Table 1 ENGINE TROUBLESHOOTING (continued)

Trouble	Probable cause	Correction
Engine stops suddenly (continued)	Governor malfunction	Repair governor
	Engine seized	Inspect and repair
Engine slows unexpectedly	Overload	Locate cause for overload and rectify
	Fuel filter or fuel lines clogged	Inspect and unclog or replace
	Air in fuel system	Bleed air in fuel system
	Water in fuel	Remove water
	Misadjusted governor	Adjust governor
	Piston or bearing seizure	Repair damaged components; determine cause
Engine will not run under full load	Clogged fuel filter	Clean fuel filter
	Faulty fuel feed pump	Repair fuel feed pump
	Worn fuel injection pump	Repair or replace fuel injection pump
Engine knocks	Excessive bearing clearance	Inspect and repair
	Loose rod bolt	Inspect and repair
	Loose flywheel or coupling bolt	Tighten bolt
	Incorrect injection timing	Adjust timing
	Excessive fuel injected into cylinder	Inspect fuel injection pump and injectors
Low oil pressure	Oil leaks	Inspect and repair
	Excessive bearing clearance	Inspect and repair
	Clogged oil filter element	Clean or replace filter element
	Faulty oil pressure regulator valve	Repair oil pressure regulator valve
	Low oil viscosity	Replace oil; check for dilution due to fuel leaking into crankcase
Overheating	Dirty cooling system	Flush cooling system
	Faulty thermostat	Replace thermostat
	Insufficient coolant flow	Check water pump; check for blockage in system
	Insufficent coolant in closed system	Fill with proper coolant
	Air entering system	Check for loose clamps and damaged hoses

Table 2 STARTER MOTOR NO-LOAD SPECIFICATIONS

Model	Volts	Max. amperage	Speed (rpm)
3HM, 3HMF, 3HM35	12	90	4000 or higher
All other models	12	60	7000 or higher

Table 3 OIL PRESSURE

At 850 rpm	
all models	50 kPa (7 psi)
At 3400 rpm	
3HM and 3HM35	300-400 kPa (43-58 psi)
At 3600 rpm	
all models	
except 3HM and 3HM35	300-400 kPa (43-58 psi)

Chapter Three

Operation, Lubrication, Maintenance and Tune-up

A diesel engine *must have* clean air, fuel, and oil. Regular preventive maintenance and proper lubrication will pay dividends in longer engine and transmission life, as well as safer boat operation.

The lubrication and maintenance intervals provided in **Table 1** are those recommended for normal operation. If the boat is used under continuous heavy duty or other severe operating conditions, including infrequent use, perform maintenance and lubrication more frequently.

Keep the engine and accessory units clean and free of dirt, grime and grease buildup. It is much easier and safer to perform service on a clean engine. It is also much easier to pinpoint any leaks.

Tables 1-6 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.

FUEL REQUIREMENTS

The recommended fuel is number 2 (2-D) diesel fuel. Be sure the fuel is clean and free of water.

NOTE

Poor fuel is one of the leading causes of rough engine operation or failure to start.

Dirty fuel or water in the fuel can cause expensive damage to the fuel injection pump and fuel injectors. Refer to Chapter Seven.

PREOPERATIONAL CHECKS

Before starting the engine for the first time each day, perform the following checks:

1. Remove the engine compartment cover or hatch and check for the presence of fuel fumes. If the boat is equipped with a bilge blower, turn it on for a few minutes. If the smell of strong fumes is present, determine the source and correct the problem before proceeding.

WARNING

Always have a Coast Guard-approved fire extinguisher close when working around the engine.

2. Check the engine oil level as described in this chapter. Add oil if the level is low.
3. Check the electrolyte level in each battery cell as described in this chapter. Add distilled water if necessary.

4. Check the condition of all drive belts. If a belt is in doubtful condition, replace it.
5. Check all water hoses for leaks, loose connections and general condition. Repair or replace as required.
6. Check the oil level in the transmission as described in this chapter. Add lubricant if necessary.
7. Check the bilge for excessive water; if present, drain or pump dry.
8. Check the propeller for damage. Repair or replace the propeller if damaged.
9. Remove any water or dirt in the fuel tank by opening the fuel tank drain valve.
10. Check the fuel level in the fuel tank and add fuel as needed.
11. Open the seacock and close any water drain valves.
12. Operate controls and check for free operation.
13. Connect the battery cables to the battery (if disconnected).
14. Open the fuel tank valve.
15. Reinstall the engine compartment cover or hatch.

STARTING CHECKLIST

After performing the preoperational checks, observe the following starting procedure:

Engines Without Remote Control

1. If equipped with a bilge blower, operate it for at least five minutes before starting the engine.
2. Move the clutch control lever to the NEUTRAL position.
3. Move the speed control lever to the MEDIUM SPEED position.
4. Hold the decompression lever in the OPERATION position.
5. Rotate the key switch to the ON position. The alarm buzzer will come on.

WARNING

Always have a fully charged fire extinguisher on hand before attempting to start the engine.

CAUTION

Do not operate the starter for more than 15 seconds, or the starter motor may be damaged due to overheating.

6. Start the engine by pushing the start button. The alarm lights and buzzer should go off.

CAUTION

If the alarm buzzer or lamps remain on after the engine starts, stop the engine and determine the cause.

Engines Equipped With Remote Control

Warm engine

1. If equipped with a bilge blower, operate it for at least five minutes before starting the engine.
2. Move the speed control lever to the MEDIUM SPEED position.
3. Rotate the key switch to the ON position. The alarm buzzer will come on.

WARNING

Always have a fully charged fire extinguisher on hand before attempting to start the engine.

CAUTION

Do not push the starter for more than 15 seconds, or the starter motor may be damaged due to overheating.

4. Start the engine by pushing the start button. The alarm lights and buzzer should go off.

CAUTION

If the alarm buzzer or lamps remain on after the engine starts, stop the engine and determine the cause.

Cold engine

1. If equipped with a bilge blower, operate it for at least five minutes before starting the engine.
2. Move the speed control lever to the HIGH SPEED position. Injection timing is retarded when starting with the lever in the HIGH SPEED position.
3. Move the decompression lever to the DECOMPRESSION position.
4. Rotate the key switch to the ON position. The alarm buzzer will come on.

WARNING

Always have a fully charged fire extinguisher on hand before attempting to start the engine.

CAUTION

Do not operated the starter for more than 15 seconds, or the starter motor may be damaged due to overheating.

5. Start the engine by pushing the start button. While engaging the starter, move the decompression lever to the COMPRESSION position. The alarm lights and buzzer should go off.

CAUTION

If the alarm buzzer or lamps remain on after the engine starts, stop the engine and determine the cause.

6. Move the speed control lever to the MEDIUM SPEED position.
7. Allow the engine to warm for approximately five minutes before applying full load to the engine.

STOPPING THE ENGINE

Note the following items when stopping the engine.
1. Place the transmission in neutral, then allow the engine to idle for five minutes before stopping the engine.
2. Momentarily raise engine speed to blow out any residue in the cylinders, then pull the engine stop knob or lever.

CAUTION

Do not stop the engine using the decompression lever. Doing so may leave sufficient fuel in the cylinders to damage the engine when started.

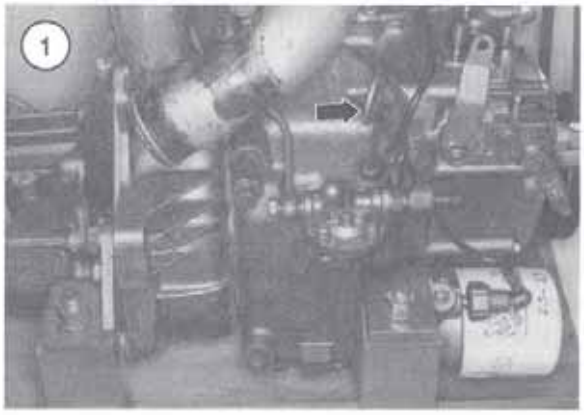
3. Close the seacock. If ambient temperature is below freezing while the engine is not running, drain water in cooling system after engine has cooled.

EMERGENCY ENGINE STOPPING

To safely stop a diesel engine when the normal stopping controls are inoperative or ineffective, block the engine's air intake. A flat plate is desirable if it will adequately cover the opening. A rag may also be used, but do not allow the rag to enter the engine.

POST-OPERATIONAL CHECKS

Perform the following maintenance after each use.
1. If the boat was used in salt or polluted water, flush the cooling system with freshwater as described in this chapter. This will minimize corrosion and buildup of deposits in the cooling system.
2. Disconnect the battery cables from the battery, negative cable first. Remove the battery from the boat to prevent theft, if necessary.
3. Shut off the fuel tank valve(s).



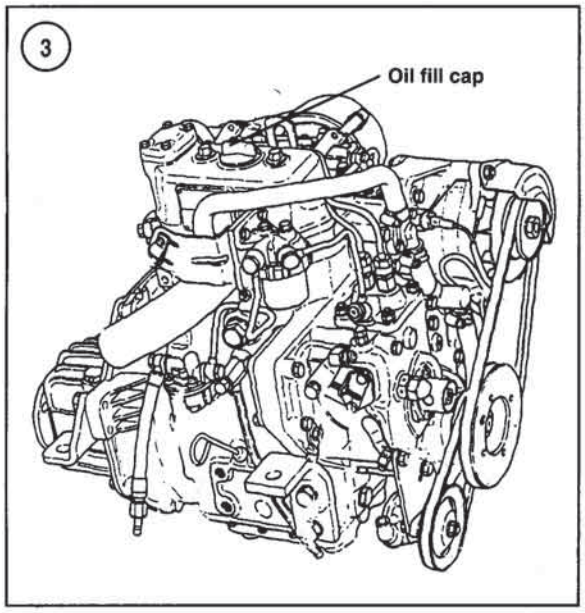
4. Top off the fuel tank(s), if possible. This will minimize the possibility of moisture condensation in the tank(s).
5. If water is present in the bilge, either drain it or pump it dry.
6. Wash the interior and exterior surfaces of the boat with freshwater.

ENGINE MAINTENANCE AND LUBRICATION

The maintenance tasks discussed in this section should be performed at the intervals indicated in **Table 1**. These intervals are only guidelines, however. Consider the frequency and extent of boat use when establishing the actual intervals. Perform the tasks more frequently if the boat is used under severe service conditions.

Engine Oil

Engine oil designed for use in diesel engines must meet specifications particular to diesel engine operation. The Society for Automotive Engineers (SAE) specifies the



criteria that engine oils must meet to attain a diesel engine oil classification of CA, CB, CC or CD. The classification system ranges from CA for light diesel engine service to CD for severe diesel engine service. Yanmar specifies engine oils with classification CB or CC for use in the Yanmar diesel engines covered in this manual.

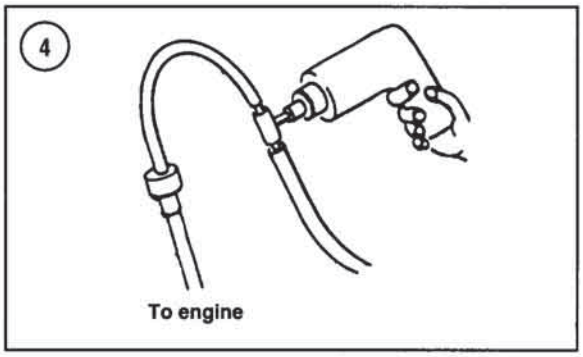
Do not mix oil brands. For instance, do not add a different oil brand than what is in the crankcase when topping off the oil level, except if necessary. Use only a high-quality oil. Yanmar recommends Shell Rotella, Caltex RPM Delo, Mobil Delvac, Esso Standard and BP Energol.

Refer to **Table 2** for the recommended oil viscosity.

Engine Oil Level Check

All engines will consume a certain amount of oil as a lubricating and cooling agent. The amount depends on engine use and engine condition. During the engine break-in period, the engine consumes more oil while the piston rings seat in the cylinder bore. Engines with high hours of use may burn more oil due to worn engine components. Engines generally consume more oil at higher engine speeds.

When to check engine oil is generally determined by the engine's oil consumption rate. If the engine has a high oil consumption rate, then check the oil level before each use or daily. If engine oil consumption is low, check the oil level weekly. The best procedure is to check the oil level before operating the engine.



Whenever checking the oil level, always allow approximately five minutes for the oil in the upper end to drain back into the crankcase oil pan.

1. With the boat at rest in the water and the engine off, pull out the dipstick. See **Figure 1** for the typical location. Wipe it with a clean rag or paper towel, reinsert it and pull it out again. Note the oil level on the dipstick.
2. Add oil, if necessary, so the oil level reaches the full mark on the dipstick. Remove the oil fill plug (**Figure 2**) or oil filler cap (**Figure 3**) and add oil through the hole in the rocker arm cover.

Engine Oil and Filter Change

During normal engine operation, change the engine oil after every 100 hours of operation. Replace the engine oil filter after every 300 hours of operation. During break-in of a new or overhauled engine, change the engine oil after the first 20 hours of use, then after the next 30 hours of use. Change the engine oil at normal intervals thereafter.

Refer to the *Engine Oil* section in this chapter for the recommended oil type. Refer to **Table 2** for viscosity and **Table 3** for crankcase oil capacity.

Most installations do not leave enough space to permit the use of the oil pan drain plug. For this reason, an oil drain suction pump is the most common device used to drain the crankcase oil. The pump has a long, flexible hose, which is inserted into the oil dipstick tube and fed into the crankcase. Several makes of pumps are available from marine supply dealers. Some are hand-operated, some are motorized and others are designed to be operated with an electric drill (**Figure 4**).

Direct the used oil into a sealable container and properly dispose of it.

NOTE

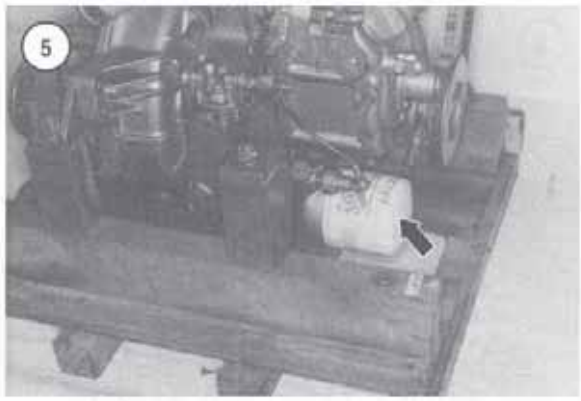
Never dispose of motor oil in the trash, on the ground, down a storm drain or overboard. Many service stations accept used

motor oil and waste haulers provide curbside used motor oil collection. Do not combine other fluids with motor oil to be recycled. To locate a recycler, contact the American Petroleum Institute (API) at ***www.recycleoil.org****.*

The oil filter is a disposable spin-on type. An oil filter wrench can be used to remove the filter, but do not use it to install the new filter. Overtightening the filter may cause it to leak.

The installed angle of the engine affects oil level in the crankcase. To assure that the oil is drained and replaced properly, perform the following procedure with the boat at rest in the water.

1. Start the engine and warm it to normal operating temperature under load, then shut it off.
2. Remove the dipstick and wipe it clean with a lint-free cloth or paper towel.
3. Insert the oil drain pump hose into the dipstick tube as far as it will go.
4. Insert the other pump hose into a sealable container large enough to hold the oil from the crankcase. Refer to **Table 3** to determine the capacity of the engine crankcase.
5. Operate the pump until it has removed all of the oil possible from the crankcase. Remove the pump hose from the dipstick tube.
6. Place a drain pan or other suitable container under the filter (**Figure 5**) to catch any oil spillage when the filter is removed.
7. Unscrew the filter counterclockwise. Use the filter wrench if the filter is tight.
8. Wipe the gasket surface on the engine block clean with a paper towel.
9. Coat the neoprene gasket on the new filter with a thin coat of clean engine oil.
10. Screw the new filter onto the engine by hand until the gasket just touches the engine block. At this point, there will be a very slight resistance when turning the filter.
11. Tighten the filter another 2/3 turn by hand. Using a filter wrench can lead to overtightening the filter. This can damage the filter or cause an oil leak.
12. Remove the oil filler cap or plug from the rocker arm cover. See **Figure 2** (single cylinder models) or **Figure 3** (multicylinder models).
13. Reinstall the dipstick in the dipstick tube.
14. Refer to **Table 3** to determine the crankcase capacity of the engine. Pour the specified amount of oil into the rocker arm cover opening and install the oil filler cap or plug. Wipe up any spills on the cover.



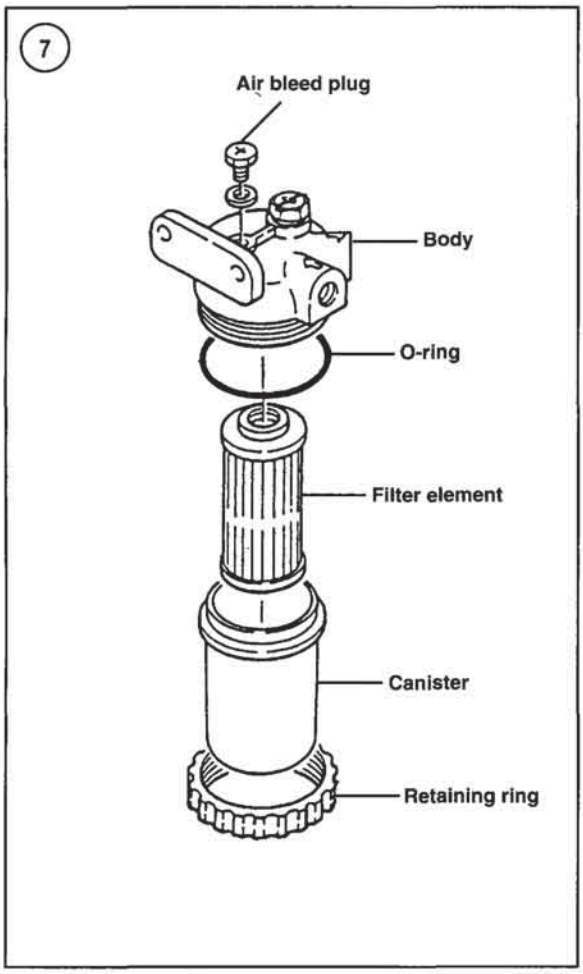
NOTE

Check the area under and around the oil filter for leaks while the engine is running in Step 15.

15. Start the engine and let it idle for five minutes, then shut off the engine.
16. Wait approximately five minutes, then remove the dipstick. Wipe the dipstick clean with a lint-free cloth or paper towel and reinsert it in the dipstick tube. Remove the dipstick a second time and check the oil level. Add oil, if necessary, to bring the level up to the full mark, but do not overfill.

Fuel System Service

Diesel fuel injection systems require clean fuel that meets the fuel requirements specified by the engine manufacturer. Due to the close tolerances required in the fuel injection system, diesel engines are particularly susceptible to dirt or other contaminants in the fuel. Use only clean



fuel and maintain the fuel filter and fuel system components to prevent a fuel system malfunction.

WARNING

Serious fire hazards always exist around diesel fuel. Do not allow any smoking in areas where fuel is present. Always have a fire extinguisher, rated for fuel and electrical fires, on hand when refueling or servicing any part of the fuel system.

Fuel lines

Periodically inspect all fuel lines for leakage and damage. Replace or tighten them as required. Do not overtighten a fitting to try to stop a leak; overtightening may damage the fitting threads or the fuel line sealing surfaces.

Air that enters the fuel system due to a damaged fuel line or loose connection may cause the engine to missfire. Bleed the fuel system as described in this chapter.

Fuel filter

Using clean fuel and maintaining the fuel system are extremely important when operating a diesel engine. Diesel fuel, in addition to its obvious function as fuel, provides lubrication for various components of the injection system. Due to close operating tolerances, dirty fuel can cause major damage to the fuel injection pump and injectors. The engine is equipped with a fuel filter (**Figure 6**, typical) to remove dirt from the fuel before it enters the fuel injection pump.

After every 50 hours of operation, or more frequently if necessary, remove and disassemble the fuel filter and clean the inside of the fuel bowl and filter element. The filter body contains a replaceable element. Replace the element after every 250 hours of operation or more frequently if dirt clogs the element after fewer hours of operation. It is a good practice to replace the fuel filter every season or if the engine has not been operated for an extended period.

NOTE

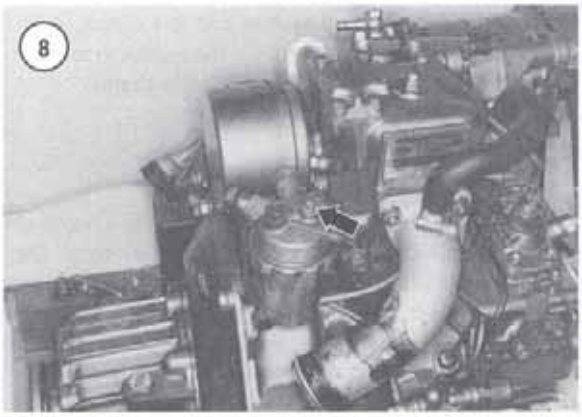
The boat may be equipped with additional fuel filters. Be sure to clean and maintain those filters according to the manufacturer's instructions.

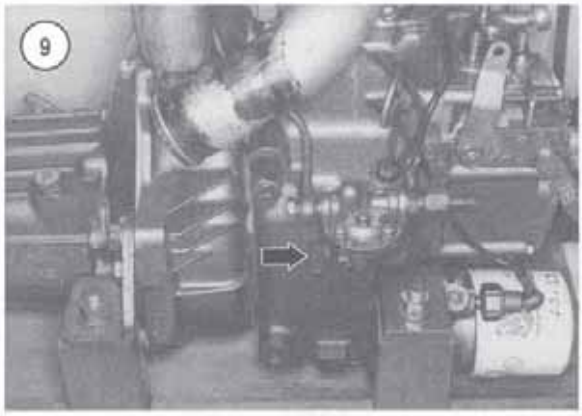
NOTE

If the fuel filtering system is inadequate to properly protect the engine, consult with a marine dealership that has experience with diesel engines for fuel filter recommendations.

Refer to **Figure 7** when using the following procedure to clean the filter or replace the filter element:

1. Position a receptacle under the filter to catch spilled fuel.
2. Unscrew the retaining ring and remove the canister and filter element. Note that the O-ring may remain on the filter body or on the canister.
3. Remove the element from the canister. If dirty or damaged, discard the element.
4. Clean the canister in clean diesel fuel.
5. Install the filter element in the canister.
6. Install a new O-ring on the canister.
7. Install the canister on the filter body, then install the retainer ring and tighten it hand-tight.





8. Loosen the air bleed plug (**Figure 8**) on top of the fuel filter body.

9. Make sure the fuel tank valve is open, then operate the primer lever on the fuel transfer pump (**Figure 9**).

10. Operate the lever while observing the fuel emitted around the bleed plug. Air will be emitted along with the fuel. Stop operating the lever when the fuel is free of air, then tighten the air bleed plug.

Bleeding air from the fuel system

Whenever air enters the fuel injection system, such as when the fuel tank runs dry, components are replaced, or a fuel line is damaged or disconnected, bleed the air from the fuel system to prevent engine misfire. Refer to Chapter Seven for the air bleeding procedure.

Air Filter

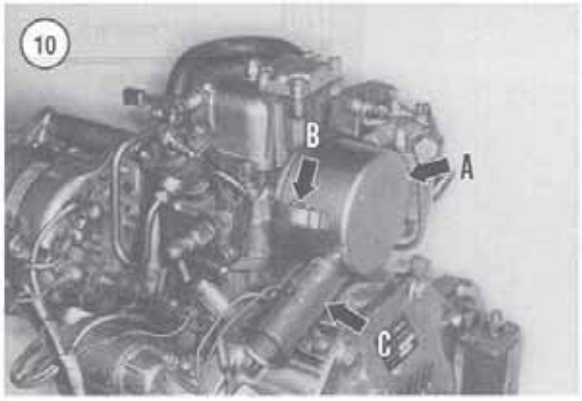
An air filter (A, **Figure 10**, typical) removes airborne dirt and debris. Within the air filter canister is a reuseable polyurethane filter element. Clean the filter element after every 250 hours of operation or more frequently if the engine operates in a dirty environment. Inspect the filter element before each operating season to be sure it is clean and undamaged.

Use the following procedure to remove and clean the filter element:

1. Unsnap the filter canister retaining clip (B, **Figure 10**) and remove the canister and filter element.

2. Separate the filter element from the canister (**Figure 11**). Note the mesh cone inside the foam filter.

3. Inspect the foam for holes, tears or other damage. Discard the foam if damaged.



4. Clean the foam filter and mesh cone in soapy water. If the foam filter cannot be cleaned, discard it and install a new filter. Let the foam filter dry.

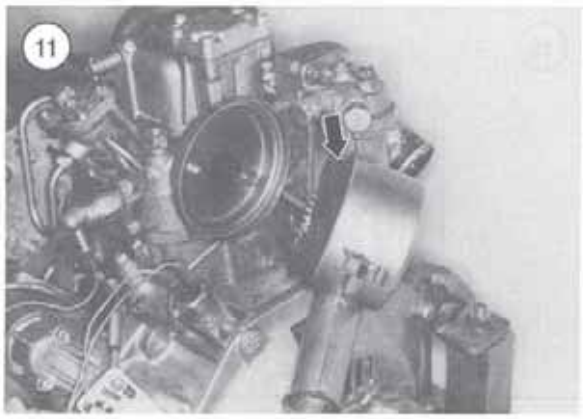
5. Reassemble and reinstall the filter by reversing the removal procedure.

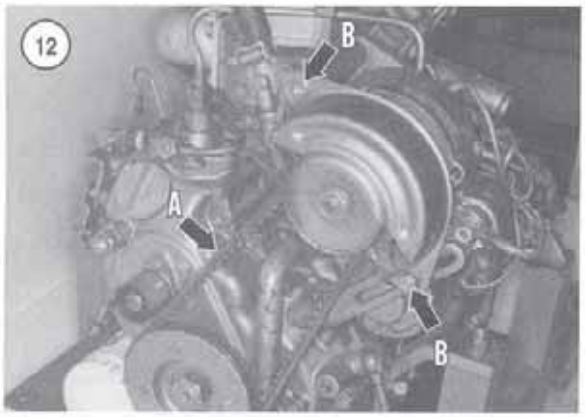
NOTE

*Be sure the intake tube (C, **Figure 10**) of the canister points slightly downward and not upward; otherwise, water can enter the tube and run into the filter.*

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. 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



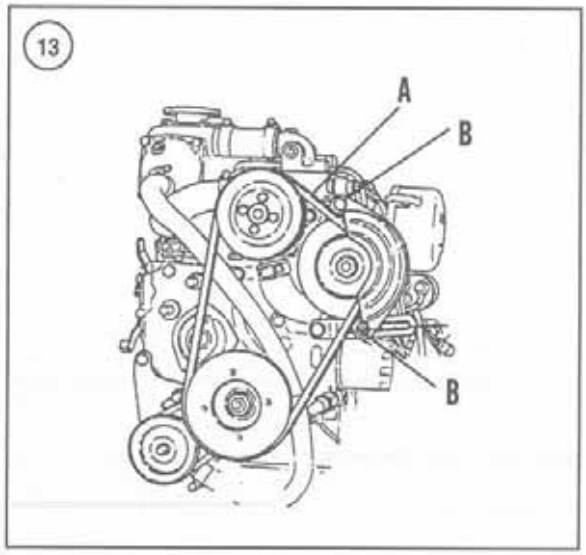


outer belt), it is a good idea to replace all belts as a set. The added expense is small compared to the cost of replacing the belts individually, and replacing each belt reduces the possibility of a breakdown on the water, which could cost far more in time and money.

Make sure the drive belts are properly tensioned at all times. If loose, the belts will not drive the driven components 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 water pump or alternator bearings, resulting in premature failure.

Alternator drive belt adjustment (models equipped with seawater cooling)

1. Check alternator drive belt tension by depressing the drive belt at the midway point on the belt (A, **Figure 12**). The belt should deflect approximately 0.4 inch (10 mm) with moderate finger pressure.



2. To adjust alternator drive belt tension, loosen the alternator retaining nuts (B, **Figure 12**), then reposition the alternator. Retighten the retaining bolts and recheck belt tension.

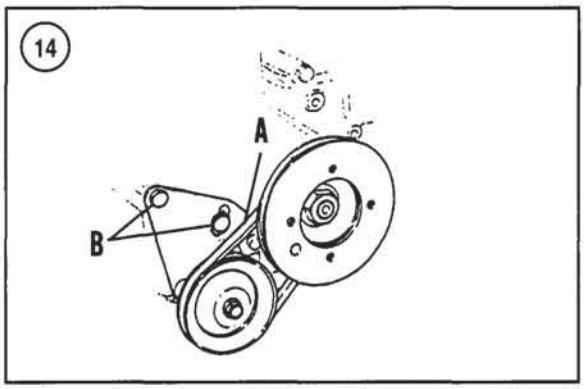
Alternator drive belt adjustment (models equipped with freshwater cooling)

The alternator drive belt also drives the freshwater cooling pump on engines so equipped.

1. Check alternator drive belt tension by depressing the drive belt at the midway point on the belt (A, **Figure 13**). The belt should deflect approximately 0.4 in (10 mm) with moderate finger pressure.
2. To adjust alternator drive belt tension, loosen the alternator retaining bolts (B, **Figure 12**), then reposition the alternator. Retighten the retaining bolts and recheck belt tension.

Seawater pump drive belt adjustment (2GM, 2GM20, 3GM, 3GM30, 3HM And 3HM35 models)

1. Check seawater pump drive belt tension by depressing the drive belt at the midway point on the belt (A, **Figure 14**). The belt should deflect approximately 0.24 in (6 mm) with moderate finger pressure.
2. To adjust seawater pump drive belt tension, loosen the screws (B, **Figure 14**) that retain the water pump mounting plate. Reposition the plate to obtain the correct belt tension, then retighten the bolt and nut. Recheck belt tension.



Alternator drive belt replacement (all models)

1. Loosen the alternator retaining nuts (B, **Figure 12**).
2. Move the alternator inward sufficiently to allow removal of the belt from the pulleys and remove the belt.
3. Clean the pulley grooves so they are dry and free of rust or other corrosion.
4. Place the new belt in the pulley grooves.
5. Adjust belt tension as previously described.

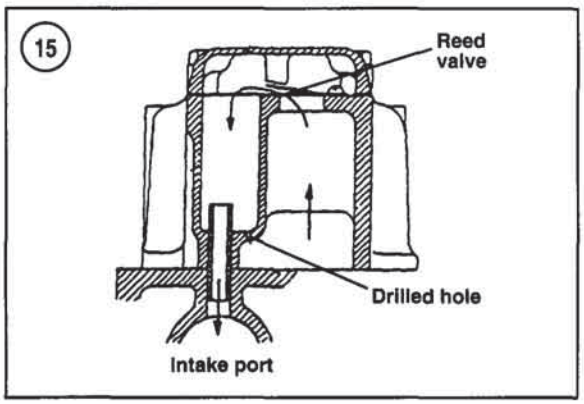
Seawater pump drive belt replacement (2GM, 2GM20, 3GM, 3GM30, 3HM and 3HM35 models)

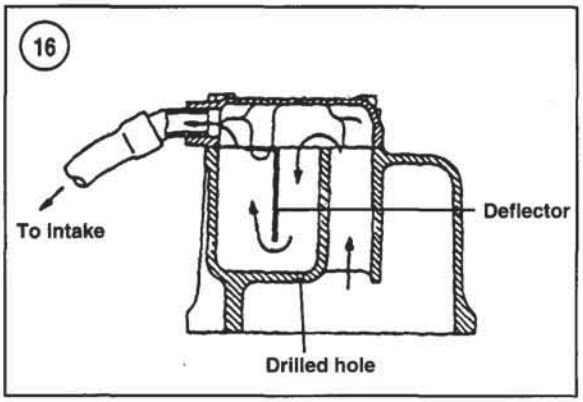
1. Remove the alternator drive belt as described in the previous section.
2. Loosen the screws that secure the seawater pump mounting plate (B, **Figure 14**).
3. Move the alternator inward sufficiently to allow removal of the belt from the pulleys and remove the belt.
4. Clean the pulley grooves so they are dry and free of rust or other corrosion.
5. Place the new belt in the pulley grooves.
6. Adjust belt tension as previously described.

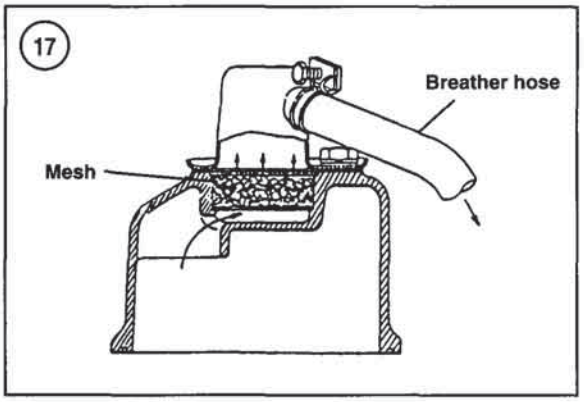
Crankcase Breather

The crankcase breather assembly vents crankcase pressure into the intake port or manifold. This produces a negative pressure in the crankcase. If the breather malfunctions, oil may be forced past the piston rings, oil seals and gaskets.

Periodic maintenance is not normally required unless excessive oil gasses clog the crankcase breather. This is usually indicated by blue exhaust smoke or oil in the intake port or manifold. If the breather must be cleaned frequently, determine the cause, such as broken or stuck piston rings.

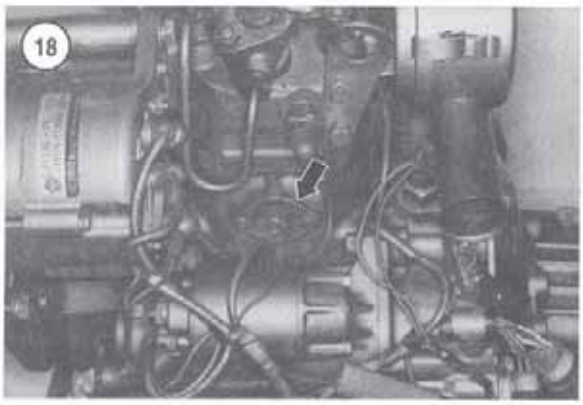






Refer to Chapter Five or Six for service procedures for the crankcase breather. Refer to the following paragraphs for a description of the breather on specific models.

On 1GM and 1GM10 models, a reed valve system located on the rocker arm cover controls crankcase gas movement. See **Figure 15**. The reed valve opens when the downward moving piston increases crankcase gas pres-



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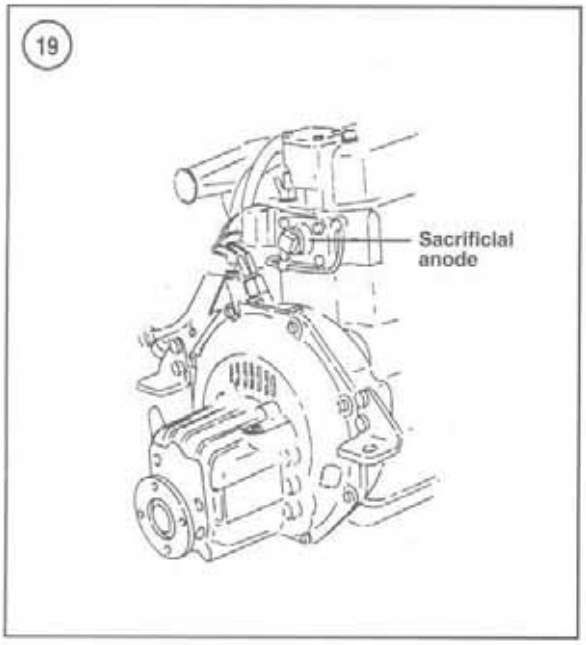

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sure. The reed valve closes when the piston moves up in the cylinder. This creates a negative pressure in the crankcase, which helps the piston rings seal against the cylinder bore. A hole in the breather chamber routes oil back to the crankcase; however, excessive oil will pass through the connecting tube into the intake port.

On 2GM, 2GM20, 3GM and 3GM30 models, the crankcase breather is located on the rocker arm cover. A labyrinth system separates oil from the crankcase gas. See **Figure 16**. A hole in the breather chamber routes oil back into the engine, however, excessive oil will pass into the breather tube to the intake port or intake manifold.

On 3HM and 3HM35 models, a mesh assembly on top of the rocker arm cover separates oil from the crankcase gases. See **Figure 17**. A breather tube routes the crankcase gases to the intake manifold.

Anticorrosion Maintenance

The engines are equipped with sacrificial anodes that provide protection against galvanic corrosion. Sacrificial anodes are relatively inexpensive and easily replaceable components that provide adequate corrosion protection in most situations where light-to-moderate corrosion conditions exist. Anodes are made of a highly active zinc alloy.

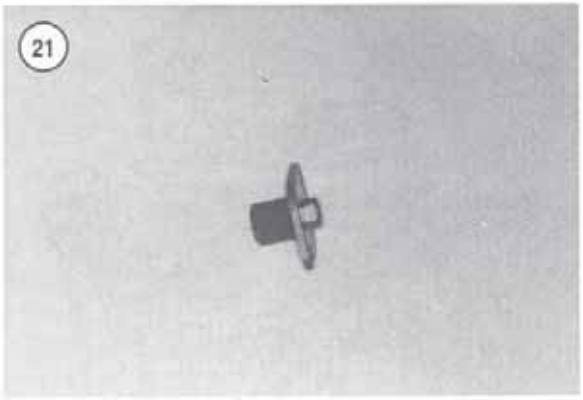
Check the condition of the anodes periodically and frequently. Replace any anode that is corroded to 50 percent of its original size.

Engine models 1GM and 1GM10 are equipped with a single sacrificial anode that is attached to a plate located on the cylinder block (**Figure 18**). A threaded type sacrificial anode is used on 2GM, 2GM20, 3GM, 3GM30, 3HM and 3HM35 model engines. One anode is located in the cylinder head (**Figure 19**), and one anode is located in the cylinder block on 2GM and 2GM20 model engines (**Figure 20**), while two anodes are located in the cylinder block on 3GM, 3GM30, 3HM and 3HM35 model engines.

Proceed as follows to service the sacrificial anodes:

1GM and 1GM10 models

1. Drain the cooling system.



2. Unscrew the mounting plate (**Figure 18**) and remove the sacrificial anode (**Figure 21**).
3. Use a wire brush and remove corrosion on the anode. Clean the mounting plate and mounting surface on the engine block.
4. Inspect the anode and compare it with the dimensions of a new anode shown in **Figure 22**. Replace the anode if dimensions are less than 50 percent of original size.
5. Install a new gasket on the anode (**Figure 23**).

NOTE

Do not apply any sealer to the anode mounting plate or to the engine block. Sealer or corroded mating surfaces will prevent good electrical contact, which is necessary for optimum anode protection.

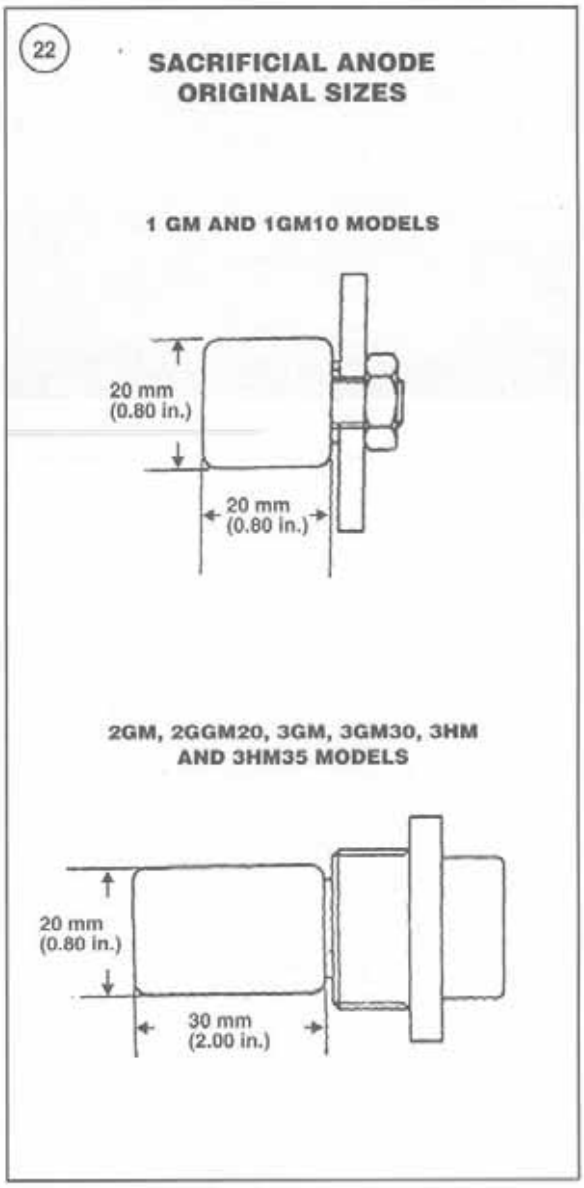
6. Reassemble and reinstall the sacrificial anode in the engine.

2GM, 2GM20, 3GM, 3GM30, 3HM and 3HM35 models

1. Drain the cooling system.
2. Unscrew the sacrificial anodes in the cylinder head (**Figure 19**) and cylinder block (**Figure 20**).
3. Use a wire brush to remove corrosion from the anode. Clean the threads on the anode and in the engine.
4. Inspect the anode and compare it with the dimensions of a new anode shown in **Figure 22**. Replace the anode if dimensions are less than 50 percent of original size.
5. Install a new gasket on the anode (**Figure 23**).

NOTE

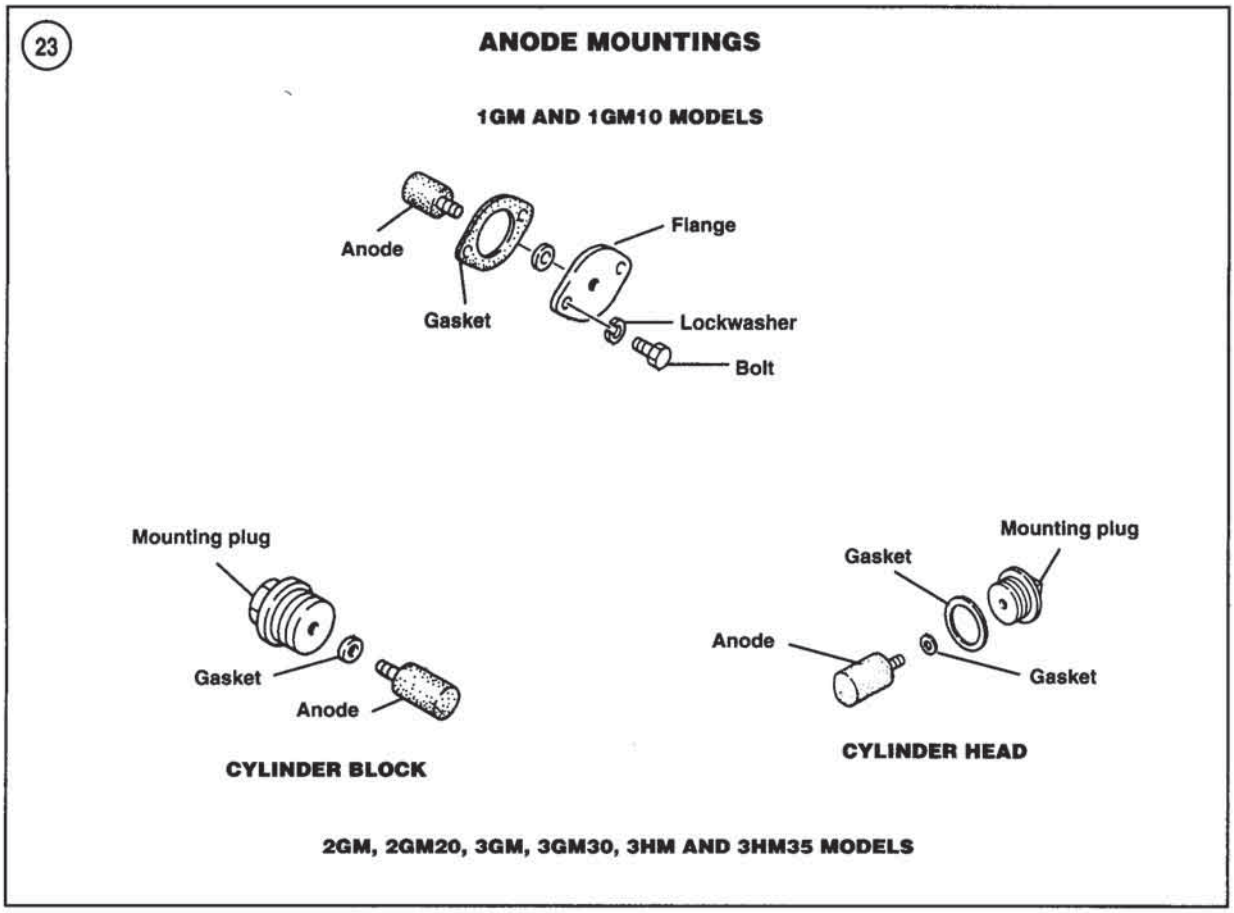
Do not apply any sealer to threads on the anode or in the engine. Sealer or corroded threads will prevent good electrical contact, which is necessary for optimum anode protection.



6. Reassemble and reinstall the sacrificial anode in the engine.

COOLING SYSTEM

Refer to Chapter Eight for a description of the two types of cooling systems that are used on the Yanmar marine diesel engines covered in this manual. A freshwater



(closed) cooling system requires additional maintenance due to the freshwater portion of the system, which includes a freshwater pump and may include an antifreeze mixture.

Seawater (Standard) Cooling Systems

Flushing the system

Flushing procedures may differ depending upon engine installation and the location of the water pump. Regardless of pump location, cooling water must always circulate through the water pump whenever the engine is running to prevent damage to the pump impeller. On models equipped with a closed cooling system, both pumps must be supplied with cooling water.

The following procedure provides steps to flush the cooling system of engines equipped with a seawater cooling system as well as the seawater portion on engines equipped with a closed cooling system. This procedure may be used for most engines, but modification of the procedure may be necessary for some installations.

1. Detach the inlet hose from the water pump.
2. Connect a hose from a water tap to the inlet of the water pump.
3. Open the water tap.
4. With the transmission in neutral, start the engine and run at normal idle until the engine reaches normal operating temperature.
5. Observe the water being flushed from the cooling system. When the flow is clear, shut the engine off, then shut off the water tap.
6. Reconnect the inlet hose to the water pump.

NOTE

Refer to Chapter Eight to flush and refill the freshwater portion of a closed cooling system or to service the heat exchanger.

Freshwater (Closed) Cooling Systems

Inspection

WARNING

*When performing any service work on the engine or cooling system, never remove the pressure fill cap on the exhaust manifold (**Figure 24**), drain coolant or disconnect any hose while the engine is hot. Scalding fluid and steam may be blown out under pressure and cause serious injury.*

Once a year, or whenever troubleshooting the cooling system, check the following items. If the proper equipment is not available, have the tests performed by a radiator shop.

1. Loosen and remove the pressure fill cap (**Figure 24**).
2. Check the cap seals for tears or cracks. Check for a bent or distorted cap. Rinse the cap under warm tap water to flush away any loose rust or dirt particles.
3. Inspect the cap neck seat for dents, distortion or contamination. Wipe the sealing surface with a clean cloth to remove any rust or dirt.
4. Check the fluid level and fill the system if necessary as described in the *Check/Fill Coolant* section in this chapter.
5. Check all cooling system hoses for damage or deterioration. Replace any hose that is questionable. Make sure all hose clamps are tight.
6. Check the heat exchanger (**Figure 25**) for cracks or damage. Service, if necessary, as described in Chapter Eight.

Check/fill coolant (not equipped with remote reservoir)

WARNING

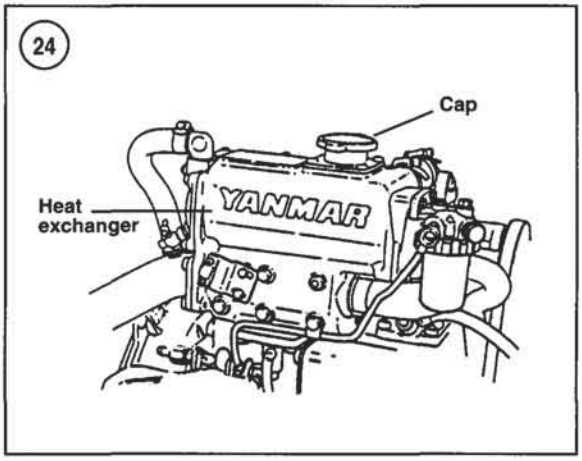
*Do not remove the fill pressure cap (**Figure 24**) from the pressurized cooling system when the engine is hot.*

1. Loosen and remove the pressure fill cap (**Figure 24**).
2. Check the level of fluid in the system. It should be level with the iron plate at the bottom of the filler neck.

NOTE

Excess coolant (above proper level) will be expelled when coolant reaches operating temperature.

3. If the exhaust manifold is not properly filled, add coolant. Refer to the *Coolant* section in this chapter for proper coolant.



Check/Fill Coolant (Equipped With a Remote Reservoir)

Refer to **Figure 26**.

1. Check the level of the coolant in the remote reservoir tank (**Figure 26**) when the engine is cold. The coolant level should be between the marks on the tank.
2. If the coolant level is low, but the tank is not dry, add coolant to the tank. Refer to the following section for the proper coolant mixture.

WARNING

*Do not remove the pressure fill cap (**Figure 24**) from the pressurized cooling system when the engine is hot.*

3. If the coolant level is low, but the tank is dry, remove the pressure fill cap on the exhaust manifold (**Figure 24**). Add coolant to the exhaust manifold so it is full, replace the cap, then add coolant to the remote reservoir tank to the proper level.
4. Run the engine until it reaches normal operating temperature, then let the engine cool. Recheck the coolant level in the remote tank and, if necessary, refill the remote reservoir tank.

Coolant

Only use a high-quality ethylene glycol-based antifreeze designed for aluminum engines. Mix the antifreeze with water in a 50/50 ratio. Coolant capacity is listed in **Table 4**. When mixing antifreeze with water, use only soft or distilled water. Distilled water can be purchased at supermarkets in gallon containers. Do not use tap or salt water because it will damage engine parts.

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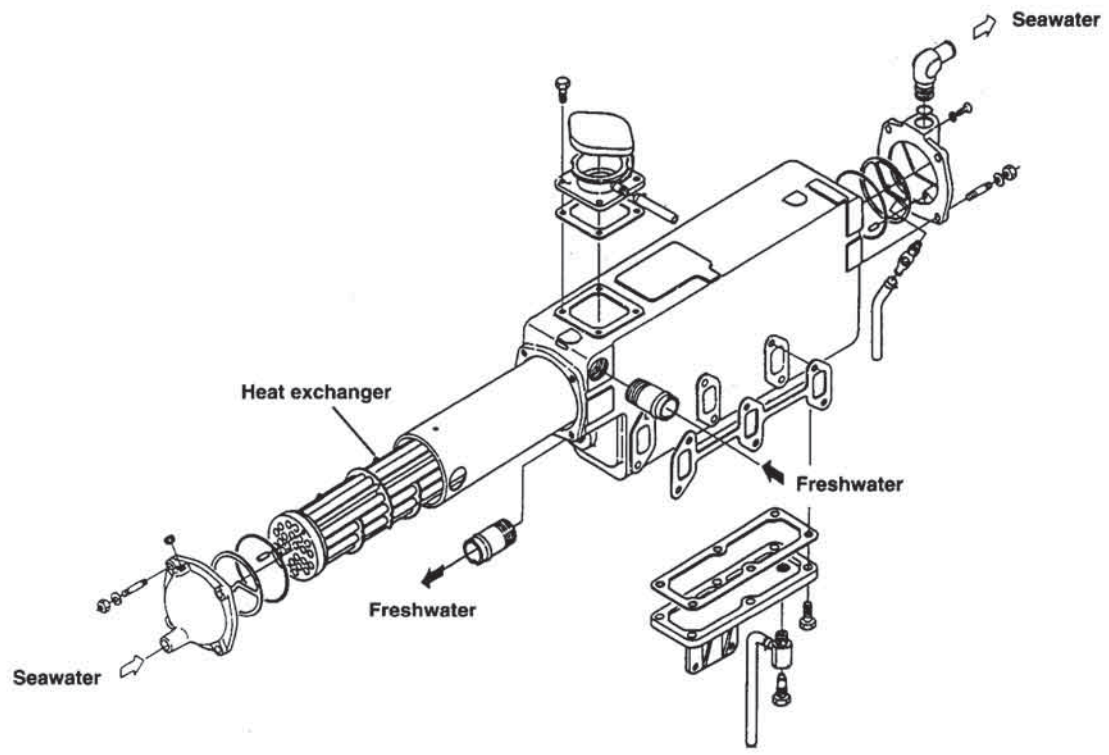
FRESHWATER HEAT EXCHANGER (TYPICAL)



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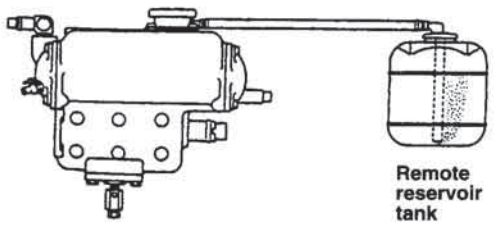


WARNING

Do not siphon coolant by mouth with a hose. The coolant mixture is poisonous and ingesting even a very small amount may cause illness. Observe warning labels on antifreeze containers. Make sure to discard used antifreeze in a safe and suitable manner and wipe up any spills. Do not store antifreeze in open containers. Keep antifreeze out of the reach of children and animals.

WARNING

The EPA has classified ethylene glycol as an environmental toxic waste. It is illegal to

flush it down a drain or pour it on the ground. Put it in suitable containers and dispose of it according to local regulations.

CAUTION

Be careful not to spill antifreeze on painted surfaces, as it may damage the surface. Wash any spilled antifreeze immediately with soapy water, then rinse the area thoroughly with clean water.

Flushing and refilling freshwater coolant system

Use the following procedure to flush and refill the freshwater coolant system. Refer to the preceding section to flush the seawater portion of a freshwater coolant system.

Replace the coolant in the freshwater coolant system after every 500 hours of operation or annually, whichever occurs first.

CAUTION

Perform the following procedure when the engine is cold.

1. Remove the pressure fill cap (**Figure 24**).

NOTE

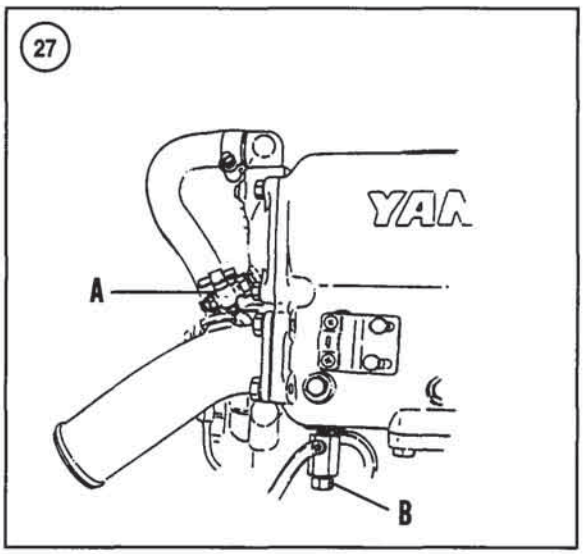
Position the drain hoses in suitable containers to catch coolant when draining the coolant from the exhaust manifold and engine.

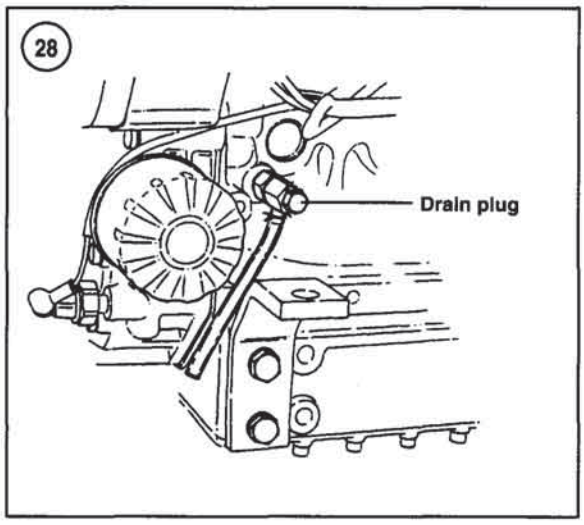
2. Open the drain valve at the end of the heat exchanger (A, **Figure 27**) and the drain plug on the underside of the exhaust manifold (B).
3. Unscrew the drain plug on the side of the engine block (**Figure 28**, typical).
4. If an excessive accumulation of scale is apparent on the interior of the cooling system, use an automotive cooling system cleaner. Be sure to thoroughly flush out the cooling system with freshwater afterward.
5. Close the drain plug on the exhaust manifold and the drain plug on the engine block.

6A. Engines without a remote reservoir—Fill the exhaust manifold with coolant. The coolant should be level with the iron plate at the bottom of the filler neck.

6B. Engines with a remote reservoir—Pour coolant into the exhaust manifold so it is full. Install the pressure fill cap, then add coolant to the remote reservoir tank to the proper level.

7. Run the engine until it reaches normal operating temperature, then let the engine cool. Recheck the coolant level and, if necessary, add coolant.





BATTERY

Inspect the electrical connections and make sure they are secure and corrosion-free. If corrosion is present at the terminal ends, detach the wires, clean the corrosion and reattach. Make sure that wires are correctly routed and will not contact moving parts or touch hot (especially exhaust) parts.

Remove the battery vent caps and check battery electrolyte level. It should be about 3/16 in. above the plates or even with the bottom of the filler wells. See **Figure 29**. Test the battery condition with a hydrometer (**Figure 30**). See Chapter Nine.

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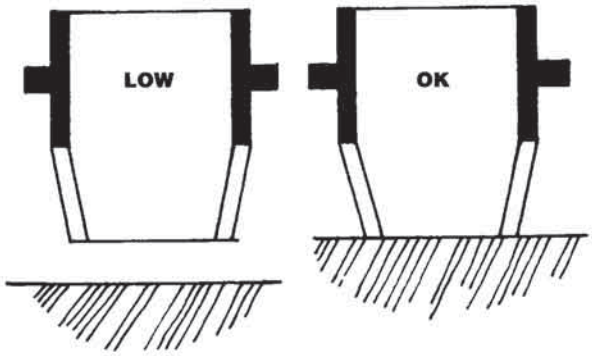
BATTERY CUTAWAY VIEW



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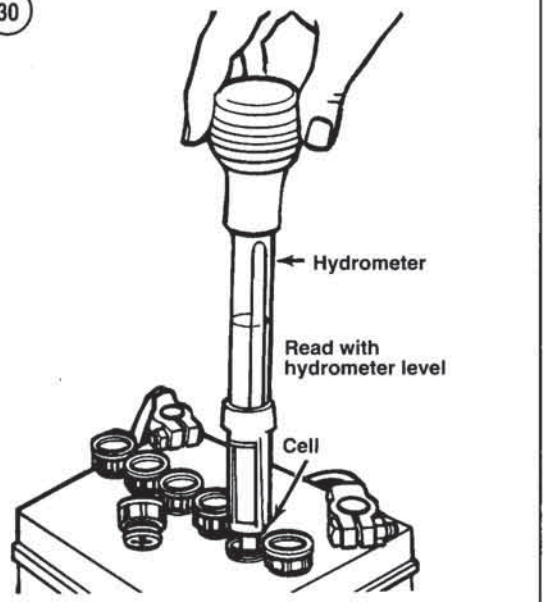


ENGINE TUNE-UP

A smooth-running, dependable marine engine is more than a convenience. At sea, it can be the difference between life and death. To keep the engine running right, follow a regular program of preventive maintenance.

Part of any preventive maintenance program is a thorough engine tune-up. A tune-up is a series of adjustments necessary to restore and maintain maximum power and performance.

Perform an engine tune-up as needed at periodic intervals to maintain maximum engine performance. If the engine is used infrequently, perform a tune-up at least once a season.

A tune-up consists of the following:

1. Compression test.
2. Valve adjustment.
3. Idle speed adjustment.

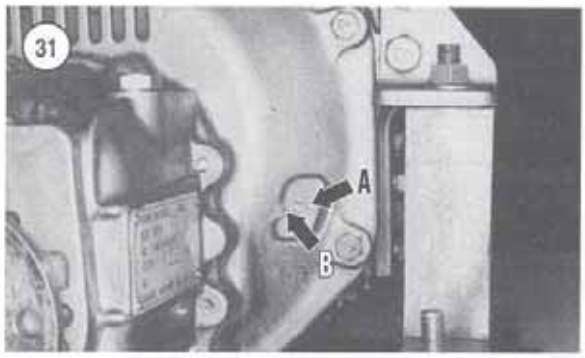
Careful and accurate adjustment is crucial to a successful engine tune-up. Each procedure in this section must be performed exactly as described and in the order presented.

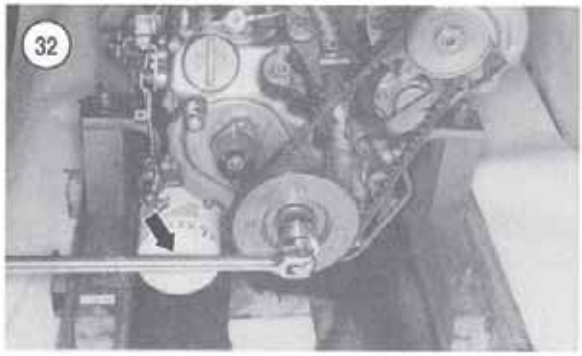
NOTE

Some engine settings, such as maximum engine speed and torque level, are controlled by adjusting screws in the governor assembly. These adjusting screws are set by the manufacturer and secured by a lockwire to prevent unauthorized adjustment. Adjustment of these screws should be performed only by trained personnel. Detaching a lockwire may void the engine warranty. Improper adjustment can cause engine damage.

Compression Test

Check the compression of each cylinder as the first step in a tune-up. A compression test measures the compression pressure at the end of the compression stroke. Its results can be used to assess general cylinder and valve





condition. In addition, it can warn of developing problems inside the engine. If more than a 43 psi. (300 kPa) difference exists between the highest and lowest reading cylinders on multicylinderengines, the engine cannot be tuned to develop its maximum power. Specified cylinder pressure is 390-470 psi (2700-3300 kPa).

A compression reading that is below the desired compression pressure indicates that engine repair is required because of worn or broken rings, leaky or sticking valves or a combination of all.

If the compression test readings are lower than desired, isolate the cause by performing a wet compression test. Remove the precombustion chamber (refer to Chapter Seven). Perform the wet compression test in the same way as the dry test, except pour approximately one tablespoon of heavy engine oil (at least SAE 30) into the injector hole before performing Steps 7-9. If the wet compression readings are significantly higher than the dry compression readings, the cause for the low dry compression reading is probably worn or broken rings. If there is little difference between the readings, the problem may be due to leaky or sticking valves or a faulty cylinder head gasket. If two adjacent cylinders on a multicylinderengine read low on both tests, the head gasket may be leaking between the cylinders.

Excessively high compression readings indicate carbon buildup in the cylinder.

NOTE

A special type compression gauge and adapter is required to measure the compression pressure in the cylinder. If the necessary compression test gauge is not available, have a diesel technician perform the test.

1. Be sure cooling water is connected to the engine.
2. Run the engine until it reaches normal operating temperature, then shut it off.

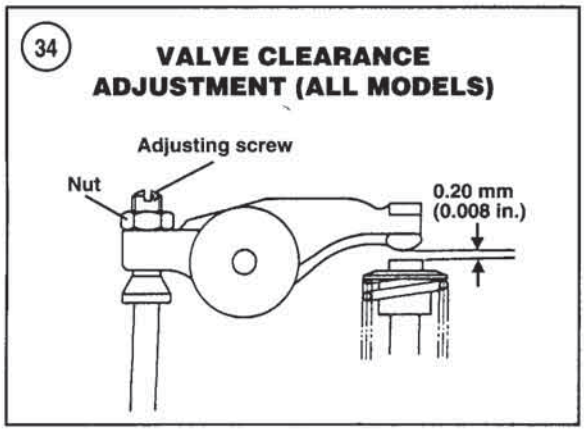
CAUTION

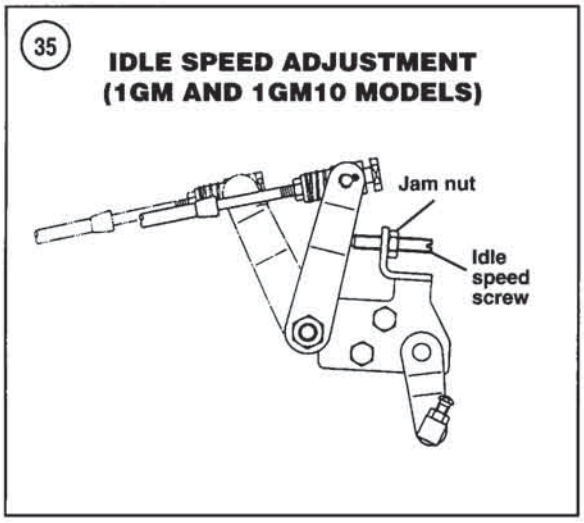
Be sure to remove all the injectors on a multicylinderengine to prevent inadvertent starting.

3. Remove the fuel injector(s) as described in Chapter Seven.
4. Clean the injector hole.
5. Rotate the engine to blow out any carbon.
6. Install the compression gauge and, if necessary, the adapter.
7. Crank the engine at least five turns or until there is no further increase in compression shown on the tester gauge.
8. Record the reading. Relieve the tester pressure valve and remove the compression tester.
9. Repeat Steps 4-8 for each remaining cylinder on multicylinderengines.

Valve Clearance Adjustment

Valve clearance is the gap between the end of the valve stem and the underside of the rocker arm. A specified valve clearance must be maintained for the valves to operate as designed. Insufficient valve clearance will cause





rough engine operation and possible engine damage, such as burnt valves. Excessive valve clearance will reduce engine performance. The recommended interval for valve adjustment is after every 300 hours of operation. However, it is a good practice to check the valve clearances during each tune-up.

The engine must be cold when adjusting valve clearance. On multicylinderengines, the cylinder nearest the flywheel is the number one cylinder.

1. Remove the rocker arm cover as described in Chapter Five or Six.
2. Observe the flywheel (A, **Figure 31**) through the opening in the clutch cover. A cylinder is at top dead center if the mark on the flywheel is aligned with the reference pointer (B) on the clutch cover.
3. Rotate the crankshaft with a wrench on the crankshaft pulley retaining nut (**Figure 32**).

CAUTION

Always rotate the crankshaft in the normal running direction (clockwise at crankshaft pulley); otherwise the water pump impeller will be damaged.

4. Rotate the crankshaft nut clockwise so the 1T mark on the flywheel aligns with the reference pointer (B, **Figure 31**) on the clutch cover. The piston must be on its compression stroke.

NOTE

*Some transmissions do not have an opening in the clutch cover. Remove the starter to view the timing marks on the flywheel (**Figure 33**).*

NOTE

When the piston is on its compression stroke and at top dead center, both valves will be closed. This can be determined by the position of the intake and exhaust rocker arms. Both should have free play, which indicates that the valves are closed.

5. Measure the clearance between the rocker arm and valve stem (**Figure 34**). Correct valve clearance is 0.2 mm (0.008 in.).
6. If the clearance is incorrect, loosen the locknut, then rotate the adjusting screw on the rocker arm (**Figure 34**). Hold the adjusting screw, then tighten the locknut. Recheck the valve clearance.

7A. 2GM and 2GM20 engines—Rotate the crankshaft 360° so the 2T mark on the flywheel aligns with the reference pointer (B, **Figure 31**) on the clutch cover. The piston for number 2 cylinder must be on its compression stroke (see preceding NOTE). Perform Steps 5 and 6.

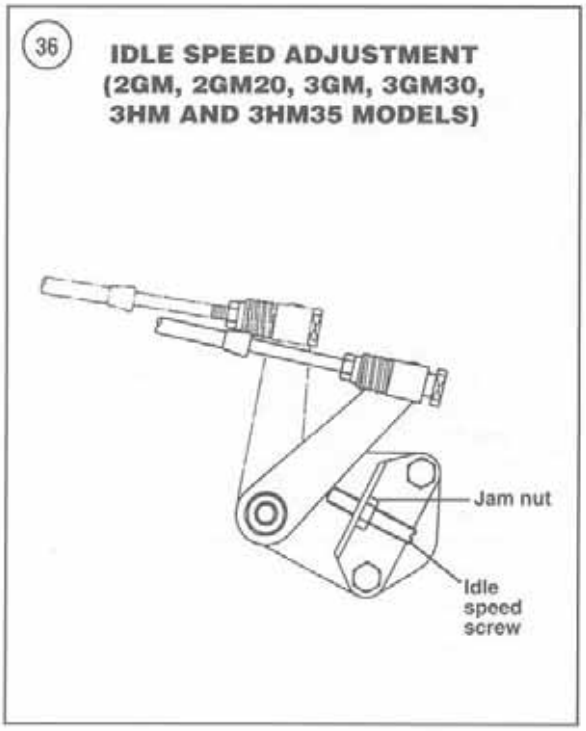
7B. 3GM, 3GM30, 3HM and 3HM35 engines—Rotate the crankshaft 240° so the 3T mark on the flywheel aligns with the reference pointer (B, **Figure 31**) on the clutch cover. The piston for number 3 cylinder must be on its compression stroke (see preceding NOTE). Perform Steps 5 and 6.

8. Reinstall the rocker arm cover.

Idle Speed Adjustment

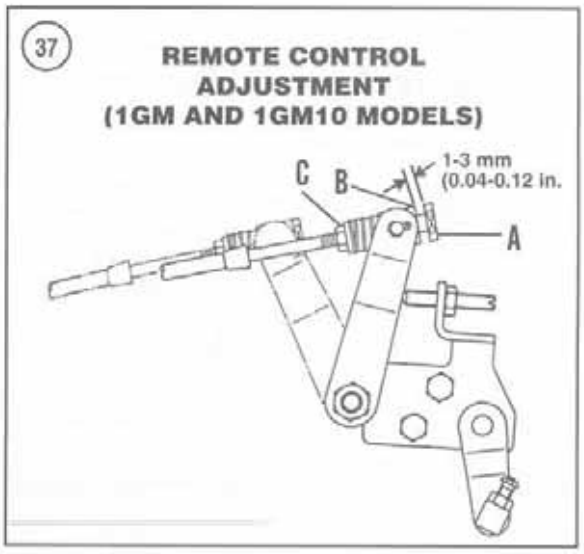
The correct idle speed is 825-875 rpm. Refer to the following procedure to adjust the idle speed.

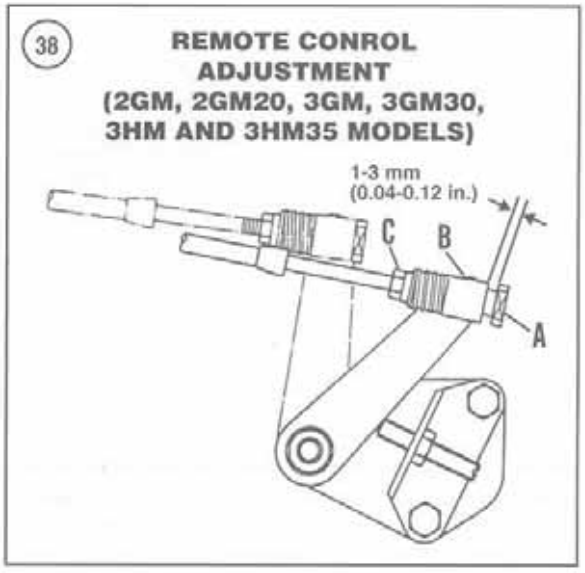
1. Run the engine until it reaches normal operating temperature.
2. Place the transmission in neutral.
3. Loosen the jam nut on the idle speed screw (**Figure 35** or **Figure 36**).



4. Adjust the idle speed screw until the engine idles at 825-875 rpm, then retighten the locknut.

5. On engines equipped with remote control, measure the gap between the cable end fitting (A, **Figure 37** or **Figure 38**) and lever fitting (B). The specified gap is 1-3 mm (0.04-0.12 in.). To adjust the gap, rotate the nut (C) on the cable.





TRANSMISSION

Transmission Oil

Transmission models KM2A, KM2C, KM2P, KM3A and KM3P

The recommended transmission oil is an engine oil that meets API classification CC. The recommended viscosity is SAE 10W-30. Change the transmission oil after every 250 hours of operation.

Transmission models KBW10D and KBW10E

The recommended transmission oil is automatic transmission oil (ATF). The oil must be classified a Dexron oil. Change the transmission oil after every 250 hours of operation.

Transmission Oil Level Check

Check the transmission oil level on a weekly basis.

1. With the boat at rest in the water and the engine off, unscrew the dipstick (**Figure 39**, typical). Wipe it with a clean rag or paper towel. Reinsert the dipstick, but do not screw it in. Pull out the dipstick and read the oil level on the dipstick.

2. Add oil, if necessary, through the dipstick hole so the oil level reaches the full mark on the dipstick. Use the oil recommended in the preceding section.

Table 1 MAINTENANCE SCHEDULE

Daily	Check fuel level
	Check engine oil level
Weekly	Check battery
	Check air filter
	Check transmission oil level
	Check drive belt tension
	Check electrical wiring
Every 50 hours	Clean fuel filter
Every 100 hours	Change engine oil
	Drain fuel tank
Every 250 hours	Replace air filter element
	Replace fuel filter element
	Change transmission oil
Every 300 hours	Replace engine oil filter
	Adjust engine valves
Every 500 hours	Inspect thermostat
Every 1500 hours	Inspect seawater pump
Every 2000 hours	Replace thermostat
Annually	Replace freshwater (closed system) antifreeze

Table 2 ENGINE OIL VISCOSITY

Ambient Temperature	Oil viscosity
Below 50° F (10° C)	10W, 20W or 20/20W
50° - 68° F (1° - 20° C)	20 or 20/20W
68° - 95° F (20° - 35° C)	30 or 40
Above 95° F (35° C)	50

Table 3 ENGINE OIL CRANKCASE CAPACITY

Model	Oil capacity
1GM, 1GM10	1.4 qt. (1.3 L)
2GM, 2GM20	2.1 qt. (2.0 L)
3GM, 3GM30	2.8 qt. (2.6 L)
3HM, 3HM35	5.7 qt. (5.4 L)

Table 4 FRESHWATER (CLOSED) COOLING SYSTEM CAPACITY

Model	Capacity
2GM20F	2.9 L (0.77 gal.)
3GM30F	3.4 L (0.9 gal.)
3HM35F	4.9 L (1.3 gal.)

Table 5 TUNE-UP SPECIFICATIONS

Model	Idle rpm (no-load)	Full throttle rpm (no-load)	Fuel injection timing	Valve clearance
1GM	850	3750	25° BTDC	0.2 m (0.008 in.)
1GM10	850	3825	15° BTDC	0.2 m (0.008 in.)
2GM	850	3750	25° BTDC	0.2 m (0.008 in.)
2GMF	850	3750	25° BTDC	0.2 m (0.008 in.)
2GM20	850	3825	15° BTDC	0.2 m (0.008 in.)
2GM20F	850	3825	15° BTDC	0.2 m (0.008 in.)
3GM	850	3750	28° BTDC	0.2 m (0.008 in.)
3GMF	850	3750	28° BTDC	0.2 m (0.008 in.)
3GMD	850	3750	28° BTDC	0.2 m (0.008 in.)
3GM30	850	3825	18° BTDC	0.2 m (0.008 in.)
3GM30F	850	3825	18° BTDC	0.2 m (0.008 in.)
3HM	850	3600	28° BTDC	0.2 m (0.008 in.)
3HMF	850	3600	28° BTDC	0.2 m (0.008 in.)
3HM35	850	3625	21° BTDC	0.2 m (0.008 in.)
3HM3SF	850	3625	21° BTDC	0.2 m (0.008 in.)

Table 6 Compression Specifications

Pressure (all models)	Maximum difference between cylinders
390-470 psi (2700-3800 kPa)	43 psi (300 kPa)