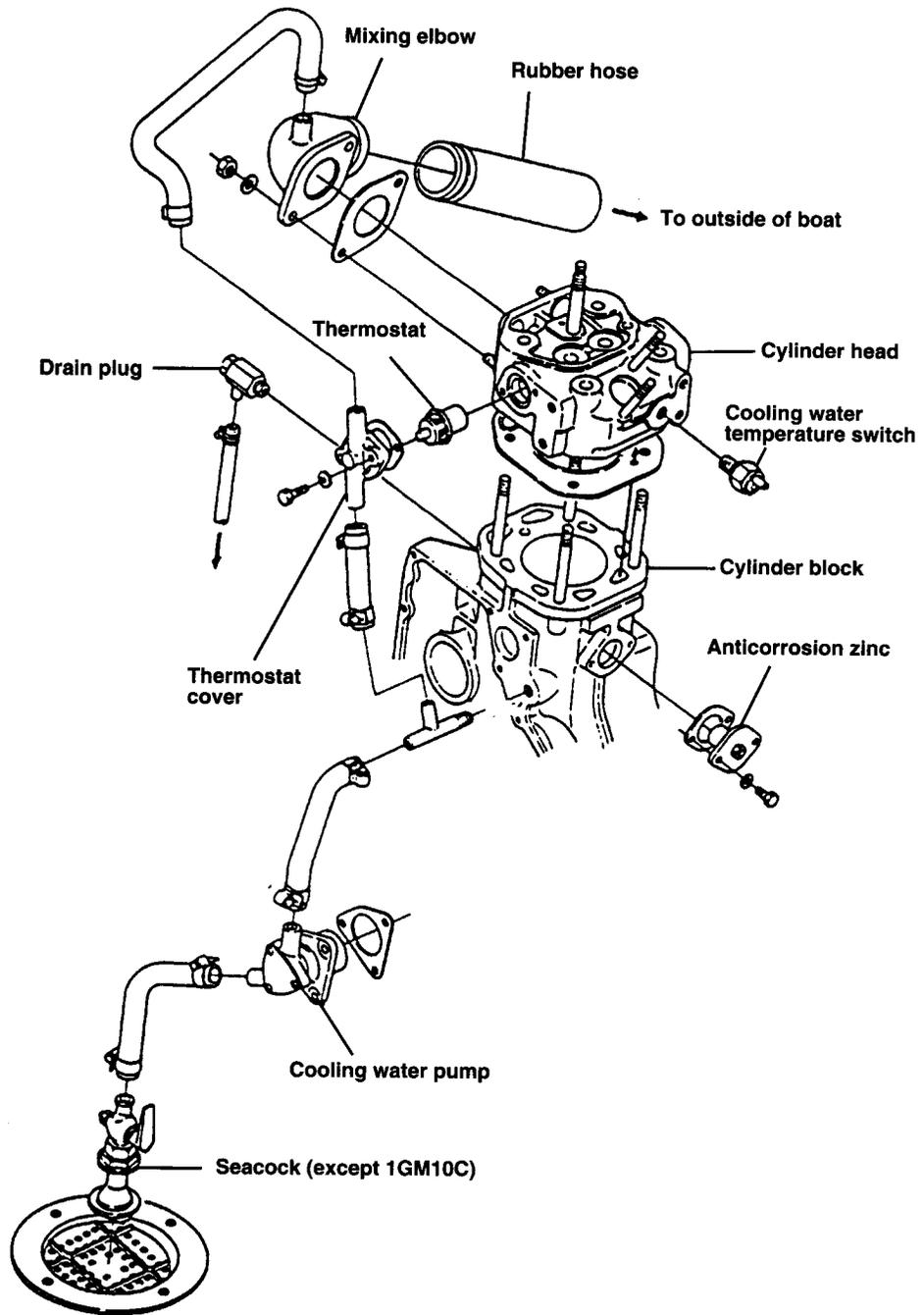
All engines are equipped with a seawater cooling system. The water in which the boat is being operated is used as a coolant to absorb engine heat. Water from outside the boat passes through the water intake to the impeller-type seawater pump located on the engine (**Figure 1**, typical). The seawater pump sends the water to the engine for circulation through the engine block, head and manifold.

A thermostat controls water circulation to provide quick engine warm-up and maintain a constant operating temperature.

Refer to typical cooling system diagrams in **Figure 2**, **Figure 3** and **Figure 4**.

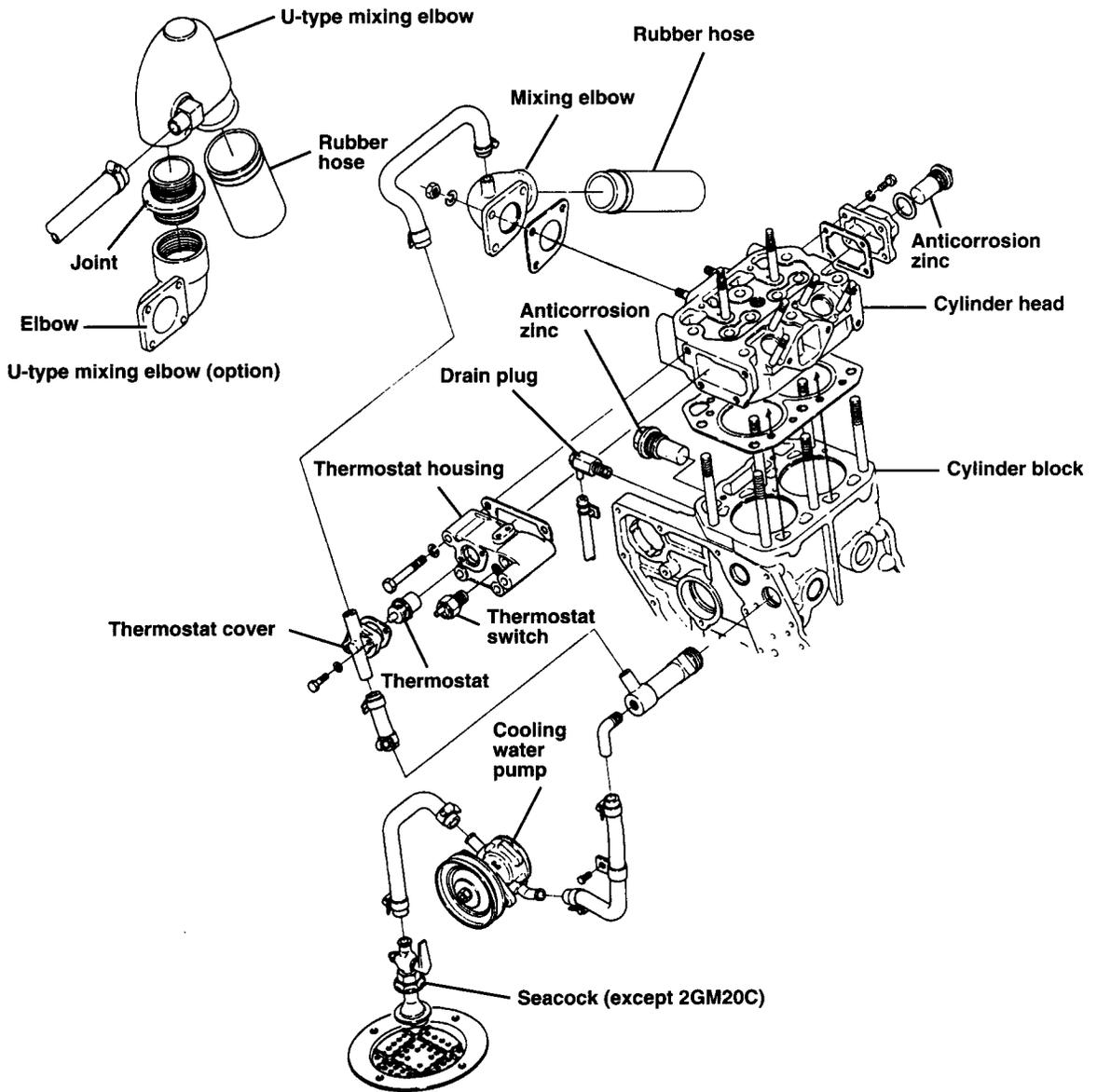
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SEAWATER COOLING SYSTEM (1GM AND 1GM10)



3

**SEAWATER COOLING SYSTEM
(2GM AND 2GM20)**

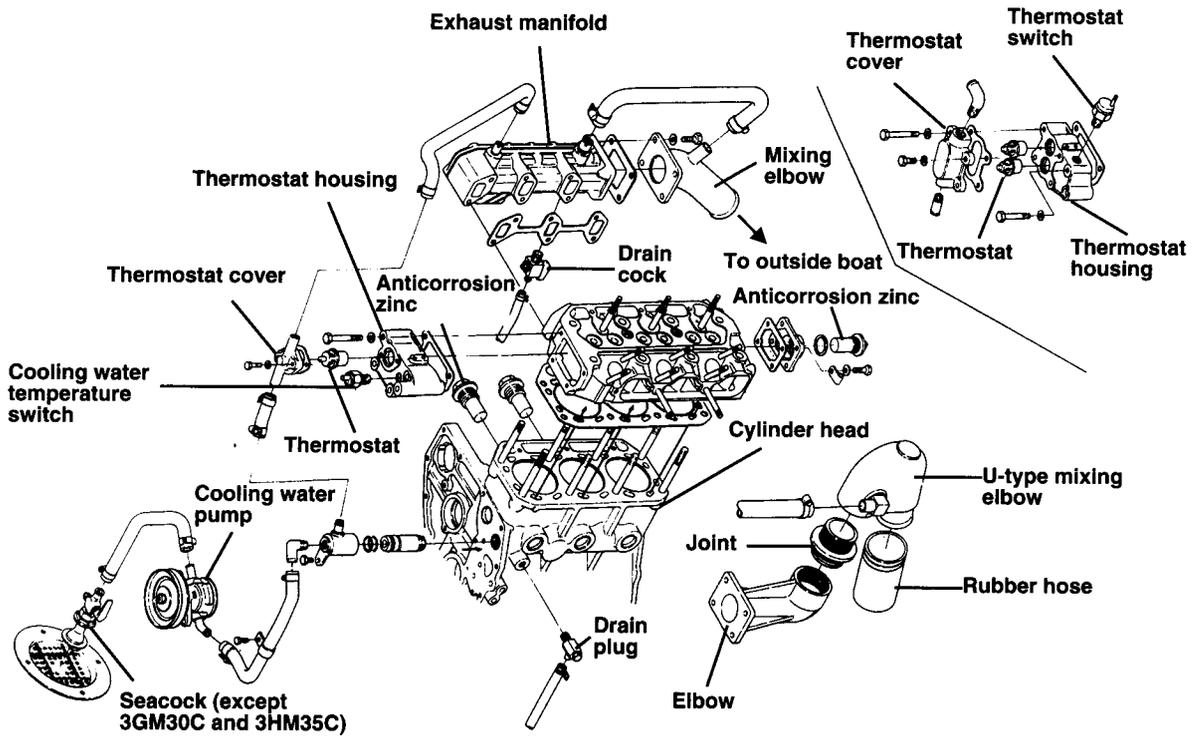


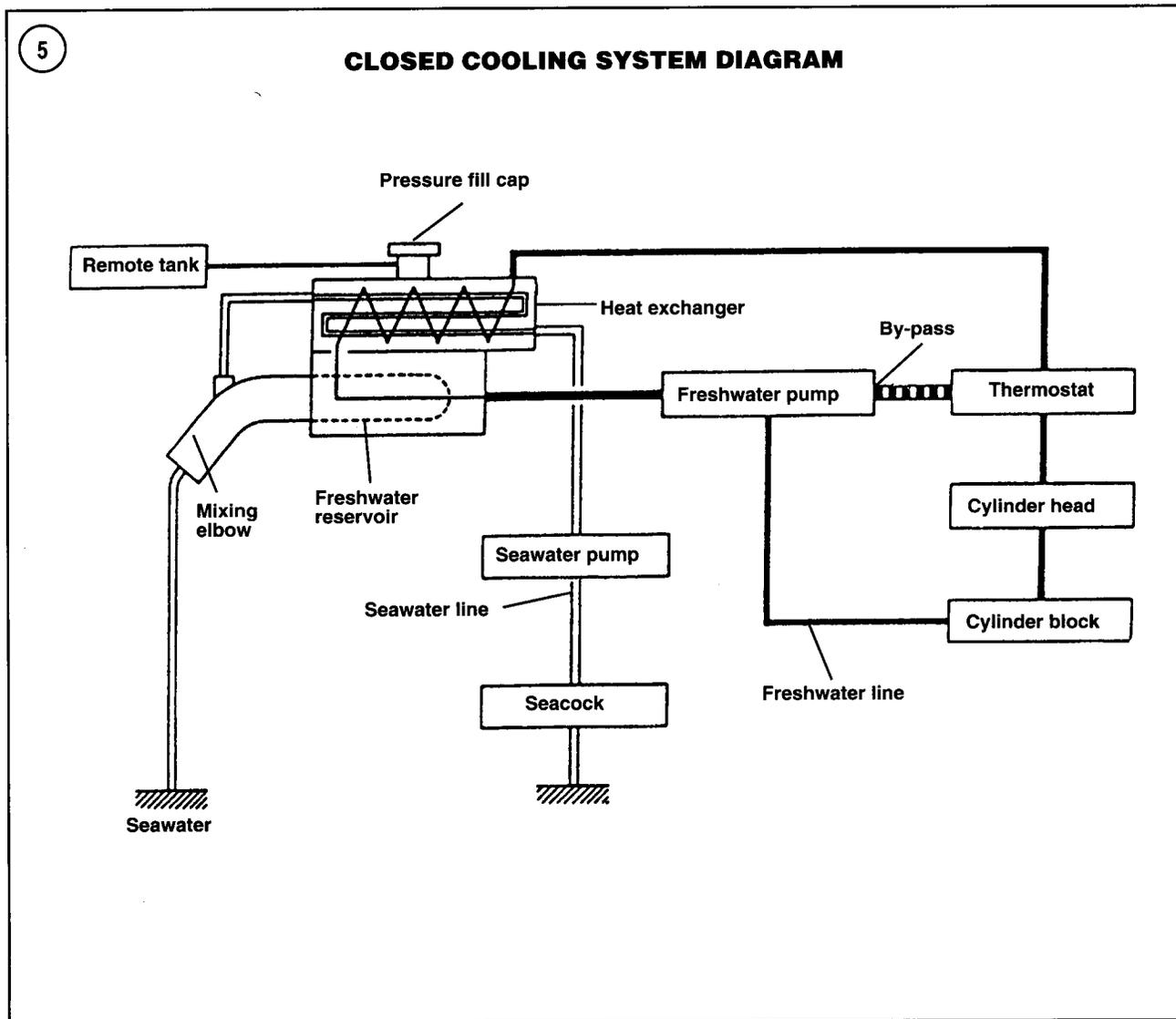
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4

SEAWATER COOLING SYSTEM (3GM AND 3GM30 MODELS)

3HM AND 3HM35





Freshwater (Closed) Cooling System

Two- and three-cylinder engines with a model number ending in F are equipped with seawater and freshwater (closed) cooling systems

The closed cooling system is divided into two separate subsystems: one uses seawater and the other uses a coolant mixture of distilled water and ethylene glycol anti-freeze. The subsystem containing the coolant is referred to as the freshwater system. Refer to the typical freshwater cooling system diagram in **Figure 5**. Typical components are shown in **Figure 6**.

Various configurations of the closed cooling system are used, but all function essentially the same. The seawater

system operation is similar to the standard cooling system previously described, except as follows:

- a. Coolant in the closed cooling system cools the engine block, cylinder head and exhaust manifold.
- b. A belt-driven seawater pump (**Figure 1**), located at the front of the engine, delivers seawater to the heat exchanger, instead of passing seawater directly into the engine.

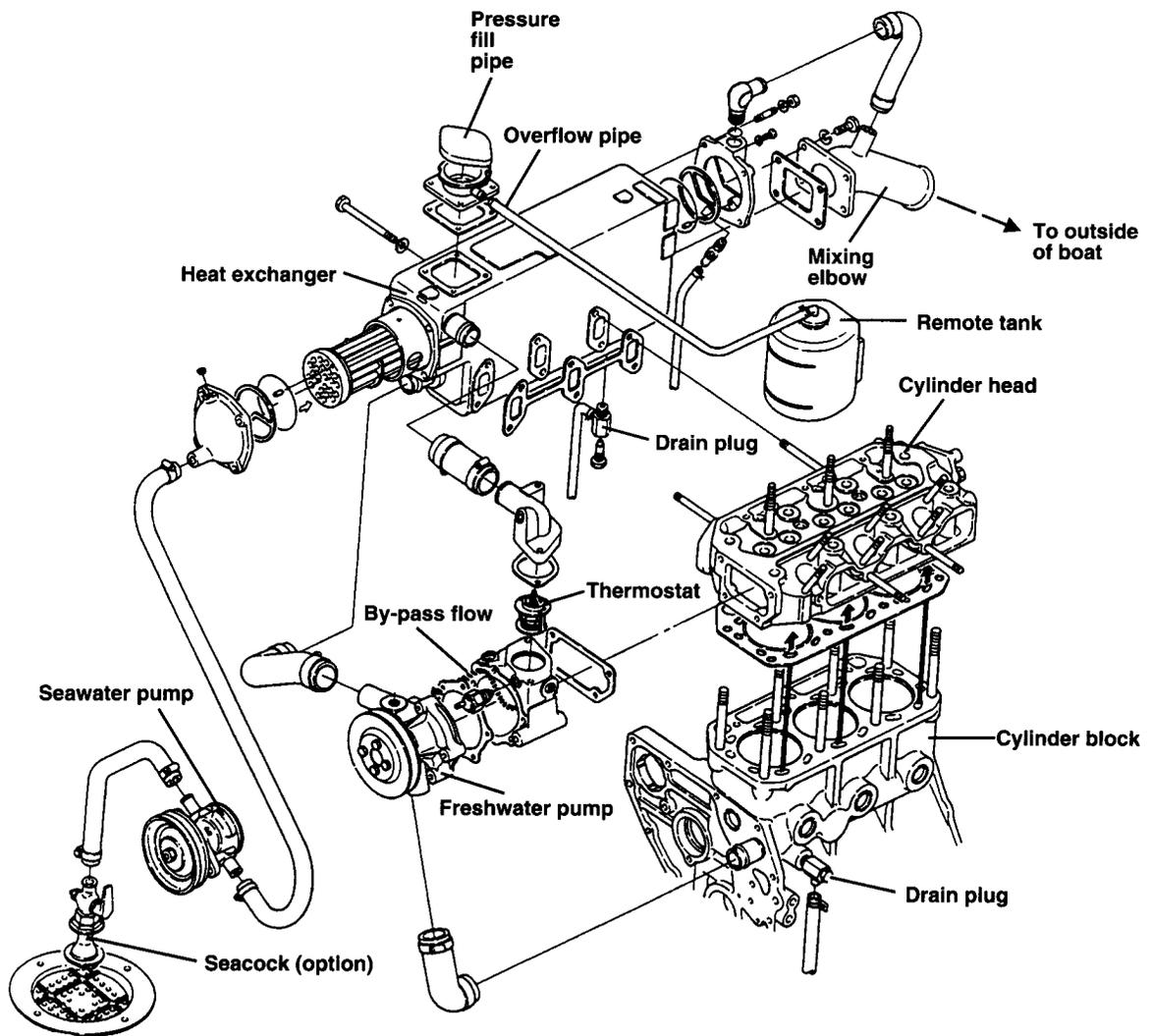
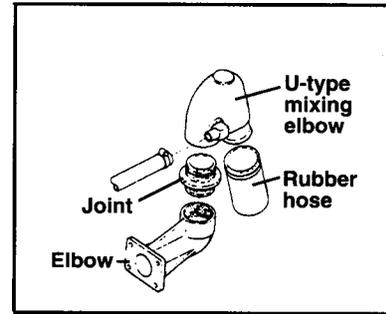
After passing through the seawater pump, the seawater travels through a series of parallel copper tubes in the heat exchanger, where it absorbs engine heat before returning to the exhaust elbow for discharge from the boat. **Figure 7** shows a typical heat exchanger.

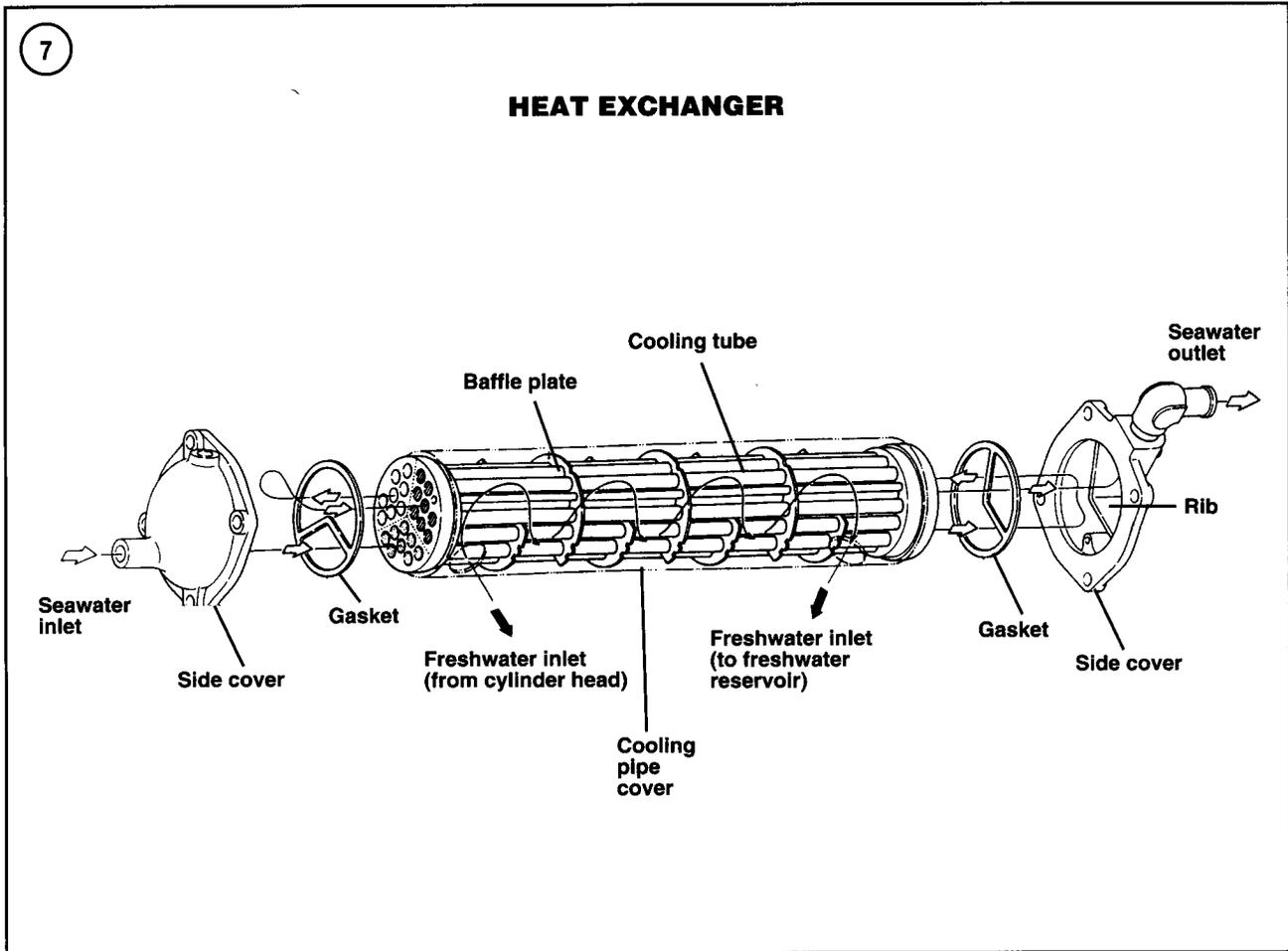
The freshwater system pump circulates the coolant mixture inside the engine to absorb engine heat. This



6

CLOSED COOLING SYSTEM (TYPICAL)





coolant travels to the heat exchanger, where the heat absorbed from engine operation passes through the parallel copper tubes to the water in the seawater system.

Engine cooling is thus accomplished without seawater entering the engine. This eliminates the corrosion, deposit buildup and debris accumulation that occurs in a standard cooling system, resulting in longer engine life—especially if the boat is used in saltwater.

Like an automotive cooling system, the freshwater section is pressurized at 13 psi. This raises the boiling point of the coolant to permit higher operating temperatures for increased engine efficiency.

A thermostat controls coolant circulation. When the thermostat closes, it prevents coolant from entering the heat exchanger, rerouting it back to the engine circulating pump. Once the thermostat opens, it closes off the passage to the circulating pump and sends the coolant through the heat exchanger before returning it to the engine pump. This provides quick engine warm-up and maintains a constant operating temperature.

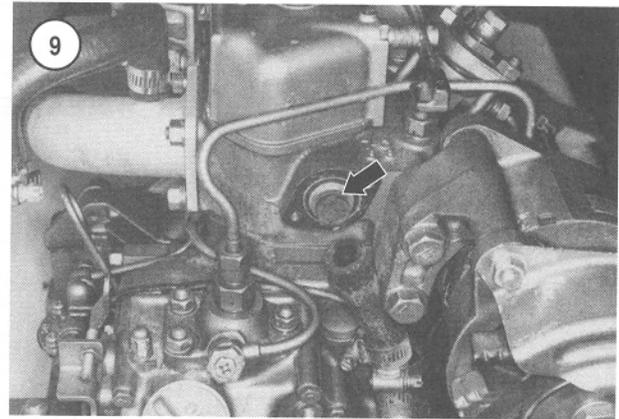
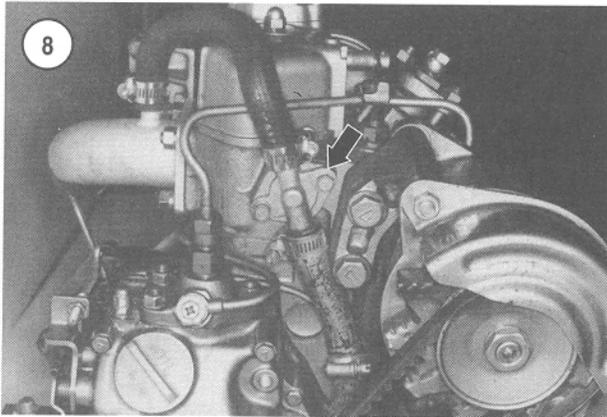
THERMOSTAT

The thermostat blocks coolant flow to the exhaust manifold (standard cooling) or heat exchanger (closed cooling) when the engine is cold. As the engine warms, the thermostat gradually opens, allowing coolant to circulate through the system.

CAUTION

Do not operate the engine without a thermostat. This can lead to serious engine damage.

Thermostats are rated according to their opening temperature. The opening temperature value is stamped on the thermostat. The thermostat should start to open at the temperature stamped on the thermostat and should be fully open at 25° F (14° C) above that temperature. Check the thermostat rating after removing the thermostat and compare it to the specifications in **Table 2**.

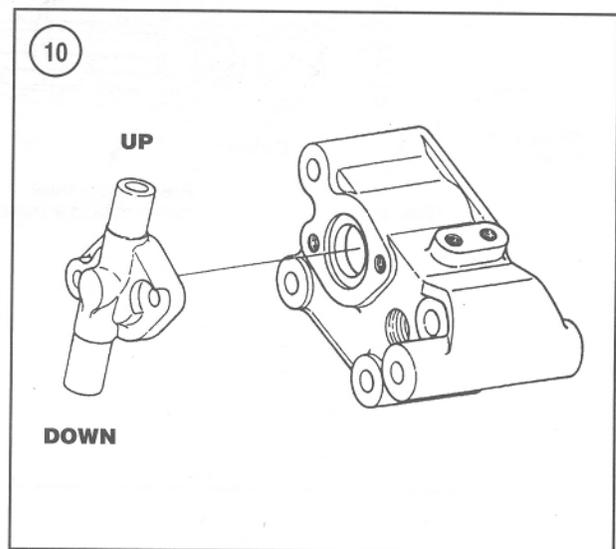


Removal/Installation

Seawater cooling systems

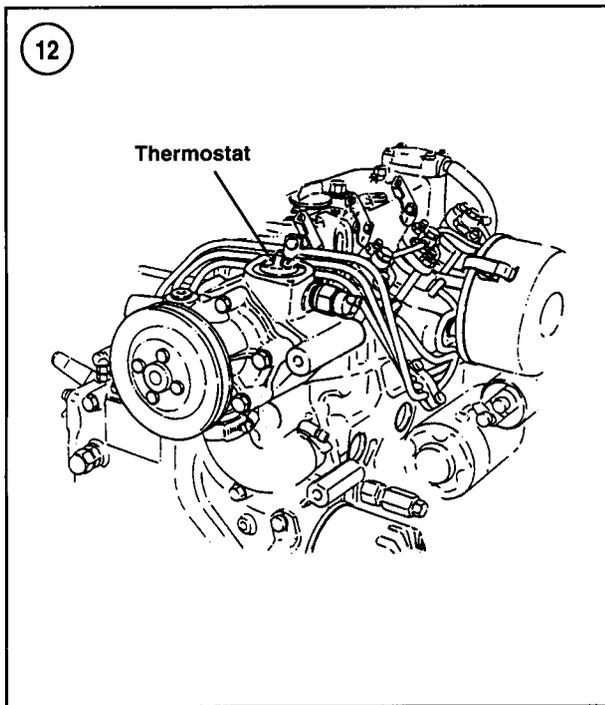
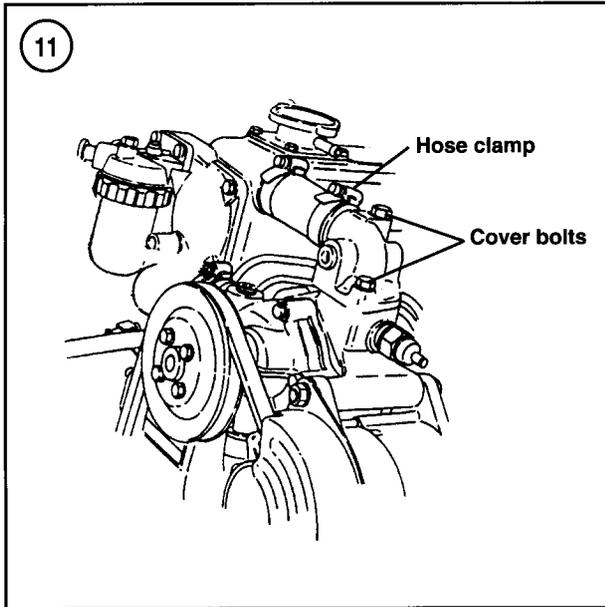
The thermostat on 1GM and 1GM10 engines is located in the cylinder head (**Figure 2**). The thermostat on two- and three-cylinder engines is located in the thermostat housing (**Figure 3** and **Figure 4**). 3HM and 3HM35 engines are equipped with two thermostats (**Figure 4**).

1. Drain the seawater from the engine as described in Chapter Four.
2. Loosen the hose clamps and disconnect the hoses from the thermostat cover (**Figure 8**).
3. Remove the thermostat cover retaining bolts and washers. Remove the cover and the gasket. Discard the gasket.
4. Remove the thermostat (**Figure 9**). On 3HM and 3HM35 engines, remove both.
5. Test the thermostats as described in this chapter.
6. Clean the thermostat cover and housing or cylinder head mating surfaces of all gasket residue.
7. Install the thermostat in the housing or cylinder head with its thermostatic element facing the engine. The thermostat flange must fit into the housing recess.
8. Coat both sides of a new gasket with sealant and install the gasket onto the thermostat cover.
9. Install the cover. Note that the inlet and outlet nipples are stepped. Install the cover so the outermost nipple faces down, as shown in **Figure 10**. Tighten the bolts securely.
10. Reconnect the hoses to the thermostat cover and tighten the clamps securely.
11. Operate the engine and check for leaks. Operate the engine until it reaches normal operating temperature. Immediately shut down the engine if overheating occurs and correct the problem.

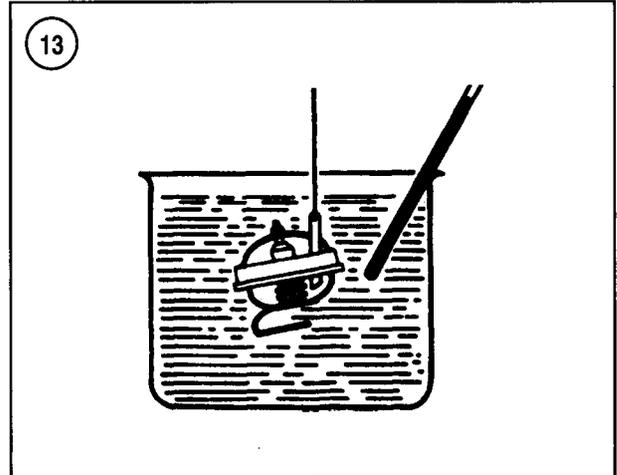


Freshwater cooling systems

1. Drain the coolant from the engine as described in Chapter Four.
2. Loosen the hose clamp (**Figure 11**) securing the coolant hose to the thermostat cover.
3. Remove the thermostat cover retaining bolts and washers (**Figure 11**). Remove the cover and the hose. Discard the gasket.
4. Remove the thermostat (**Figure 12**).
5. Test the thermostat as described in this chapter.
6. Clean the thermostat cover and housing mating surfaces of all gasket residue.
7. Install the thermostat in the housing with its thermostatic element facing the housing. The thermostat flange must fit into the housing recess.
8. Coat both sides of a new gasket with sealant and install the gasket onto the thermostat cover.



9. Install the cover while connecting it to the coolant hose. Tighten the bolts securely.
10. Tighten the hose clamp securely.
11. Operate the engine and check for leaks. Operate the engine until it reaches normal operating temperature. Immediately shut down the engine if overheating occurs and correct the problem.



Testing (Out of Engine)

1. Pour some tap water (not distilled water or coolant) into a container that can be heated. Submerge the thermostat in the water and suspend a thermometer as shown in **Figure 13**.

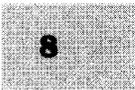
NOTE

Suspend the thermostat with wire so it does not contact the pan.

2. Heat the water until the thermostat starts to open. Check the water temperature on the thermometer. It should be approximately the same as the temperature value stamped on the thermostat. If the thermostat has not started to open at this temperature, replace it.
3. Heat the water another 25° F (14° C) above the temperature value stamped on thermostat. The thermostat should now be fully open. If it is not, replace it.
4. Allow the water to cool to 10° F (6° C) under the thermostat's rated opening temperature. If the thermostat valve is not fully closed at this temperature, replace it.
5. Remove the thermostat from the water and let it cool to room temperature. Make sure the valve seals tightly by holding the thermostat up to a light. If light is visible around the edge of the valve, replace the thermostat.

Testing (In Engine)

Thermostat operation can be tested without removing it from the engine or reservoir. This procedure requires the use of two thermomelt sticks (**Figure 14**) available from marine supply or automotive parts stores. A thermomelt stick looks like a carpenter's pencil and is made of a chemically impregnated wax material that melts at a specific temperature.



This technique can be used to check thermostat opening by marking the thermostat housing with two thermomelt sticks: one with a temperature lower than the thermostat opening temperature, and one with a temperature higher than the full open position. When the coolant or water reaches the first temperature, the mark made by that stick will melt. The mark made by the second stick will not melt until the coolant or water increases to that temperature.

WARNING

Do not remove the pressure fill cap from a freshwater (closed) cooling system while the engine is warm. Coolant may blow out of the heat exchanger and cause serious personal injury.

Overheated Engine

1. Relieve the freshwater cooling system pressure by carefully removing the pressure fill cap from the heat exchanger. See **Figure 15**, typical.
2. Rub a 180° F (82° C) thermomelt stick on the thermostat cover.
3. Start the engine and run at a fast idle.
4. If no coolant flows into the heat exchanger by the time the mark starts to melt, either the thermostat is stuck closed or the water pump is failing. Remove the thermostat and test it as described in this chapter. If the results are satisfactory, replace the water pump.

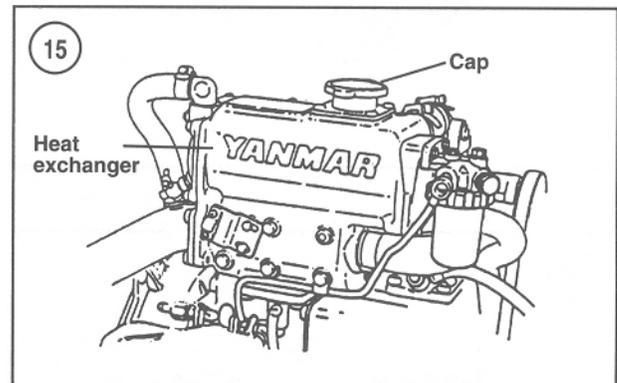
Slow Engine Warm-Up

1. Relieve the freshwater cooling system pressure by carefully removing the pressure fill cap from the heat exchanger. See **Figure 15**, typical.
2. Rub the 160° F (71° C) thermomelt stick on the thermostat cover.
3. Start the engine and run at a fast idle.
4. If coolant or water flows into the heat exchanger before the mark starts to melt, the thermostat is stuck open and should be replaced.

HOSE REPLACEMENT

Replace any hoses that are cracked, brittle, or very soft and spongy. If a hose is in doubtful condition, replace it to be on the safe side. Hoses in some installations are extremely difficult to change; attention to hose condition can prevent a failure while off-shore.

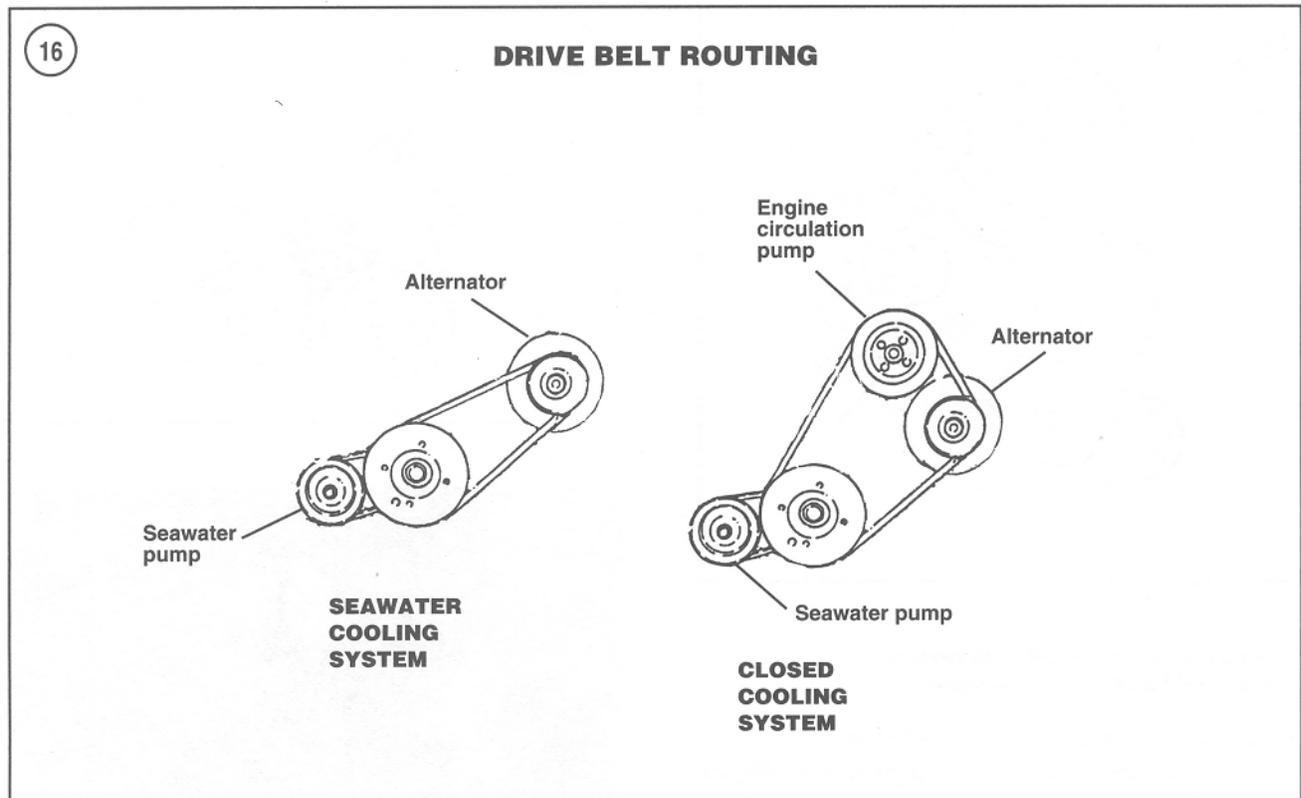
Hose manufacturers generally rate cooling system hose life at two years. How long the hoses will last depends a great deal on how much the boat is used and how well the



system is maintained; however, it is a good idea to change all hoses every two years. Always replace a cooling system hose with the same type as removed. Pleated rubber hoses do not have the same strength as reinforced molded hoses. Check the hose clamp condition and install new marine-grade clamps with a new hose, if necessary.

Partially drain the cooling system when replacing upper hoses. Completely drain it when replacing lower hoses.

1. Loosen the clamp at each end of the hose to be removed. Grasp the hose and twist it off the fitting with a pulling motion.
2. If the hose is corroded to the fitting and will not twist free, remove the clamp and insert a small screwdriver or pick tool between the hose and the fitting. Work the tool around the fitting, then remove the hose.
3. Clean any rust or corrosion from the fitting with a wire brush.
4. Wipe the inside diameter of the new hose with liquid detergent and install the hose ends on the fittings with a twisting motion.
5. Position the new clamps at least 1/4 in. (6.4 mm) from the end of the hose. Make sure to position the clamp screw for easy access with a screwdriver or nut driver. Tighten each clamp snugly.



6. Refill the cooling system. Start the engine and check for leaks. Recheck the clamps for tightness after operating the engine for a few hours.

DRIVE BELTS

Inspect all drive belts at regular intervals to make sure they are in good condition and are properly tensioned. Replace worn, frayed, cracked or glazed belts immediately. The components to which they direct power are essential to the safe and reliable operation of the boat. If correct adjustment is maintained on each belt, all will usually give the same service life. For this reason, and because of the cost involved in replacing an inner belt (requiring the removal of the outer belt), it is a good idea to replace all belts as a set. The added expense is small compared to the cost of replacing the belts individually and eliminates the possibility of a breakdown on the water, which could cost far more in time and money.

Drive belts should be properly tensioned at all times. If loose, the belts will not permit the driven components to operate at maximum efficiency. The belts will also wear rapidly because of the increased friction caused by slippage. Belts that are too tight will be overstressed and prone to premature failure. An excessively tight belt will

also overstress the bearings, resulting in premature failure.

Only install heavy-duty belts. Do not install light-duty belts, such as those designed for automobile use.

Refer to **Figure 16** for drive belt routing diagrams.

Belt Adjustment

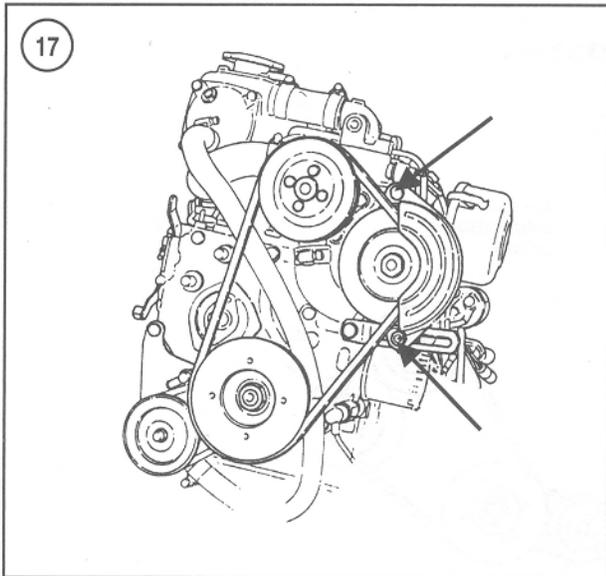
Refer to Chapter Three for belt adjustment procedures.

Belt Replacement

Alternator drive belt replacement

Replace the alternator drive belt as follows:

1. Loosen the alternator bracket and pivot bolts (**Figure 17**, typical).
2. Move the alternator toward the engine and slip the belt off the crankshaft and alternator pulleys, and if equipped with freshwater cooling, the circulating water pump pulley.
3. Install a new belt over the pulleys.
4. Move the alternator away from the engine and adjust the belt tension as described in Chapter Three.



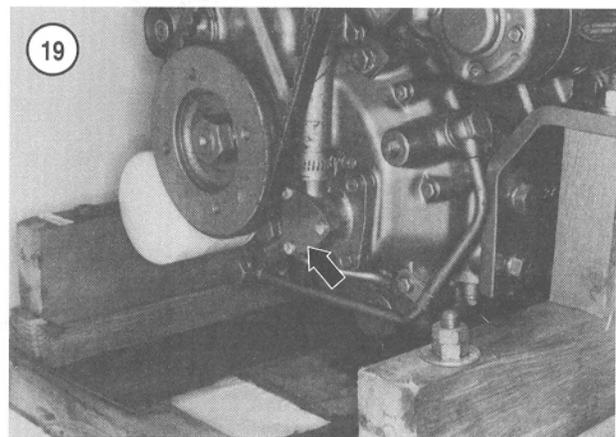
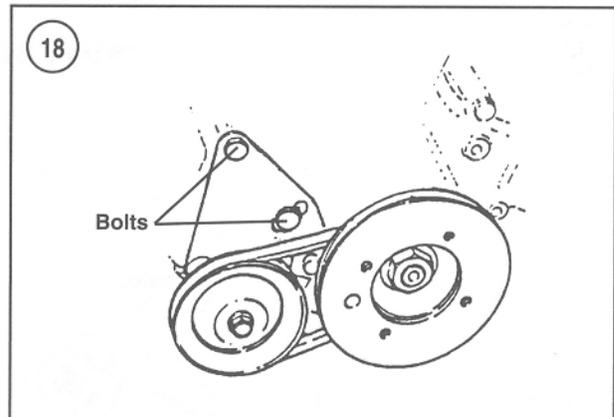
Seawater pump drive belt replacement (except 1GM and 1GM10 engines)

Replace the seawater drive belt as follows:

1. Loosen the alternator bracket and pivot bolts (**Figure 17**, typical).
2. Move the alternator toward the engine and slip the belt off the crankshaft and alternator pulleys, and if equipped with freshwater cooling, the circulating water pump pulley.
3. Loosen the seawater pump bracket and pivot bolts (**Figure 18**, typical).
4. Move the seawater pump toward the engine and slip the belt off the crankshaft and pump pulleys.
5. Install a new belt over the pulleys.
6. Move the seawater pump away from the engine and adjust the belt tension as described in Chapter Three.
7. Install the alternator drive belt onto the crankshaft and alternator pulleys, and if equipped with freshwater cooling, the circulating water pump pulley.
8. Move the alternator away from the engine and adjust the belt tension as described in Chapter Three.

SEAWATER PUMP

All engines covered in this manual use a seawater pump (**Figure 19**, typical). The seawater pump on 1GM and 1GM10 engines is driven by the end of the oil pump driveshaft. All other engines use a belt-driven seawater pump. A rubber impeller inside the pump moves water through the pump. The pump draws water into the intake port as the impeller vanes flex outward, and it pumps wa-

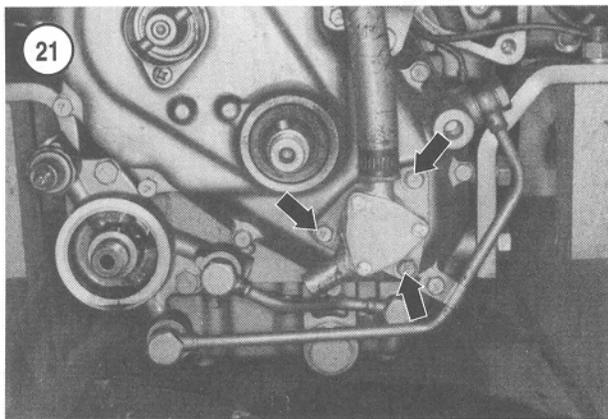
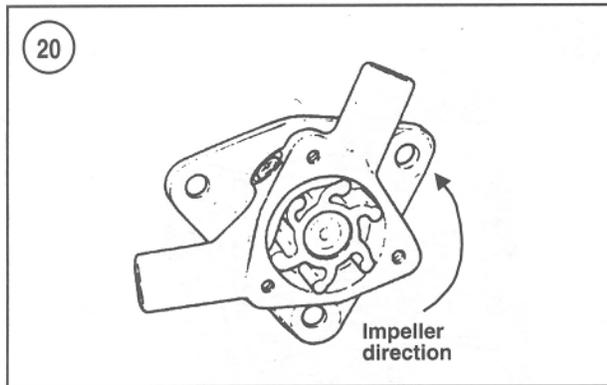


ter out of the discharge port as the impeller vanes flex inward, as shown in **Figure 20**.

The impeller only operates in a counterclockwise rotation (viewed from cover side of pump) and remains in a flexed (compressed) position at all times. Over time, this causes the impeller to take a set in one direction. Turning an impeller over and attempting to turn it against its natural set will cause premature impeller failure and engine damage from overheating.

Replace the impeller every time the water pump is disassembled. The impeller must only be reused if there is no other option. If the impeller must be reused, reinstall the impeller in its original position.

Overheating and extensive engine damage can result from a faulty water pump. Therefore, it is highly recommended that the water pump impeller, seals and gaskets be inspected after every 1,500 hours of operation as a preventive maintenance measure. Individual operating conditions may dictate that the pump will require service more often.



Seawater Pump Precautions

The seawater pump suffers from many misconceptions about its ability to withstand operation without water being supplied to it. All impellers are made of some variation of rubber. The water pump housing is made of metal. If a piece of rubber is rubbed across a piece of metal, there is severe friction and considerable heat buildup. However, if the metal is flooded with water while the rubber is moved across it; the friction would be greatly reduced and the heat buildup non-existent.

Basically, the water pump works the same way. The water passing through the pump lubricates and cools the impeller and pump housing. Without the water, the pump will overheat and the impeller will begin to melt almost instantaneously. Of course, this can be secondary to the potential damage to the engine from overheating.

Once the impeller sustains *any* damage, its pumping ability is greatly diminished because the impeller can no longer seal adequately. The impeller must seal on its edges, as well as the blade tips.

If the engine was run without an adequate supply of water to the pump, disassemble the pump and replace the impeller and any other damaged parts.

Water Pump Operating Mistakes

Do not run an engine immediately after pulling a boat out of water. This is an extremely risky operation, but here is why some people often seem to get away with it. If an engine has just been pulled out of the water, there is residual water in the cooling system and engine that drains back down to the water pump. This water will lubricate the water pump for a short period of time (perhaps a couple of minutes), but the pump will be damaged as soon as the heat from operation evaporates all water in the system. Do not operate the pump without an adequate water supply.

Do not start an engine with the boat out of the water, but without a water supply, to make sure the motor will run when the boat is launched. This is an unacceptable and very dangerous procedure. If an engine has been sitting for any length of time, the water pump is completely dry and the impeller will sustain immediate damage if the engine is operated without an adequate water supply. Water must be supplied to the pump through the boat's water intake or supplied under pressure from a flushing device.

CAUTION

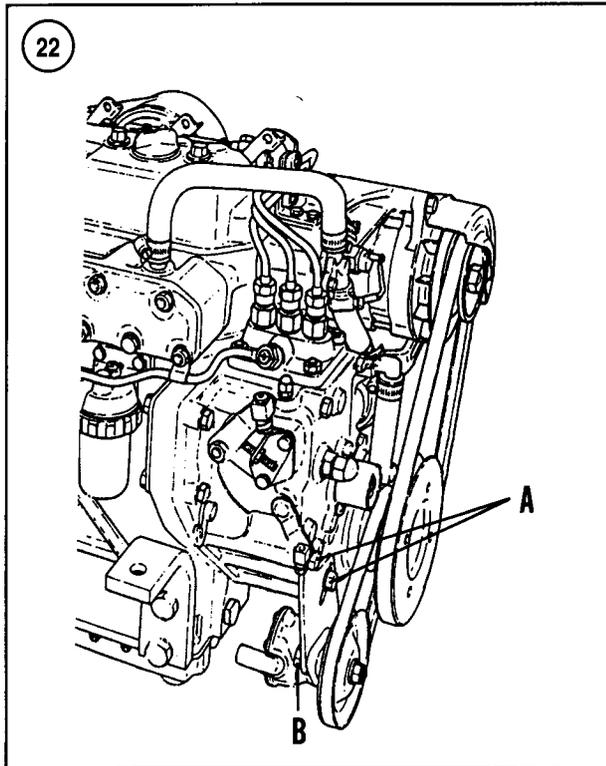
Supply the pump with an adequate water supply anytime the engine is running.

Do not crank the engine for an extended period, such as during troubleshooting. This is detrimental to a water pump that is completely dry. Consider attaching a flushing device before initially cranking an engine with a dry water pump. This will ensure the pump is wet and will not be damaged. It will not be necessary to keep the water supply flowing during all cranking periods; it is just important to keep the pump wet during extended cranking.

Removal/Installation

1GM and 1GM10

1. If the boat is in water, make sure the seacock is closed.
2. Drain the seawater from the engine as described in Chapter Four.
3. Loosen the hose clamps, then detach the water hoses from the seawater pump.
4. Remove the pump retaining screws (**Figure 21**) and remove the pump. Remove and discard the gasket, if so

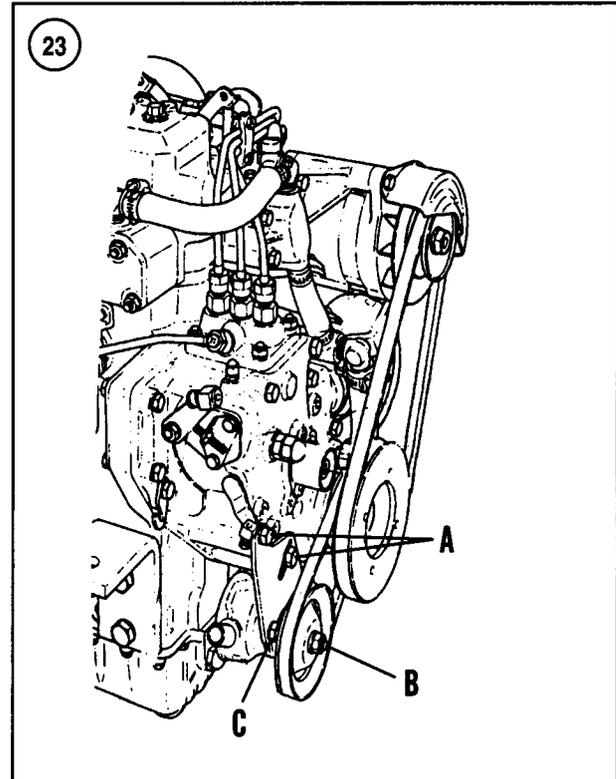


equipped. Some engines are equipped with an O-ring that seals between the pump and engine.

5. Reverse the removal steps to install the pump. Refer to **Table 1** for the tightening torque of the pump retaining screws.

2GM, 2GM20, 3GM and 3GM30

1. If the boat is in water, make sure the seacock is closed.
2. Drain the seawater from the engine as described in Chapter Four.
3. Loosen the hose clamps, then detach the water hoses from the seawater pump.
4. Loosen the seawater pump bracket and pivot bolts (A, **Figure 22**).
5. Move the seawater pump toward the engine and slip the drive belt off the pump pulley.
6. Remove the pump mounting bolts (B, **Figure 22**), then separate the pump from the mounting bracket.
7. Reverse the removal steps to install the pump. Refer to **Table 1** for the tightening torque of the pump mounting bolts. Adjust the belt tension as described in Chapter Three.



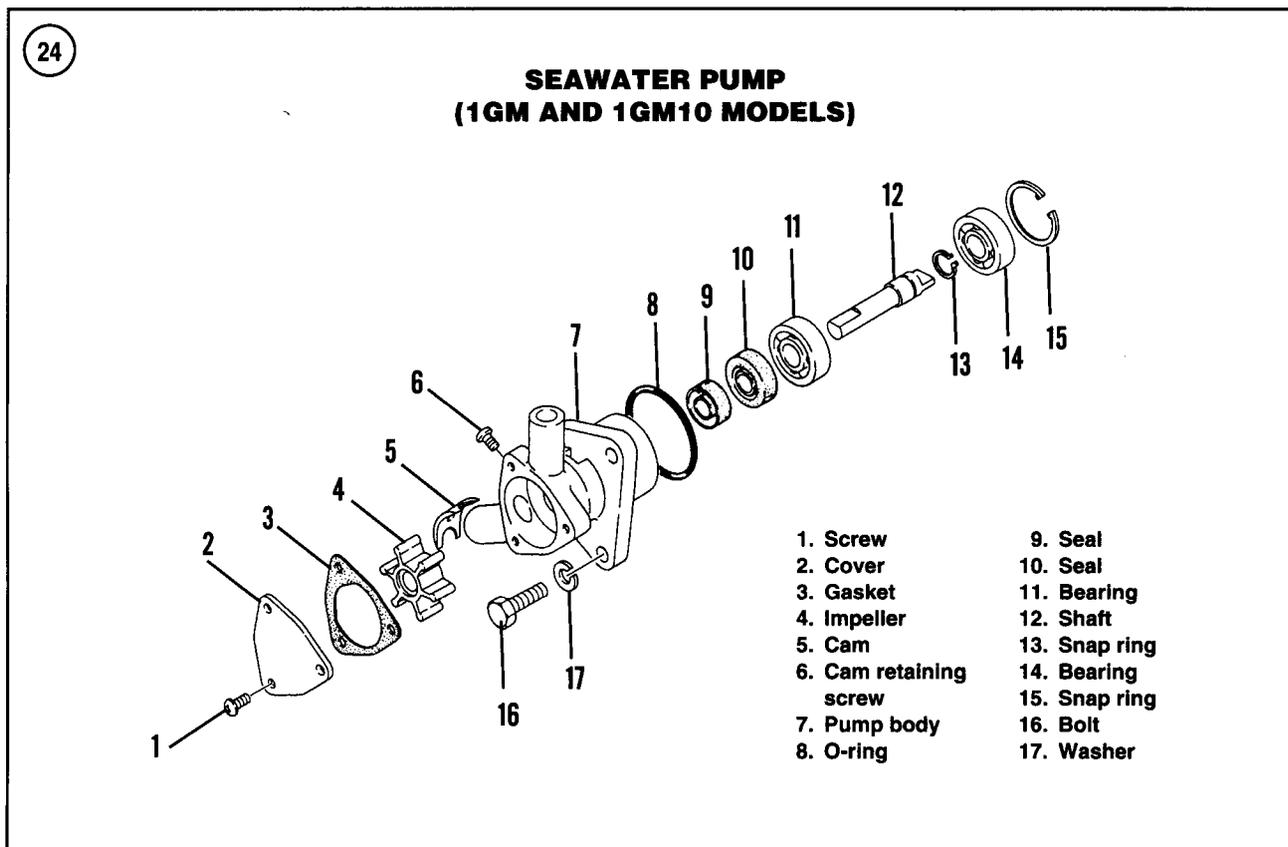
3HM and 3HM35

1. If the boat is in water, make sure the seacock is closed.
2. Drain the seawater from the engine as described in Chapter Four.
3. Loosen the hose clamps, then detach the water hoses from the seawater pump.
4. Loosen the seawater pump bracket and pivot bolts.
5. Move the seawater pump toward the engine and slip the drive belt off the pump pulley.
6. Unscrew the pulley retaining nut (B, **Figure 23**), then remove the pulley for access to the pump mounting bolts.
7. Remove the mounting bolts (C, **Figure 23**), then separate the pump from the mounting bracket.
8. Reverse the removal steps to install the pump. Refer to **Table 1** for the tightening torque of the pump mounting bolts. Adjust the belt tension as described in Chapter Three.

Disassembly/Reassembly

1GM and 1GM10

1. Remove the three screws securing the pump cover to the body (1, **Figure 24**).



2. Remove the cover (2, **Figure 24**) and gasket (3). Discard the gasket.
3. Extract the impeller (4, **Figure 24**) from the pump body.
4. Rotate the pump shaft to check the bearings for roughness, excessive wear or other damage. Do not remove the shaft assembly unless replacement is necessary.
5. Unscrew the cam retaining screw (6, **Figure 24**), then remove the cam (5).
6. Remove the snap ring (15, **Figure 24**) at the rear of the pump body.
7. Lightly tap the impeller shaft toward the rear of the pump to remove the impeller shaft and bearing assembly.

NOTE

When removing bearings, note the snap ring located between the bearings.

8. Press the bearings (11 and 14, **Figure 24**) from the pump shaft (12) using a universal press plate and arbor press. Force each bearing away from the locating snap ring (13, **Figure 24**).
9. Extract or push out the seals (9 and 10, **Figure 24**).

10. Clean all metal components with solvent, then dry them with compressed air.
11. Thoroughly clean all gasket material from all mating surfaces.
12. Inspect the pump shaft (12, **Figure 24**) for grooves in the seal contact area.
13. Inspect the impeller (4, **Figure 24**) for cracked blades or excessive wear at the tips of the blades. Replace the impeller if any defects are observed.
14. Inspect the pump body and cover for grooves or other damage. A damaged or excessively worn body or cover will reduce pump efficiency and may damage a new impeller.
15. Install the shaft seal (9, **Figure 24**) so the lip is toward the impeller side of the pump body.
16. Install the oil seal (10, **Figure 24**) so the lip is toward the bearing side of the pump body.
17. If removed, install the snap ring (13, **Figure 24**) into the groove in the impeller shaft.
18. Press the shaft bearings onto the pump shaft until they seat fully against the snap ring. Press only on the bearing inner races.
19. Install the shaft and bearing assembly into the body. Install the snap ring (15, **Figure 24**).

20. Install the cam (5, **Figure 24**) and the cam retaining screw (6).

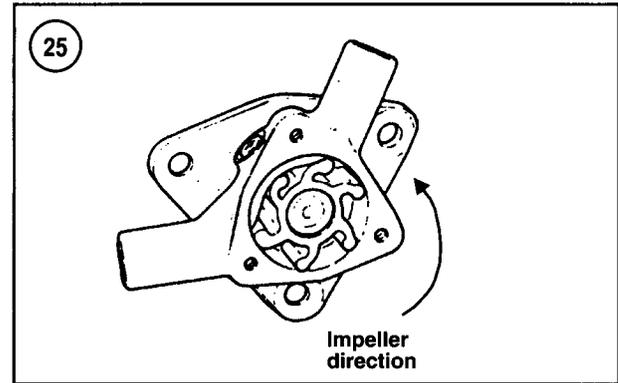
NOTE

Replace the pump impeller anytime it is removed from the pump. If the original impeller must be reused, make sure to install it in the same rotational direction as originally installed.

21. Lightly lubricate the tips and sides of the impeller. Install the impeller into the pump body by rotating the impeller counterclockwise. Be certain all impeller blades bend in the same direction (**Figure 25**).
22. Install the cover and gasket.
23. Install the three screws securing the pump cover to the body.

2GM, 2GM20, 3GM and 3GM30

1. Remove the six screws securing the pump cover (19, **Figure 26**) to the body (12).
2. Remove the cover and gasket. Discard the gasket.
3. Extract the impeller (17, **Figure 26**) from the pump body.
4. Rotate the pump shaft to check the bearings for roughness, excessive wear or other damage. Do not remove the shaft assembly unless replacement is necessary.
5. Unscrew the pulley retaining nut, then remove the pulley (3, **Figure 26**) and spacer (4).
6. Remove the snap ring (5, **Figure 26**) at the rear of the pump body.
7. Lightly tap the impeller shaft (9, **Figure 26**) toward the front of the pump to remove the impeller shaft and bearing assembly.
8. Unscrew the cam retaining screw (13, **Figure 26**), then remove the cam (16).
9. Remove the seal ring (10, **Figure 26**) and bearing cover (8) from the shaft.
10. Press the bearings from the pump shaft using a universal press plate and arbor press. Force each bearing toward the threaded end of the shaft. Note the spacer (7, **Figure 26**) between the bearings.
11. Extract or push out the seal.
12. Clean all metal components in solvent, then dry them with compressed air.
13. Thoroughly clean all gasket material from all mating surfaces.
14. Inspect the pump shaft for grooves in the seal contact area.
15. Inspect the impeller for cracked blades or excessive wear at the tips of the blades. Replace the impeller if any defects are observed.



16. Inspect the pump body and cover for grooves or other damage. A damaged or excessively worn body or cover will reduce pump efficiency and may damage a new impeller.
17. Press the bearings onto the shaft with the spacer (7, **Figure 26**) between the bearings. Seat the bearings against the shoulder on the shaft. Press only on the bearing inner races.
18. Install the seal (11, **Figure 26**) into the pump body so the lip is toward the impeller side of the body.
19. Install the cam (16, **Figure 26**), then install the cam retaining screw (13).
20. Install the bearing cover (8, **Figure 26**) with the concave side toward the bearing.
21. Install the seal ring (10, **Figure 26**) onto the shaft.
22. Install the shaft assembly into the pump body.
23. Install the snap ring (5, **Figure 26**).
24. Install the spacer (4, **Figure 26**), pulley (3), washer (2) and nut (1), then tighten the nut.

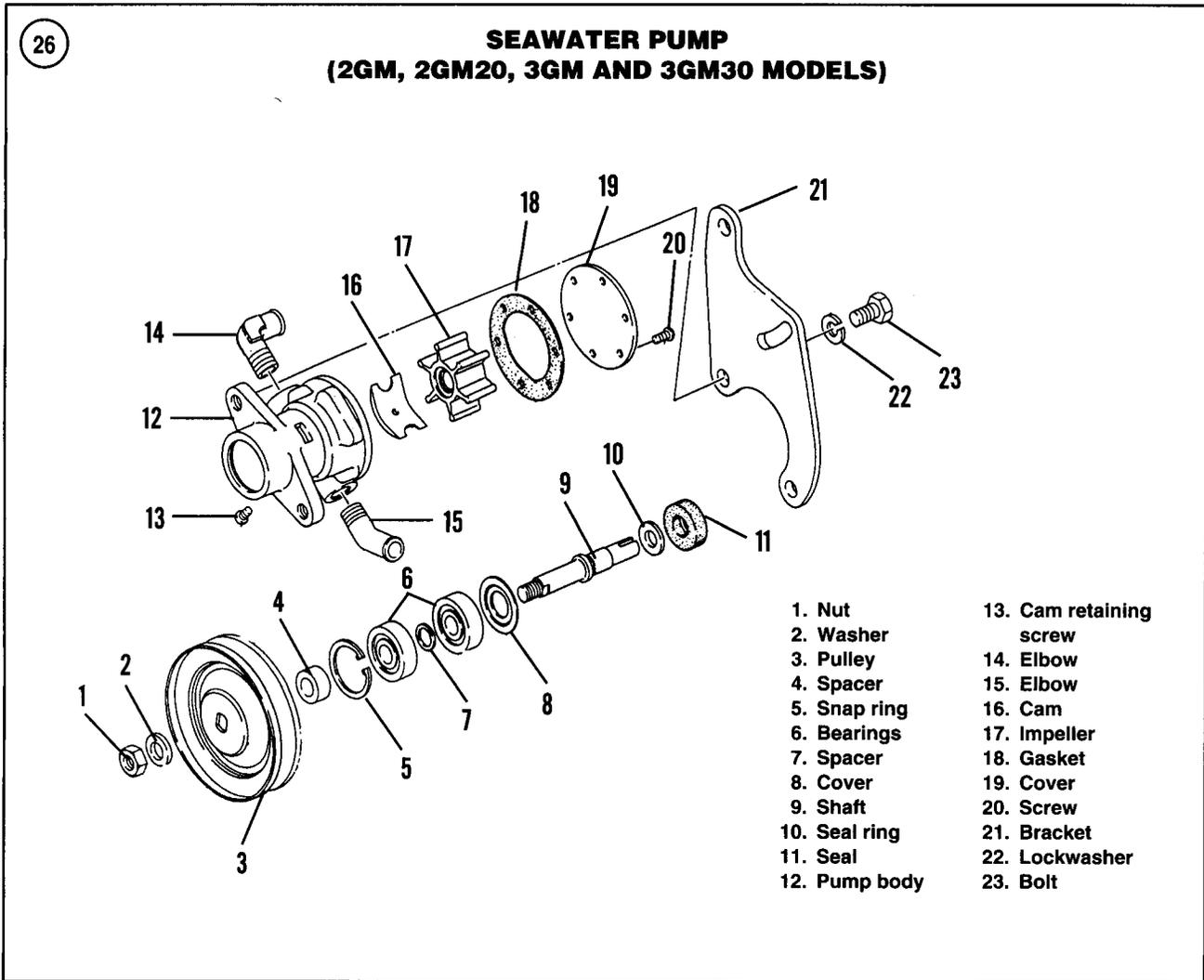
NOTE

Replace the pump impeller anytime it is removed from the pump. If the original impeller must be reused, make sure to install it in the same rotational direction as originally installed.

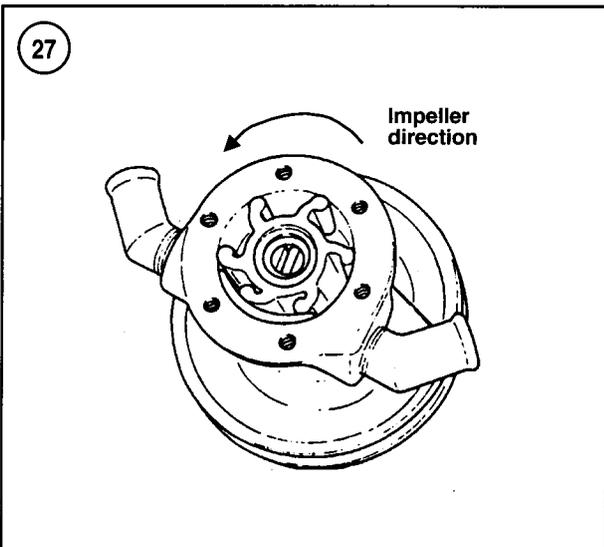
25. Lightly lubricate the tips and sides of the impeller. Install the impeller into the pump body by rotating the impeller counterclockwise. Be certain all impeller blades bend in the same direction (**Figure 27**).
26. Install the cover (19, **Figure 26**) and gasket.
27. Install the six screws securing the pump cover to the body.

3HM and 3HM35

1. Remove the six screws (19, **Figure 28**) securing the pump cover (18) to the body (12).

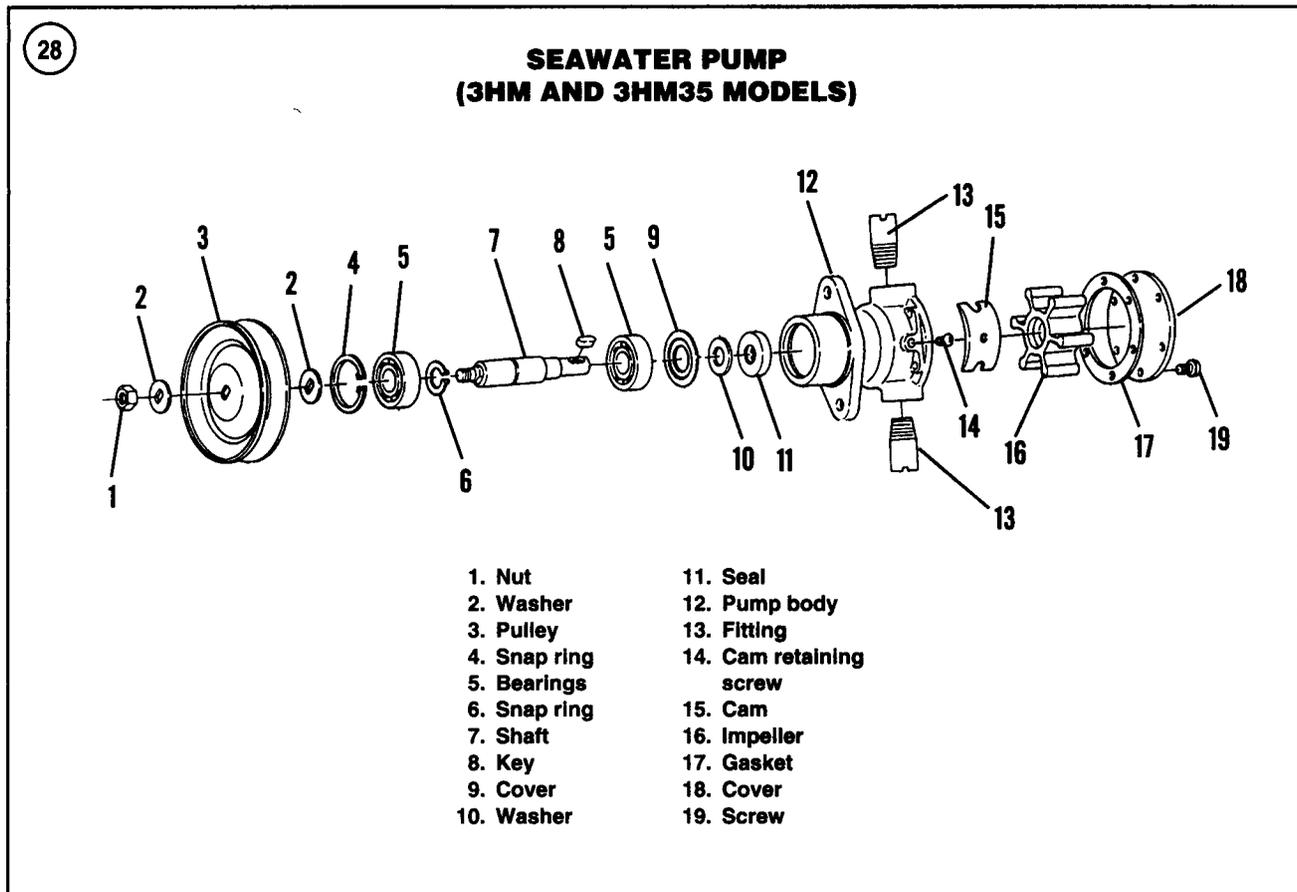


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2. Remove the cover (18, **Figure 28**) and gasket (17). Discard the gasket.
3. Extract the impeller (16, **Figure 28**) from the pump body and remove the drive key (8).
4. Rotate the pump shaft to check the bearings for roughness, excessive wear or other damage. Do not remove the shaft assembly unless replacement is necessary.
5. Remove the snap ring (4, **Figure 28**).
6. Lightly tap the impeller shaft (7, **Figure 28**) toward the front of the pump to remove the impeller shaft and bearing assembly.
7. Unscrew the cam retaining screw (14, **Figure 28**), then remove the cam (15).

NOTE
When removing bearings, note the snap ring located between the bearings.



8. Press the bearings from the pump shaft using a universal press plate and arbor press. Force each bearing away from the locating snap ring (6, **Figure 28**).

9. Extract or push out the seal (11, **Figure 28**).

10. Clean all metal components solvent, then dry them with compressed air.

11. Thoroughly clean all gasket material from all mating surfaces.

12. Inspect the pump shaft for grooves in the seal contact area.

13. Inspect the impeller for cracked blades or excessive wear at the tips of the blades. Replace the impeller if any defects are observed.

14. Inspect the pump body and cover for grooves or other damage. A damaged or excessively worn body or cover will reduce pump efficiency and may damage a new impeller.

15. Install the shaft seal (11, **Figure 28**) so the lip is toward the impeller side of the pump body.

16. If removed, install the snap ring (6, **Figure 28**) into the groove in the impeller shaft.

17. Press the shaft bearings onto the pump shaft until fully seated against the snap ring. Press only on the bearing inner races.

18. Install the bearing cover (9, **Figure 28**) with the concave side toward the bearing.

19. Install the washer (10, **Figure 28**) onto the shaft.

20. Install the shaft assembly into the pump body. Install the snap ring (4, **Figure 28**).

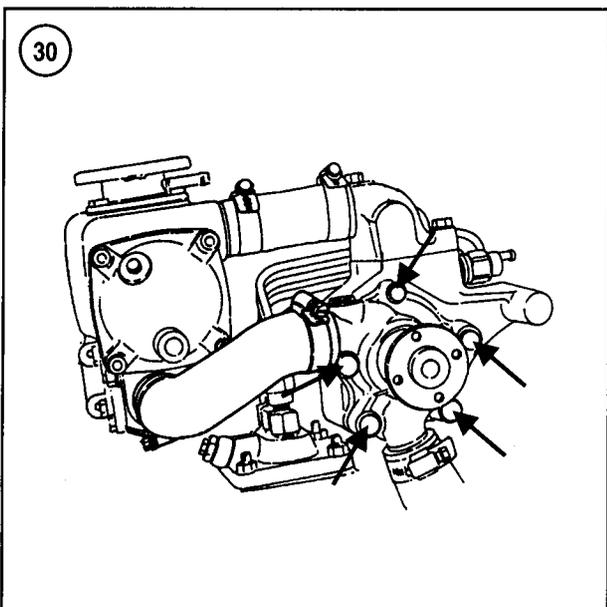
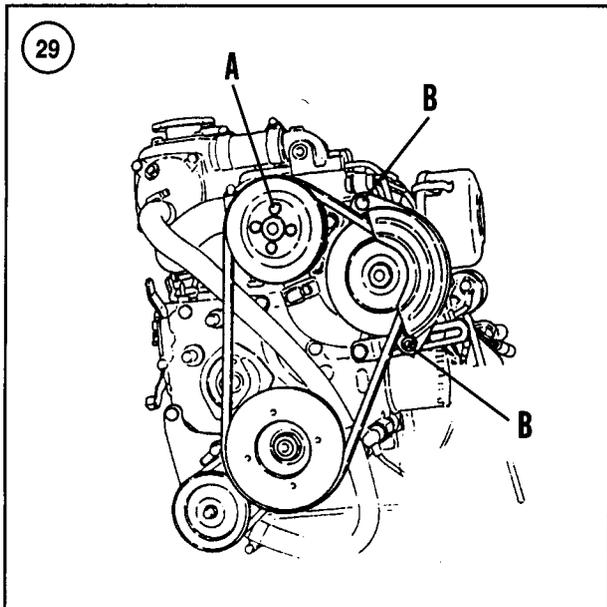
21. Install the slotted washers (2, **Figure 28**), pulley (3) and nut (1), then tighten the nut.

22. Install the impeller drive key (8, **Figure 28**) in the slot in the impeller shaft.

NOTE

Replace the pump impeller anytime it is removed from the pump. If the original impeller must be reused, be sure to install it in the same rotational direction as originally installed.

23. Lightly lubricate the tips and sides of the impeller. Install the impeller into the pump body by rotating the im-



peller counterclockwise. Be certain all impeller blades are facing the same direction (Figure 27).

24. Install the cover (18, Figure 28) and gasket.
25. Install the six screws securing the pump cover to the body.

FRESHWATER PUMP

The freshwater circulating pump may warn of impending failure by making noise. If the seal is defective, cool-

ant or water may leak from behind the pump pulley. It is recommended that the pump be replaced as an assembly. Individual replacement parts are available.

Removal/Installation

1. Drain the freshwater cooling system. Refer to Chapter Four.

NOTE

If pump pulley removal is not necessary, proceed to Step 3.

2. Loosen, but do not remove, the pump pulley retaining bolts (A, Figure 29).
3. Loosen the alternator adjusting and pivot bolts (B, Figure 29). Swivel the alternator toward the engine and remove the drive belt from the pump pulley.
4. Unscrew the pump pulley screws and remove the pulley.
5. Unclamp and disconnect the hoses from the circulating pump and detach any hose brackets that interfere with access to the water pump bolts.

NOTE

Note the length of the pump retaining bolts during removal and, if necessary, mark them according to location.

6. Remove the pump retaining bolts (Figure 30). Remove the pump and gasket. Discard the gasket.
7. Clean all gasket residue from the pump and engine block mounting surfaces.
8. Installation is the reverse of removal. Tighten the water pump fasteners to the tightening torque specified in Table 1. Adjust drive belts as described in Chapter Three. Fill the freshwater section of closed cooling systems with coolant. See Chapter Three. Start the engine and check for leaks.

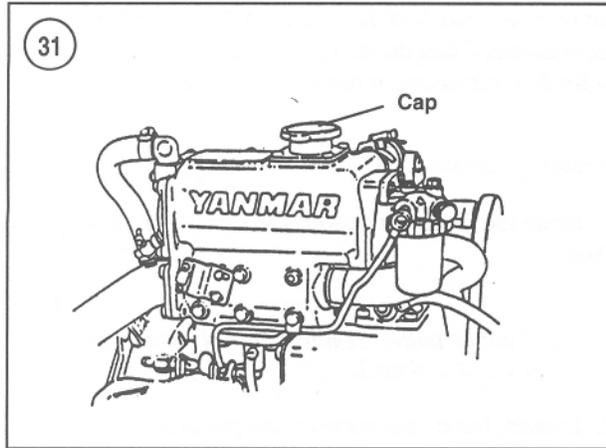
FRESHWATER COOLING SYSTEM MAINTENANCE

Pressure Testing

If the freshwater (closed) cooling system requires frequent topping off, it probably has a leak. Small leaks in a cooling system are not easy to locate; the hot coolant evaporates as fast as it leaks out, preventing the formation of tell-tale rusty or grayish-white stains.

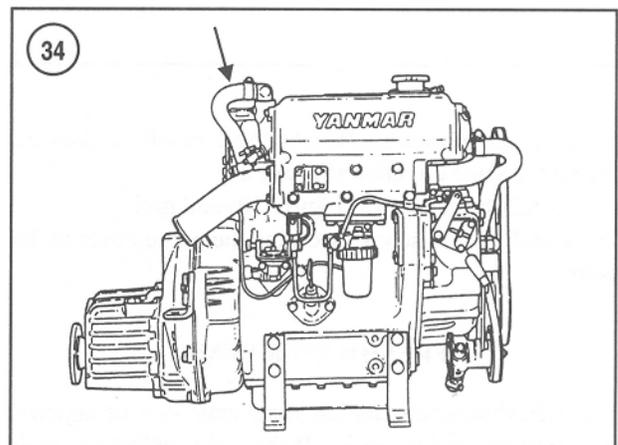
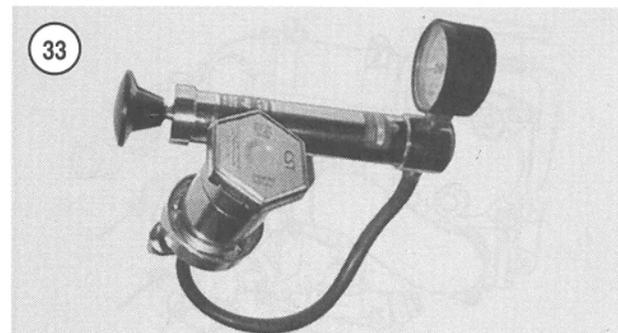
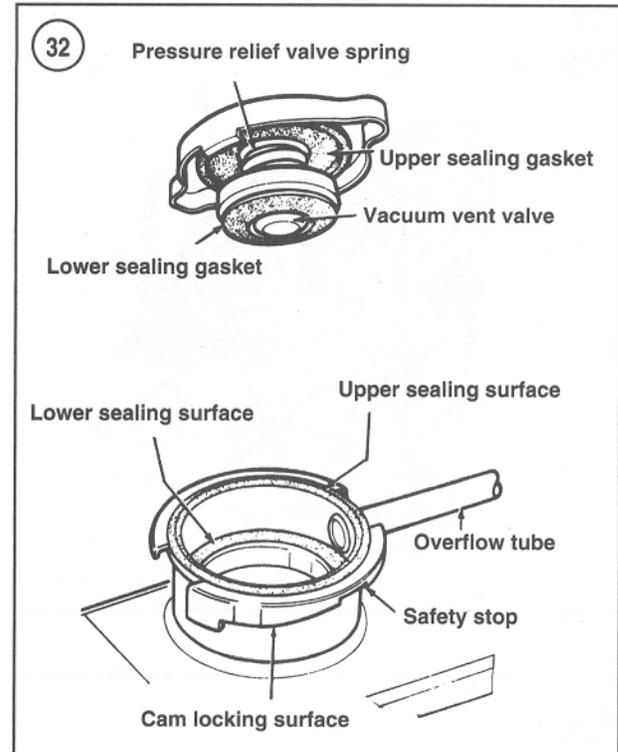
A pressure test of the freshwater section will usually help to pinpoint the source of the leak. The procedure is very similar to that used in pressure testing automotive

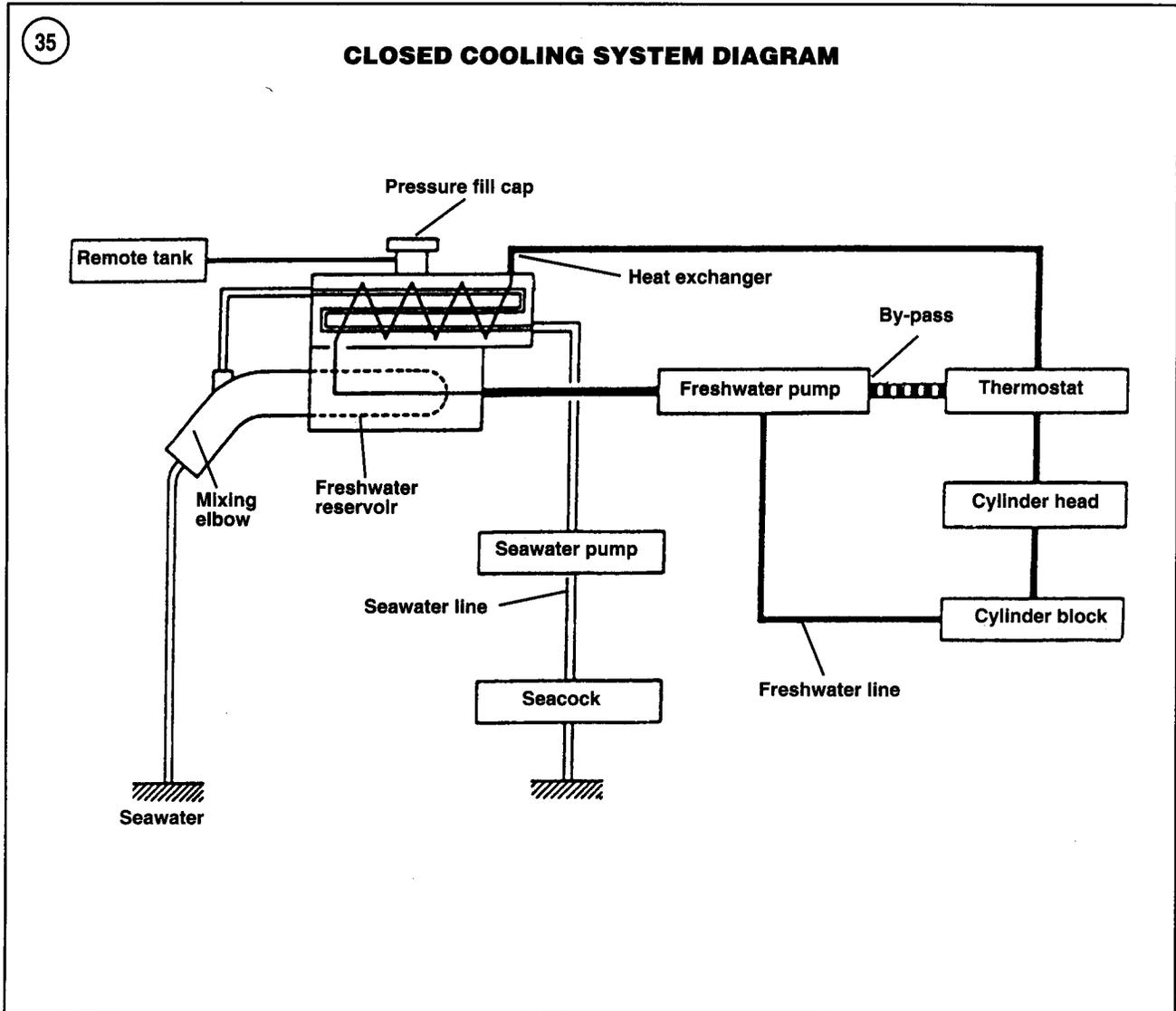




cooling systems and requires the same type of pressure tester.

1. Remove the pressure fill cap from the heat exchanger. See **Figure 31**, typical.
2. Wash the cap with clean water to remove any debris or deposits from its sealing surfaces.
3. Check the gasket, if so equipped, and rubber seal on the cap for cuts, cracks, tears or deterioration. See **Figure 32**. Replace the cap if the seal is damaged. Make sure the locking tabs on the cap are not damaged or bent.
4. Dip the cap in water and attach it to a cooling system pressure tester, using the adapters supplied with the tester. See **Figure 33**.
5. Pump the pressure to 13 psi (90 kPa). If the cap fails to hold pressure for 30 seconds without dropping under 11 psi (76 kPa), replace it.
6. Inspect the filler neck seat and sealing surface (**Figure 32**) for nicks, dents, distortion or contamination. Wipe the sealing surface with a clean cloth to remove any rust or dirt. Make sure the locking cams are not bent or damaged.
7. Check coolant level. It should be within 1 in. (25.4 mm) of the filler neck. Top off if necessary.
8. Connect the cooling system pressure tester to the filler neck and pressurize the system to 15 psi (104 kPa). If pressure does not hold constant for at least two minutes, check all hoses, gaskets, drain plugs, drain valves and other potential leak points for leakage. Listen for a hissing or bubbling sound while the system is under pressure.
9. If no leaks are found, disconnect the seawater outlet hose from the heat exchanger (**Figure 34**). Repressurize the system to 15 psi (104 kPa) and note the outlet connection on the heat exchanger. If water flows from the connection, air bubbles are visible in the water or a bubbling or hissing noise is heard, there is probably a leak between the fresh and seawater sections within the heat exchanger.





10. If no signs of leakage can be found in Step 8 or Step 9, yet the coolant level continues to require frequent topping off, there is probably an internal leak. This could be caused by a blown head gasket, loose cylinder head, or a cracked or porous head or block.

If extremely dirty or corroded, flush out the remaining deposits with a pressure flushing device. Refer to the cooling system flow diagram (Figure 35) and follow the manufacturer's instructions regarding the connection of the pressure flushing device and procedure to be followed.

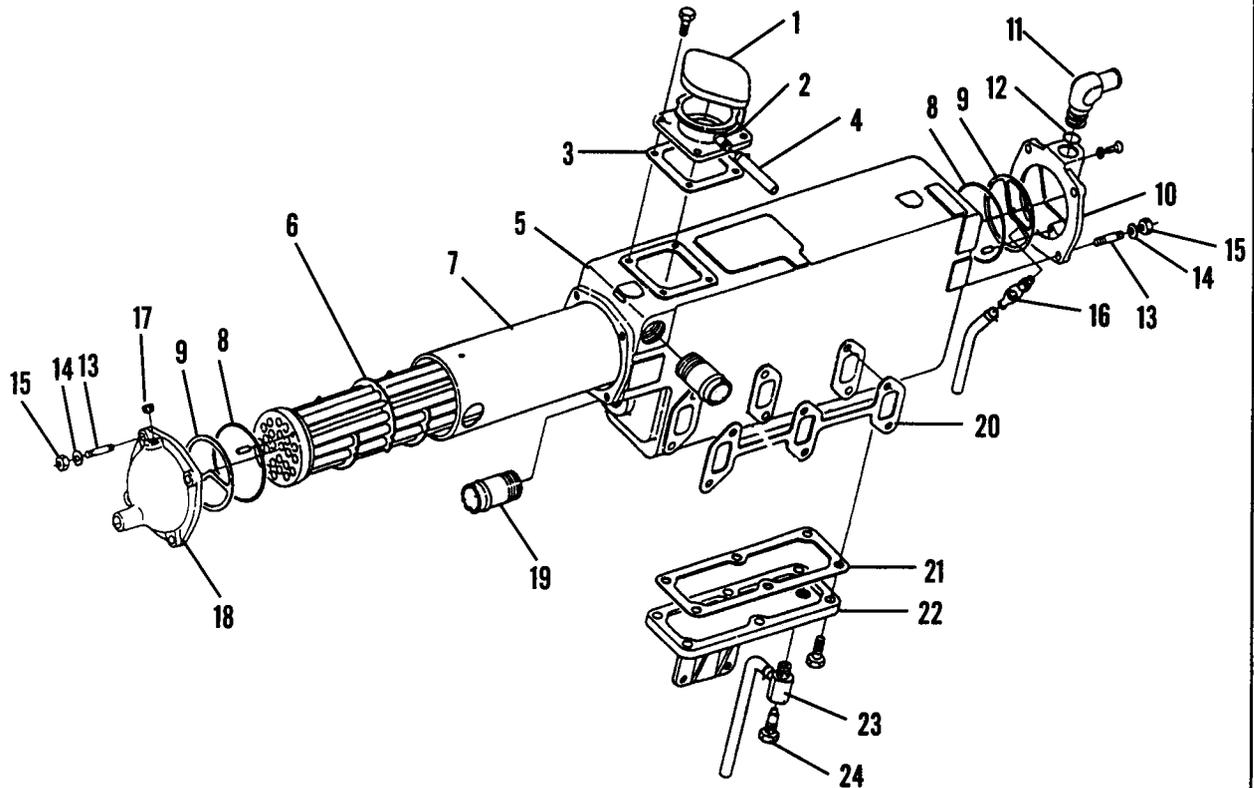
Cleaning

Flush and clean the freshwater section every other season or periodically as needed. Use any high-quality automotive cooling system cleaning solution to remove scale, rust, mineral deposits or other contamination. Use the cleaning solution according to the manufacturer's directions.

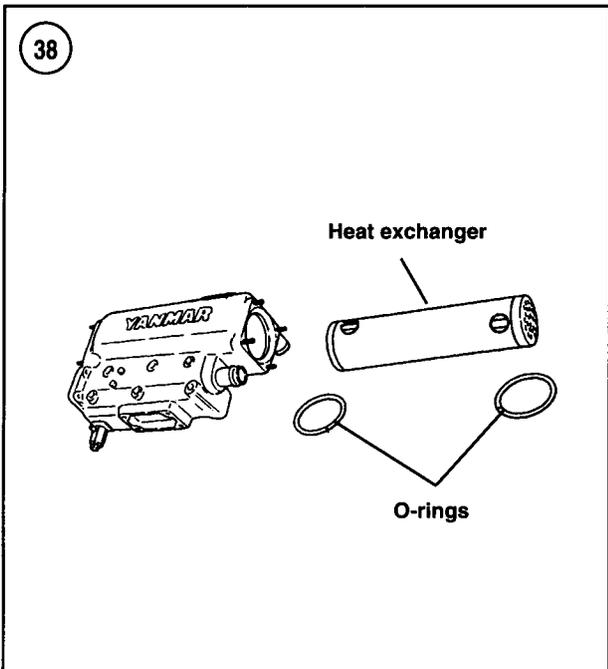
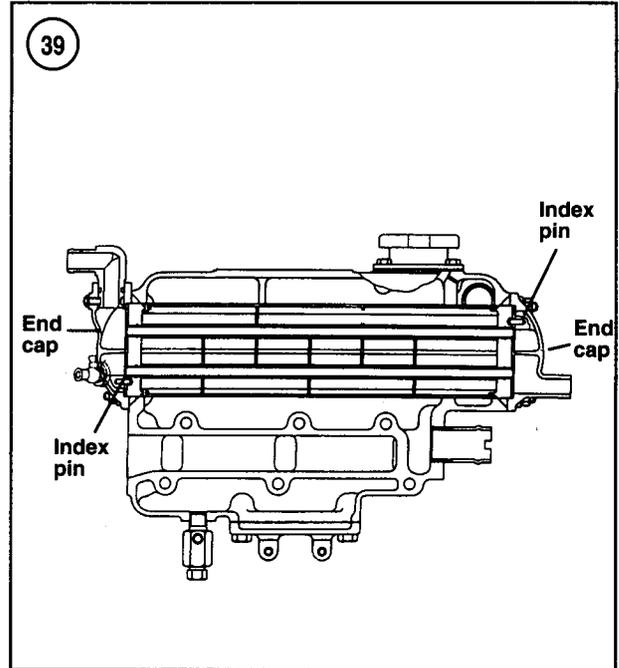
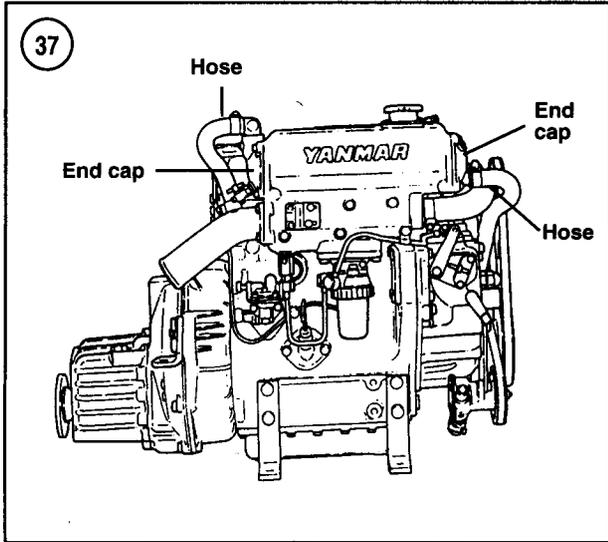
Cleaning the Seawater Section of the Heat Exchanger

Contaminants and minerals collect inside the copper tubes in the seawater section of the heat exchanger during engine operation. Such foreign material reduces the ability of the heat exchanger to operate efficiently and, if not removed periodically, will eventually lead to engine over-

36

FRESHWATER EXHAUST MANIFOLD/HEAT EXCHANGER

- | | |
|------------------------------------|-------------------|
| 1. Pressure cap | 13. Stud |
| 2. Filler neck | 14. Washer |
| 3. Gasket | 15. Nut |
| 4. Overflow tube | 16. Drain valve |
| 5. Exhaust manifold/heat exchanger | 17. Plug |
| 6. Heat exchanger core | 18. End cap |
| 7. Cover | 19. Fitting |
| 8. O-ring | 20. Gasket |
| 9. Gasket | 21. Gasket |
| 10. End cap | 22. Cover |
| 11. Elbow | 23. Drain fitting |
| 12. O-ring | 24. Drain valve |



heating. It is recommended to remove and clean the heat exchanger whenever the coolant is changed. Refer to **Figure 36**.

1. Drain both sections of the cooling system. Refer to Chapter Four. Loosen the hose clamps and disconnect the seawater inlet and outlet hoses from the end caps (**Figure 37**).
2. Remove the end cap retaining bolts.
3. Remove the heat exchanger end caps. Remove and discard the gaskets.

4. Remove the heat exchanger (**Figure 38**).

NOTE

If the heat exchanger is plugged or contains heavy scale deposits, take it to a marine dealership or automotive radiator repair shop for proper cleaning to avoid potential damage to the unit.

5. Clean all gasket residue from the end caps and heat exchanger sealing surfaces.
6. Insert an appropriate-size wire brush into each passage in the heat exchanger. Work the brush back and forth with a vigorous motion, but work carefully to avoid damage to the soldered joints.
7. Remove the brush, hold the heat exchanger vertically and blow loosened particles out with compressed air.
8. Repeat Step 6 and Step 7 as necessary to remove as much of the accumulated deposits as possible.
9. Reinstall the heat exchanger by reversing the removal procedure. Position the heat exchanger so the index pins (**Figure 39**) in both ends fit in the holes in the end caps.
10. Fill the freshwater section with coolant. Refer to Chapter Three. Start the engine and check for leaks.

SEAWATER COOLING SYSTEM MAINTENANCE

The only maintenance required for the seawater cooling system is periodic flushing. Refer to Chapter Three.

Table 1 TIGHTENING TORQUES

Fastener	N•m	ft.-lb.	in.-lb.
Seawater pump 1GM, 1GM10	9	–	80
All other models	25	18	–
Freshwater pump	20-25	–	177-221

Table 2 RECOMMENDED THERMOSTAT

Model	Opening temperature	Full open temperature
All engines		
Seawater system	108° F (42° C)	126° F (52° C)
Freshwater system	160° F (71° C)	185° F (85° C)