YANMAR

DIESEL INBOARD SHOP MANUAL

ONE, TWO & THREE CYLINDER ENGINES

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TUNE-UP SPECIFICATIONS

Model	Idle rpm (no-load)	Full throttle rpm (no-load)	Fuel injection timing	Value clearance all models
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.)

APPROXIMATE ENGINE OIL CAPACITIES

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)

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.)

ENGINE MODELS

Model	Number of cylinders	Displacement	Horsepower/ rpm	Gearbox	Gearbox ratio (forward gear)
1GM	1	293 cc (17.9 cu. in.)	6.5 hp/3400 rpm	KM2A	2.21, 2.62 or 3.22
1GM10	1	318 cc (19.4 cu. in.)	8 hp/3400 rpm	KM2C or KM2P	2.21, 2.62 or 3.22
2GM	2	586 cc (35.7 cu. in.)	13 hp/3400 rpm	KM2A	2.21, 2.62 or 3.22
2GMF	2	586 cc (35.7 cu. in.)	13 hp/3400 rpm	KM2A	2.21, 2.62 or 3.22
2GM20	2	636 cc (38.8 cu. in.)	16 hp/3400 rpm	KM2C or KM2P	2.21, 2.62 or 3.22

(continued)

ENGINE MODELS (continued)

Model	Number of cylinders	Displacement	Horsepower/ rpm	Gearbox	Gearbox ratio (forward gear)
2GM20F	2	636 cc (38.8 cu. in.)	16 hp/3400 rpm	KM2C or KM2P	2.21, 2.62 or 3.22
3GM	3	879 cc (53.6 cu. in.)	20 hp/3400 rpm	KBW10D	2.14, 2.63 or 2.83
3GMF	3	879 cc (53.6 cu. in.)	20 hp/3400 rpm	KBW10D	2.14, 2.63 or 2.83
3GMD	3	879 cc (53.6 cu. in.)	20 hp/3400 rpm	KM3A	2.36, 2.61 or 3.20
3GM30	3	954 cc (58.2 cu. in.)	24 hp/3400 rpm	KM3A or KM3P	2.36, 2.61 or 3.20
3GM30F	3	954 cc (58.2 cu. in.)	24 hp/3400 rpm	KM3A or KM3P	2.36, 2.61 or 3.20
3HM	3	1126 cc (68.7 cu. in.)	27 hp/3200 rpm	KBW10E	2.14 or 2.83
3HMF	3	1126 cc (68.7 cu. in.)	27 hp/3200 rpm	KBW10E	2.14 or 2.83
3HM35	3	1282 cc (78.2 cu. in.)	30 hp/3200 rpm	KBW10E	2.14 or 2.83
3HM35F	3	1282 cc (78.2 cu. in.)	30 hp/3200 rpm	KBW10E	2.14 or 2.83

GENERAL TORQUE SPECIFICATIONS

Thread diameter	N•m	ft.-lb.	in.-lb.
M6	8-10	–	71-88
M8	23-27	17-20	204-240
M10	44-50	32-37	–
M12	75-85	55-63	–
M14	125-135	92-100	–
M16	200-210	147-155	–

Chapter One

General Information

This [redacted] shop manual covers the GM Yanmar marine diesel engine series identified in **Table 1**.

Troubleshooting, tune-up, maintenance and repair are not difficult, if you know what tools and equipment to use and what to do. Step-by-step instructions guide you through jobs ranging from simple maintenance to complete engine overhaul.

This manual can be used by anyone from a first-time do-it-yourselfer to a professional mechanic. Detailed drawings and clear photographs provide all the information needed to do the work right.

Some of the procedures in this manual require the use of special tools. The resourceful mechanic can, in many cases, think of acceptable substitutes for special tools. However, using a substitute for a special tool is not recommended, as it can be dangerous and may damage the part. If a tool can be designed and safely made, but will require some type of machine work, contact a local community college or high school that has a machine shop curriculum. Shop teachers sometimes welcome outside work that can be used as practical shop applications for students.

Each Yanmar marine diesel can be identified by its individual model number. The model numbers for all Yanmar marine diesel engines covered in this manual are listed in **Table 1**.

Some engine model numbers end with the letters F or D, such as 2GMF or 3GMD. Suffix letter F indicates the engine is equipped with a freshwater (closed) cooling system. Suffix letter D indicates the engine is equipped with a Kanzaki KBW10D transmission.

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.

NOTE
Engine models ending with the letters C (sail drive) or V (V-drive transmission) are not covered in this manual.

Metric and U.S. standards are used throughout this manual. U.S. to metric conversions are in **Table 2**.

Critical torque specifications are provided at the end of each chapter (as required). Use the general torque specifications listed in **Table 3** if a torque specification is not listed for a specific component or assembly.

Metric drill tap sizes are in **Table 4**.

Tables 1-4 are located at the end of the chapter.

MANUAL ORGANIZATION

This chapter provides general information useful to engine owners and mechanics. In addition, this chapter discusses the tools and techniques for preventive maintenance, troubleshooting and repair.

Chapter Two provides methods and suggestions for quick and accurate problem diagnosis and repair. Troubleshooting procedures discuss typical symptoms and logical methods to pinpoint the trouble.

Chapter Three explains all periodic lubrication and routine maintenance necessary to keep the engine operating well. Chapter Three also includes recommended tune-up procedures, eliminating the need to constantly consult other chapters on the various assemblies.

Subsequent chapters describe specific systems, providing disassembly, repair, assembly and adjustment procedures in simple step-by-step form. If a repair is impractical for a home mechanic, it is so indicated. It is usually faster and less expensive to take such repairs to a dealer or repair shop. Specifications concerning a specific system are included at the end of the appropriate chapter.

NOTES, CAUTIONS AND WARNINGS

The terms NOTE, CAUTION and WARNING have specific meanings in this manual. A NOTE provides additional information to make a step or procedure easier or clearer. Disregarding a NOTE could cause inconvenience but would not cause damage or personal injury.

A CAUTION emphasizes areas where equipment damage could occur. Disregarding a CAUTION could cause permanent mechanical damage; however, personal injury is unlikely.

A WARNING emphasizes areas where personal injury or even death could result from negligence. Mechanical damage may also occur. WARNINGS *are to be taken seriously*. In some cases, serious injury or death has resulted from disregarding similar warnings.

SAFETY FIRST

Professional mechanics can work for years and never sustain a serious injury. By observing a few rules of common sense and safety, it is possible to enjoy many safe hours servicing the machine. Ignoring these rules can cause injury or damage to equipment.

1. Never use gasoline as a cleaning solvent.
2. Never smoke or use a torch in the vicinity of flammable liquids, such as cleaning solvent, in open containers.
3. Use proper sized wrenches to avoid damage to fasteners and personal injury.
4. When loosening a tight or stuck nut, remember what could happen if the wrench should slip. Be careful; protect yourself accordingly.

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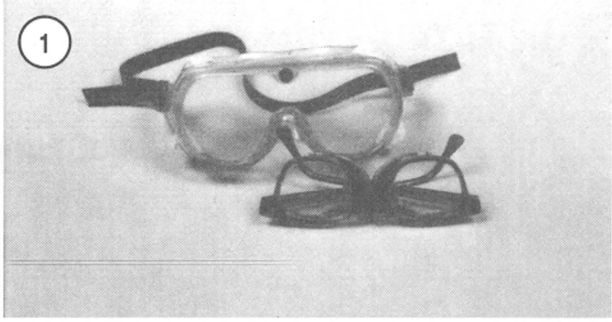

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5. When replacing a fastener, make sure to use one with the same measurements and strength as the old one. Incorrect or mismatched fasteners can result in damage to the engine and possible personal injury. Beware of fastener kits that are filled with poorly made nuts, bolts, washers and cotter pins. Refer to *Fasteners* in this chapter for additional information.
6. Keep all hand and power tools in good condition. Wipe greasy and oily tools after using them. They are difficult to hold and can cause injury. Replace or repair worn or damaged tools.
7. Keep the work area clean and uncluttered.
8. Wear safety goggles (**Figure 1**) during all operations involving drilling, grinding, the use of a cold chisel or *any* time the safety of the eyes is compromised. Safety goggles should be worn when using solvent and compressed air.
9. Keep an approved fire extinguisher nearby (**Figure 2**). Make sure it is rated for gasoline (Class B) and electrical (Class C) fires.
10. When drying bearings or other rotating parts with compressed air, never allow the air jet to rotate the bearing or part. The air jet is capable of rotating them at speeds far

in excess of those for which they were designed. The bearing or rotating part can disintegrate and cause serious injury and damage. Hold the inner bearing race by hand to prevent bearing damage when using compressed air.

SERVICE HINTS

Most of the service procedures covered are straightforward and can be performed by anyone reasonably handy with tools. It is suggested, however, that you consider your capabilities carefully before attempting any operation involving major disassembly.

1. When disassembling engine or drive components, mark the parts for location and mark all parts that mate together. Small parts, such as bolts, can be identified by placing them in plastic sandwich bags (**Figure 3**). Seal the bags and label them. If reassembly will take place immediately, an accepted practice is to place nuts and bolts in a cupcake tin or egg carton in the order of disassembly. Because many types of ink fade if applied to tape, use a permanent ink pen.
2. Protect finished surfaces from physical damage or corrosion. Keep gasoline off painted surfaces.
3. Use penetrating oil on frozen or tight bolts, then strike the bolt head a few times with a hammer and punch (use a screwdriver on screws). Avoid the use of heat where possible, as it can warp, melt or affect the temper of parts. Heat also damages finishes, especially paint and plastics.
4. No parts removed or installed (other than bushings and bearings) in the procedures described in this manual should require unusual force during disassembly or assembly. If a part is difficult to remove or install, find out why before proceeding.
5. Cover all openings after removing parts or components to prevent contaminants and small tools from falling in.
6. Read each procedure *completely* while looking at the actual parts before starting a job. Make sure you *thoroughly* understand what is to be done and then carefully follow the procedure, step by step.

NOTE

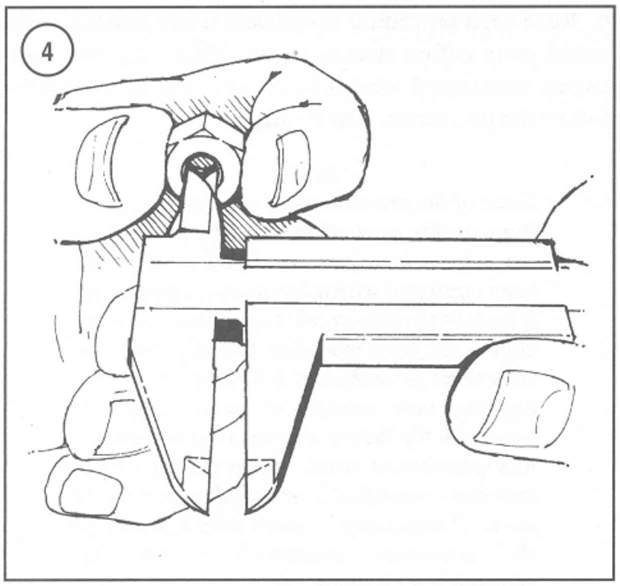
Some of the procedures or service specifications in this manual may not be accurate if the engine has been modified or if it has been equipped with after-market equipment. If installing after-market equipment or if the engine has been modified, file all printed instructions or technical information regarding the new equipment in a folder or notebook for future reference. If the engine was purchased used, the previous owner may have modified it or installed non-stock parts. If necessary, consult with a dealer or the accessory manufacturer on service-related changes.

7. Recommendations are occasionally made to refer service or maintenance to a marine dealership or a specialist in a particular field. In these cases, the work will be done more quickly and economically than performing the work at home.
8. In procedural steps, the term *replace* means to discard a defective part and replace it with a new or exchange unit. *Overhaul* means to remove, disassemble, inspect, measure, repair or replace defective parts, reassemble and install major systems or parts.
9. Some operations require the use of a hydraulic press. It would be wiser to have these operations performed by a shop equipped for such work, rather than to try to do the job yourself with makeshift equipment that may damage the machine.
10. Repairs go much faster and easier if the machine is clean before beginning work. There are many special cleaners on the market for washing the engine and related parts. Follow the manufacturer's directions on the container for the best results. Clean all oily or greasy parts with cleaning solvent as they are removed.

WARNING

Never use gasoline as a cleaning agent. Be sure to work in a well-ventilated area when using cleaning solvent. Keep a fire extinguisher, rated for gasoline fires, on hand.

11. Much of the labor charges for repairs made by dealers are for the time involved in the removal, disassembly, assembly and reinstallation of other parts in order to reach the defective part. It is often possible to perform the preliminary operations and then take the defective unit to the dealer for repair at considerable savings.



12. If special tools are required, make arrangements to get them before starting. It is frustrating and time-consuming to start a job and then be unable to complete it.

13. Make diagrams (or take a Polaroid picture) wherever similar-appearing parts are found. For instance, retaining bolts for a particular part may not be the same length. It is difficult to remember where everything came from—and mistakes are costly. It is also possible that you may be sidetracked and not return to work for days or even weeks—in which time carefully laid out parts may be disturbed.

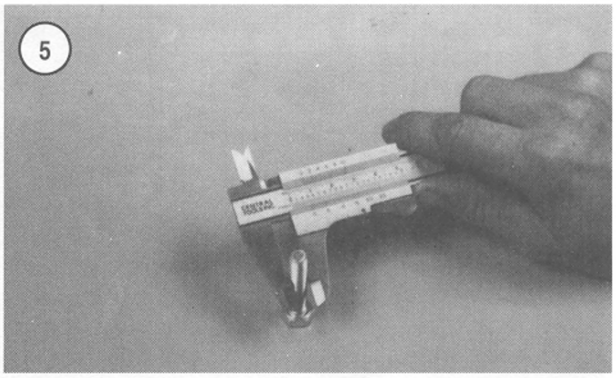
14. When assembling parts, make sure all shims and washers are replaced exactly where they were before removal.

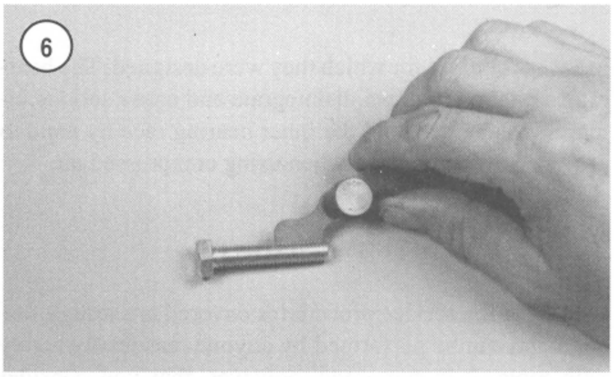
15. Whenever a rotating part contacts a stationary part, look for a shim or washer. Use new gaskets if there is any doubt about the condition of the old ones. A thin coat of silicone sealant on non-pressure-type gaskets may help them seal more effectively.

16. If it becomes necessary to purchase gasket material to make a gasket for the engine, measure the thickness of the old gasket (at an uncompressed point) and purchase gasket material with the same approximate thickness.

17. Use heavy grease to hold small parts in place if they tend to fall out during assembly. However, keep grease and oil away from electrical components.

18. Take time and do the job right. Do not forget that a newly rebuilt engine must be broken in just like a new one.





PARTS REPLACEMENT

Engine manufacturers often modify the parts of an engine during the lifetime of the engine model. When ordering parts from the dealer or other parts distributor, always order by the model and engine serial number. Refer to Chapter Six or Seven. Write the numbers down and have them available. Compare new parts to old before purchasing them. If they are not alike, have the parts manager explain the difference. **Table 1** lists model numbers.

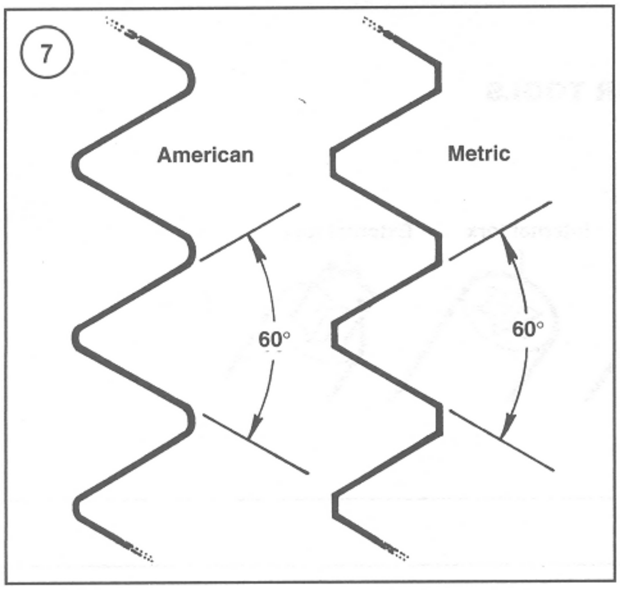
TORQUE SPECIFICATIONS

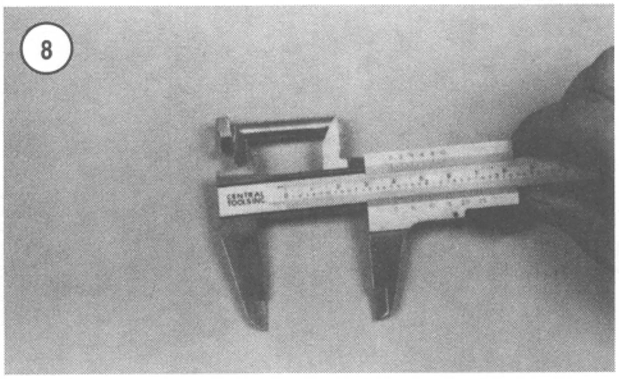
Torque specifications throughout this manual are given in Newton-meters (N•m) and foot-pounds (ft.-lb.).

Table 3 lists general torque specifications for nuts and bolts that are not listed in the respective chapters. To use the table, first determine the size of the nut or bolt by measuring it with a vernier caliper. **Figure 4** and **Figure 5** show how to do this.

FASTENERS

The materials and designs of the various fasteners used on the engine are not arrived at by chance or accident. Fas-





tener design determines the type of tool required to work the fastener. Fastener material is carefully selected to decrease the possibility of failure.

Nuts, bolts and screws are manufactured in a wide range of thread patterns. To join a nut and bolt, the diameter of the bolt and the diameter of the hole in the nut must be the same. It is also important that the threads on both be properly matched.

The best way to tell if the threads on two fasteners match is to turn the nut on the bolt (or the bolt into the threaded hole) by hand. Make sure both pieces are clean; remove Loctite or other sealer residue from threads if present. If excessive force is required, check the thread condition on each fastener. If the thread condition is good but the fasteners jam, the threads are not compatible. A thread pitch gauge (**Figure 6**) can also be used to determine pitch. Yanmar marine engines are manufactured with ISO (International Organization for Standardization) metric fasteners. The threads are cut differently than those of American fasteners (**Figure 7**).

Most threads are cut so that the fastener must be turned clockwise to tighten it. These are called right-hand threads. Some fasteners have left-hand threads; they must be turned counterclockwise to be tightened. Left-hand threads are used in locations where normal rotation of the equipment would tend to loosen a right-hand threaded fastener.

ISO Metric Screw Threads

ISO metric threads come in three standard thread sizes: coarse, fine and constant pitch. The ISO coarse pitch is used for most common fastener applications. The fine pitch thread is used on certain precision tools and instruments. The constant pitch thread is used mainly on machine parts and not for fasteners. The constant pitch thread, however, is used on all metric thread spark plugs.

ISO metric threads are specified by the capital letter M followed by the diameter in millimeters and the pitch (or the distance between each thread) in millimeters separated by the sign —. For example, a M8 — 1.25 bolt has a diameter of 8 millimeters with a distance of 1.25 millimeters between each thread. The measurement across two flats on the head of the bolt indicates the wrench size to be used. **Figure 5** shows how to determine bolt diameter.

NOTE

*If purchasing a bolt from a dealer or parts store, it is important to know how to specify bolt length. The correct way to measure bolt length is to measure from underneath the bolt head to the end of the bolt (**Figure 8**). Always measure bolt length in this manner to avoid purchasing or installing bolts that are too long.*

Machine Screws

There are many different types of machine screws. **Figure 9** shows a number of screw heads requiring different types of turning tools. Heads are also designed to protrude above the metal (round) or to be slightly recessed in the metal (flat). See **Figure 10**.

Bolts

Commonly called bolts, the technical name for these fasteners is *cap screw*. Metric bolts are described by the diameter and pitch (or the distance between each thread).

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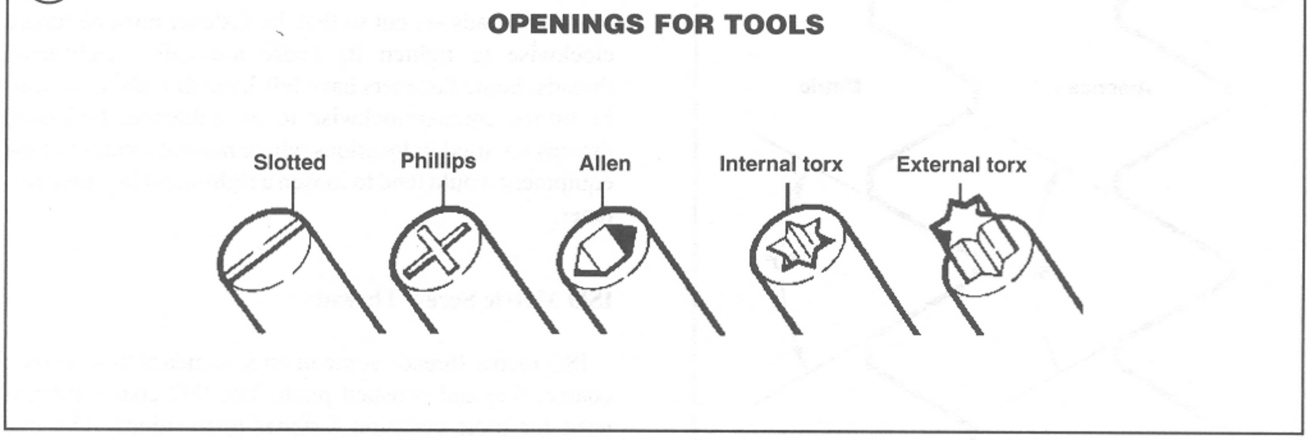

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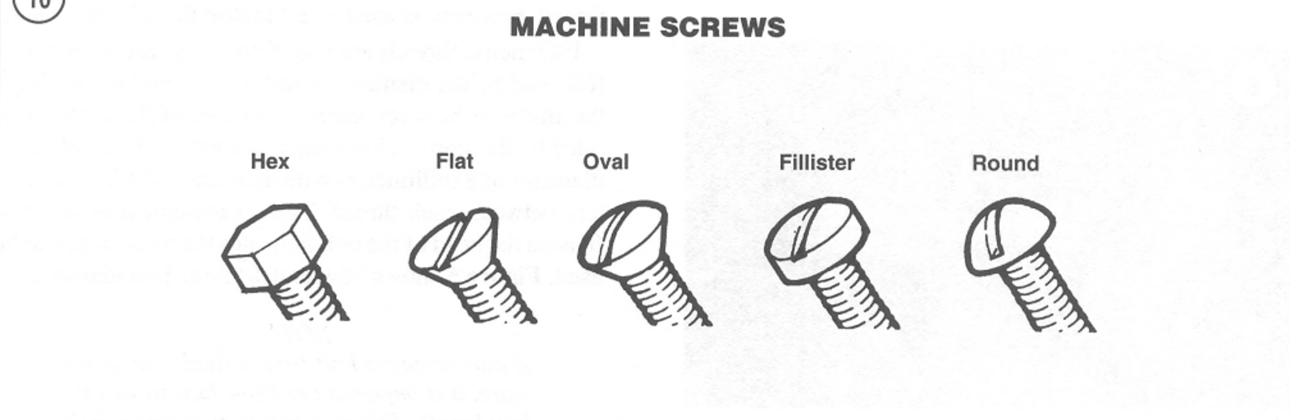


Nuts

Nuts are manufactured in a variety of types and sizes. Most are hexagonal (6-sided) and fit on bolts, screws and studs with the same diameter and pitch.

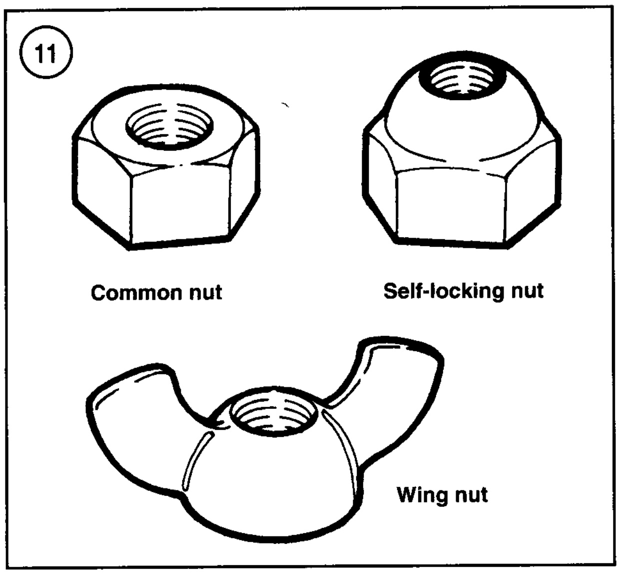
Figure 11 shows several types of nuts. The common nut is generally used with a lockwasher. Self-locking nuts have a nylon insert that prevents the nut from loosening; no lockwasher is required. Wing nuts are designed for fast removal by hand. Wing nuts are used for convenience in non-critical locations.

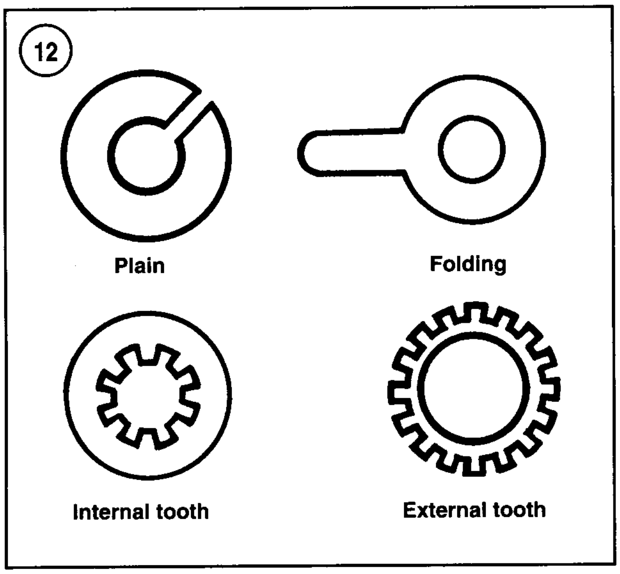
To indicate the size of a metric nut, manufacturers specify the diameter of the opening and the thread pitch. This is similar to bolt specifications, but without the length dimension. The measurement across two flats on the nut indicates the wrench size to be used.

Self-Locking Fasteners

Several types of bolts, screws and nuts incorporate a system that develops an interference between the bolt, screw, nut or tapped hole threads. Interference is achieved in various ways: by distorting threads, coating threads with dry adhesive or nylon, distorting the top of an all-metal nut, or using a nylon insert in the center or at the top of a nut.

Self-locking fasteners offer greater holding strength and better vibration resistance. Some self-locking fasteners can be reused if in good condition. Others, like the nylon insert nut, form an initial locking condition when the nut is first installed – the nylon forms closely to the bolt thread pattern, thus reducing any tendency for the nut to loosen. When the nut is removed, the locking efficiency is greatly reduced. It is recommended that new self-locking fasteners be installed after they are removed.

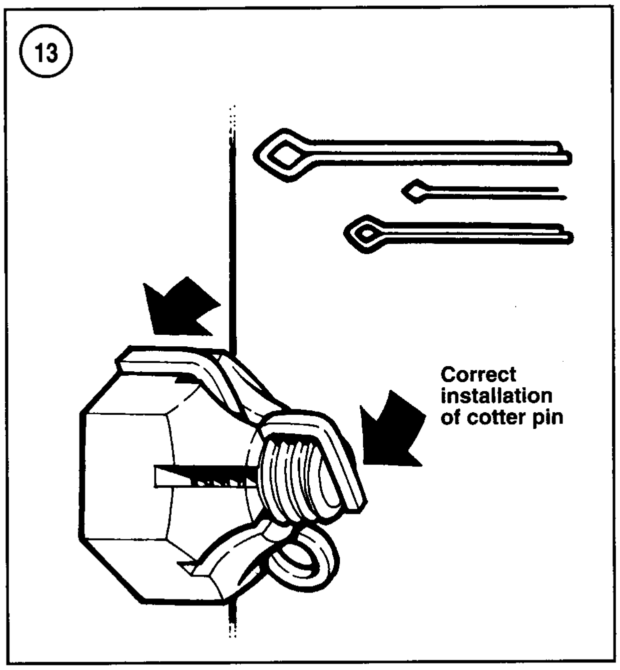




Washers

There are two basic types of washers: flat washers and lockwashers. Flat washers are simple discs with a hole to fit a screw or bolt. Lockwashers are designed to prevent a fastener from working loose due to vibration, expansion and contraction. **Figure 12** shows several types of washers. Washers are also used in the following functions:

a. As spacers.
b. To prevent galling or damage of the equipment by the fastener.
c. To help distribute fastener load during torquing.
d. As seals.



Flat washers are often used between a lockwasher and a fastener to provide a smooth bearing surface. This allows the fastener to be turned easily with a tool.

NOTE
As much care should be given to the selection and purchase of washers as that given to bolts, nuts and other fasteners. Avoid washers that are made of thin, weak materials. These will deform and crush the first time they are torqued, allowing the nut or bolt to loosen.

Cotter Pins

Cotter pins (**Figure 13**) are used to secure fasteners in a special location. The threaded stud or bolt must have a hole in it. The nut or nut lock piece will have castellations around its upper edge into which the cotter pin fits to keep it from loosening. When *properly* installed, a cotter pin is a positive locking device.

Purchase a cotter pin that will fit snugly when inserted through the nut and the mating thread part. The cotter pin should not be so tight that it has to be driven in and out, but it should not be so loose that it can move or float after it is installed.

Before installing a cotter pin, tighten the nut to the recommended torque specification. If the castellations in thc nut do not line up with the hole in the bolt or stud, tighten the nut until alignment is achieved. Do not loosen the nut to make alignment. Insert a *new* cotter pin through the nut and hole, then tap the head lightly to seat it. Bend one arm over the flat on the nut and the other against the top of the stud or bolt (**Figure 13**). Cut the arms to a suitable length to prevent them from snagging on clothing or skin. When the cotter pin is bent and its arms cut to length, it should be tight. If it can be wiggled, it is improperly installed.

Do not reuse cotter pins, as their ends may break and allow the cotter pin to fall out and the fastener to loosen.

Circlips

Circlips can be internal or external design. They are used to retain items on shafts (external type) or within tubes (internal type). In some applications, circlips of varying thickness are used to control the end play of parts assemblies. These are often called selective circlips. Replace circlips during installation, as removal weakens and deforms them.

Two basic styles of circlips are available: machined and stamped circlips. Machined circlips (**Figure 14**) can be installed in either direction (shaft or housing) because both faces are machined, thus creating two sharp edges. Stamped circlips (**Figure 15**) are manufactured with one sharp edge and one rounded edge. When installing stamped circlips in a thrust situation, the sharp edge must face away from the part producing the thrust. When installing circlips, observe the following:

a. Remove and install circlips with circlip pliers. See *Circlip Pliers* in this chapter.
b. Compress or expand circlips only enough to install them.
c. After the circlip is installed, make sure it is completely seated in its groove.

LUBRICANTS

Periodic lubrication ensures long life for any type of equipment. The *type* of lubricant used is as important as the lubrication service itself, although in an emergency the wrong type of lubricant is better than none at all. The following paragraphs describe the types of lubricants most often required. Be sure to follow the manufacturer's recommendations for lubricant types.

Generally, all liquid lubricants are called oil. They may be mineral-based (including petroleum bases), natural-based (vegetable and animal bases), synthetic-based or emulsions (mixtures). Grease is an oil to which a thickening base has been added so that the end product is semi-solid. Grease is often classified by the type of thickener added; lithium soap is commonly used.

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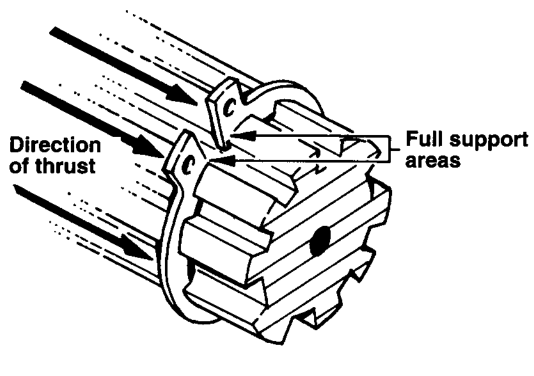

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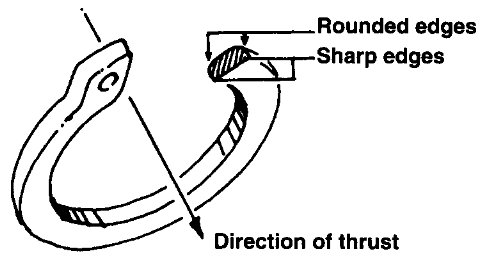

Engine Oil

Oil for marine and automotive four-stroke engines is classified by the American Petroleum Institute (API) and the Society of Automotive Engineers (SAE) in several categories. Oil containers display these classifications on the top or label. API oil classification is indicated by letters; oils for gasoline engines are identified by an "S" and oils for diesel engines are identified by a "C".

Viscosity is an indication of the oil's thickness. The SAE uses numbers to indicate viscosity; thin oils have low numbers while thick oils have high numbers. A "W" after the number indicates that the viscosity testing was done at low temperature to simulate cold-weather operation. Engine oils fall into the 5W-30 and 20W-50 range.

Multi-grade oils (for example 10W-40) are less viscous (thinner) at low temperatures and more viscous (thicker) at high temperatures. This allows the oil to perform efficiently across a wide range of engine operating condi-

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tions. The lower the number, the easier the engine will turn over in cold climates. Higher numbers are usually recommended for engine running in hot weather conditions.

Additional information is provided in Chapter Four.

Grease

Greases are graded by the National Lubricating Grease Institute (NLGI). Greases are graded by number according to the consistency of the grease; these range from No. 000 to No. 6, with No. 6 being the most solid. A typical multipurpose grease is NLGI No. 2. For specific applications, equipment manufacturers may require grease with an additive such as molybdenum disulfide (MoS_2).

RTV GASKET SEALANT

Room temperature vulcanizing (RTV) sealant is used on some pre-formed gaskets and to seal some components. RTV is a silicone gel supplied in tubes and can be purchased in a number of different colors.

Moisture in the air causes RTV to cure. Always place the cap on the tube as soon as possible when using RTV. RTV has a shelf life of one year and will not cure properly if the shelf life has expired. Check the expiration date on RTV tubes before use, and keep partially used tubes tightly sealed.

Applying RTV Sealant

Clean all gasket residue and contaminants from mating surfaces. Remove all RTV gasket material from blind attaching holes, as it will affect bolt torque.

Apply RTV sealant in a continuous bead 2-3 mm (0.08-0.12 in.) thick. Circle all mounting holes unless otherwise specified. Torque mating parts within 10 minutes after application.

THREADLOCK

Because of the marine engine's operating conditions, a threadlock (**Figure 16**) is required to help secure many of the fasteners. A threadlock will lock fasteners against vibration loosening and seal against leaks. Loctite 242 (blue) and 271 (red) are recommended for many threadlock requirements described in this manual.

Loctite 242 (blue) is a medium-strength threadlock, and component disassembly can be performed with normal hand tools. Loctite 271 (red) is a high-strength threadlock, and heat or special tools, such as a press or puller, are required for component disassembly.

Applying Threadlock

Surfaces should be clean. If a threadlock was previously applied to the component, this residue should also be removed.

Shake the Loctite container thoroughly and apply to both parts. Assemble parts and/or tighten fasteners.

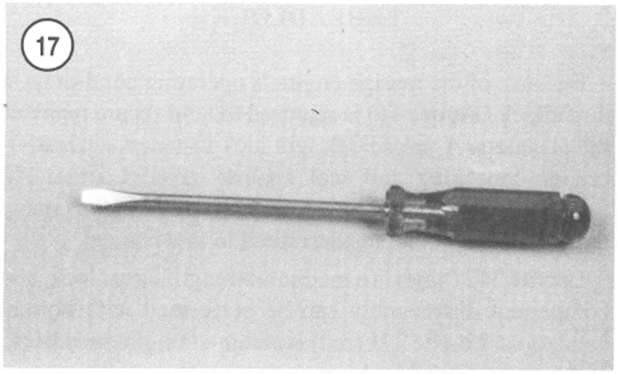
BASIC HAND TOOLS

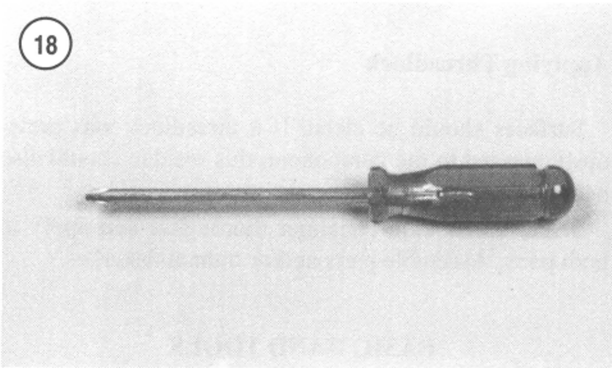
Many of the procedures in this manual can accomplished with simple hand tools and test equipment familiar to the average home mechanic. Keep tools clean and organized in a toolbox. After using a tool, wipe off dirt and grease and return the tool to its correct place. Wiping tools off is especially important if servicing the craft in areas where they can come in contact with sand. Sand is very abrasive and will cause premature wear to engine parts.

High-quality tools are essential; they are also more economical in the long run. Stay away from the advertised specials featured at some stores. These are usually a poor grade tool that can be sold cheaply. They are usually made of inferior material and are thick, heavy and clumsy. Their rough finish makes them difficult to clean, and they usually don't last very long.

Quality tools are made of alloy steel and are heat treated for greater strength. They are lighter and better balanced than poorly made ones. Their surface is smooth, making them a pleasure to work with and easy to clean. The initial cost of quality tools may be more, but they are less expensive in the long run.

The following tools are required to perform virtually any repair job. Each tool is described and the recommended sizes given. Metric size tools are required to service Yanmar diesels.



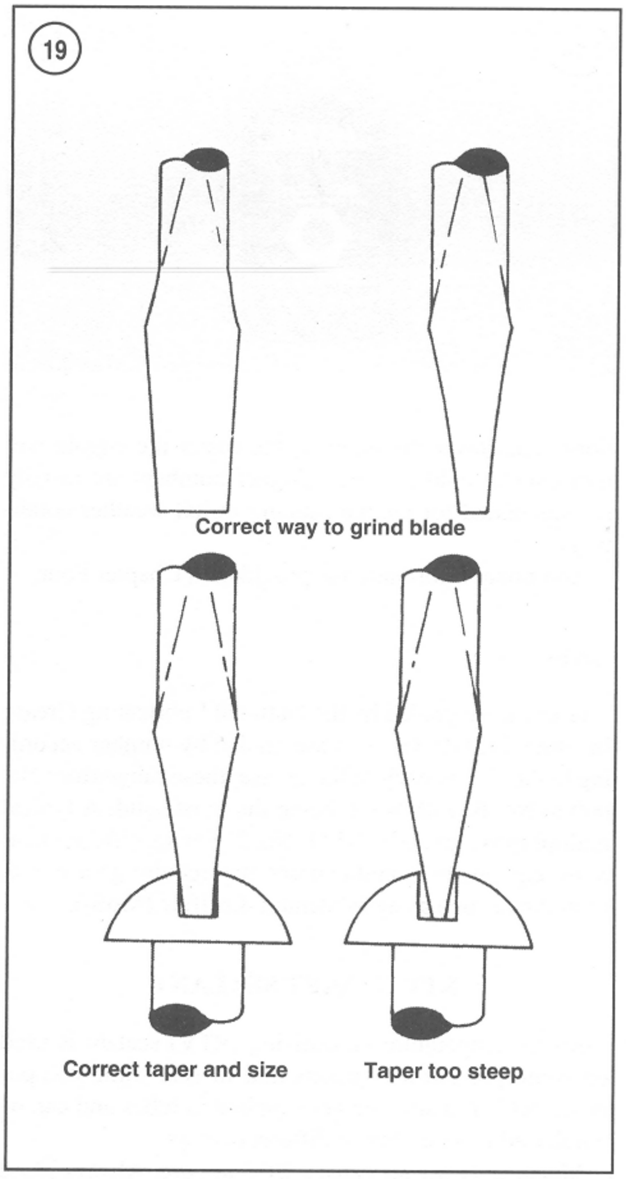


Screwdrivers

The screwdriver is a very basic tool, but if used improperly it will do more damage than good. The slot on a screw has a definite dimension and shape. Through improper use or selection, a screwdriver can damage the screw head, making removal of the screw difficult. A screwdriver must be selected to conform to the shape of the screw head used. Two basic types of screwdrivers are required: standard (flat- or slot-blade) screwdrivers (**Figure 17**) and Phillips screwdrivers (**Figure 18**).

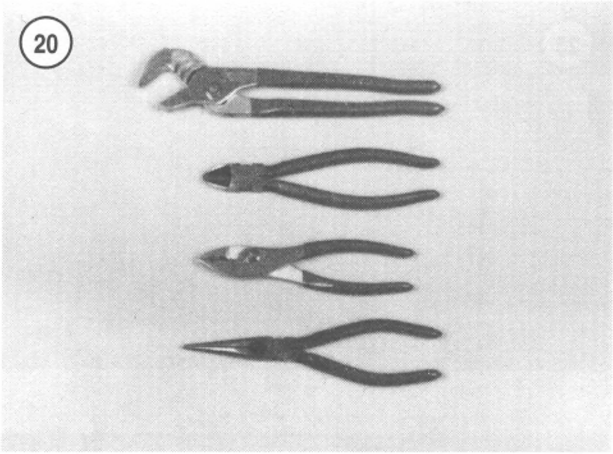
Note the following when selecting and using screwdrivers:

1. The screwdriver must always fit the screw head. If the screwdriver blade is too small for the screw slot, damage may occur to the screw slot and screwdriver. If the blade is too large, it cannot engage the slot properly and will result in damage to the screw head.
2. Standard screwdrivers are identified by the length of their blade. A 6-inch screwdriver has a blade six inches long. The width of the screwdriver blade will vary, so make sure that the blade engages the screw slot completely.
3. Phillips screwdrivers are sized according to their point size. They are numbered one, two, three and four. The degree of taper determines the point size; the No. 1 Phillips screwdriver will be the most pointed. The points become more blunt as their number increases.



NOTE

There is another screwdriver similar to the Phillips, and that is the Reed and Prince tip. Like the Phillips, the Reed and Prince screwdriver tip forms an "X", but the Reed and Prince tip has a much more pointed tip. The Reed and Prince screwdriver should never be used on Phillips screws and vise versa. Intermixing these screwdrivers will cause damage to the screw and screwdriver.



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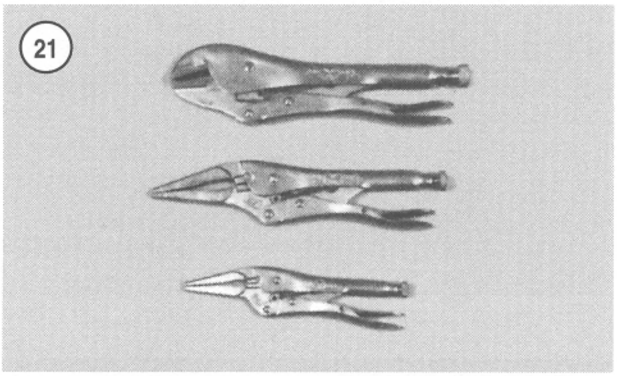

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Identify them by painting the screwdriver shank underneath the handle.

4. When selecting screwdrivers, note that more power can be applied with less effort with a longer screwdriver than with a short one. Of course, there will be situations where only a short handle screwdriver can be used. Keep this in mind though, when trying to remove tight screws.

5. Because the working end of a screwdriver receives quite a bit of abuse, you should purchase screwdrivers with hardened tips. The extra money will be well spent.

6. Screwdrivers are available in sets, which often include an assortment of common and Phillips blades. If purchasing them individually, buy at least the following:

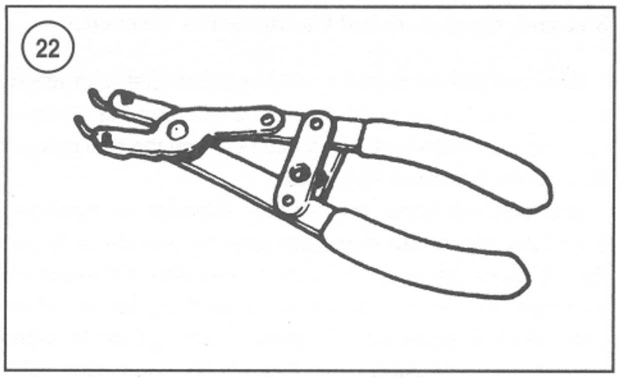
   a. Common screwdriver—5/16 × 6 in. blade.

   b. Common screwdriver—3/8 × 12 in. blade.

   c. Phillips screwdriver—size 2 tip, 6 in. blade.

   d. Phillips screwdriver—size 3 tip, 6 and 8 in. blade.

7. Use screwdrivers only for driving screws. Never use a screwdriver for prying or chiseling metal. Do not try to remove a Phillips, Torx or Allen head screw with a standard screwdriver (unless the screw has a combination head that



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will accept either type); this can damage the head so that the proper tool will be unable to remove it.

8. Keep screwdrivers in the proper condition, and they will last longer and perform better. Always keep the tip of a standard screwdriver in good condition. **Figure 19** shows how to grind the tip to the proper shape if it becomes damaged. Note the symmetrical sides of the tip.

Pliers

Pliers come in a wide range of types and sizes. Pliers are useful for cutting, bending and crimping. They should never be used to cut hardened objects or to turn bolts or nuts. **Figure 20** shows several types of pliers.

Each type of pliers has a specialized function. Combination pliers are general-purpose pliers and are used mainly for holding and for bending. Needlenose pliers are used to hold or bend small objects. Adjustable pliers (commonly referred to as channel locks) can be adjusted to hold various sizes of objects; the jaws remain parallel to grip around objects such as pipe or tubing.

Locking Pliers

Locking pliers (**Figure 21**) are used to hold objects very tightly while another task is performed on the object. Locking pliers are available in many types for more specific tasks.

Circlip Pliers

Circlip pliers (**Figure 22**) are used to remove circlips from shafts or within engine or suspension housings. When purchasing circlip pliers, there are two types. External pliers (spreading) are used to remove circlips that fit on the outside of a shaft. Internal pliers (squeezing) are used to remove circlips that fit inside a housing.

Box-end, Open-end and Combination Wrenches

Box-end and open-end wrenches are available in sets or separately in a variety of sizes. The size number stamped near the end refers to the distance between the two parallel flats on the hex head bolt or nut.

Box-end wrenches are usually superior to open-end wrenches. Open-end wrenches grip the nut on only two flats. Unless a wrench fits well, it may slip and round off the points on the nut. The box-end wrench grips on all six flats. Both 6-point and 12-point openings on box-end wrenches are available. The 6-point gives superior holding power; the 12-point allows a shorter swing radius.

Combination wrenches (**Figure 23**) are open on one side and boxed on the other. Both ends are the same size.

Adjustable Wrenches

An adjustable wrench fits a variety of nuts or bolt heads (**Figure 24**). However, it can loosen and slip, causing damage to the nut and possibly causing injury. Use an adjustable wrench only when other wrenches are not available.

Adjustable wrenches come in various sizes.

Socket Wrenches

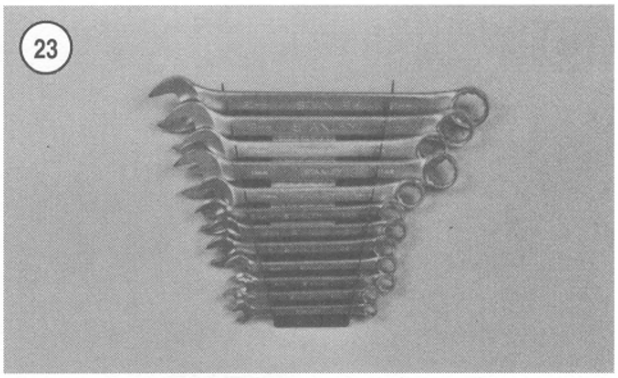
This type is undoubtedly the fastest, safest and most convenient to use. Sockets that attach to a ratchet handle (**Figure 25**) are available with 6-point or 12-point openings and 1/4, 3/8, 1/2 and 3/4 in. drives (**Figure 26**). The drive size indicates the size of the square hole that mates with the ratchet handle.

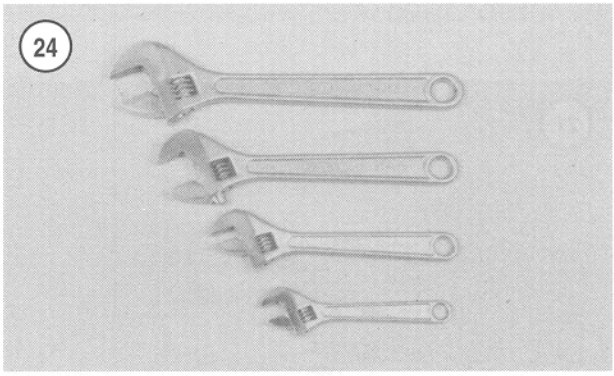
Torque Wrench

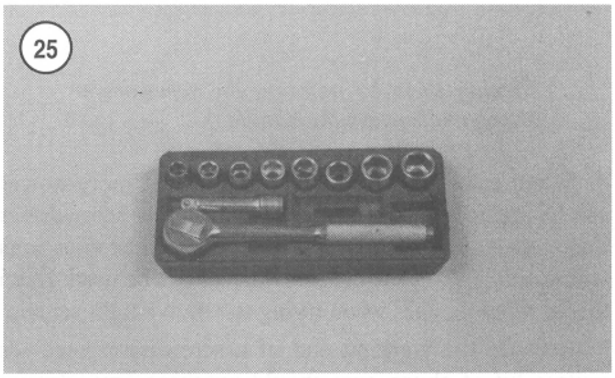
A torque wrench (**Figure 27**) is used with a socket to measure how tightly a nut or bolt is installed. Torque wrenches come in a wide price range and in different drive sizes. The drive size is the size of the square drive that mates with the socket.

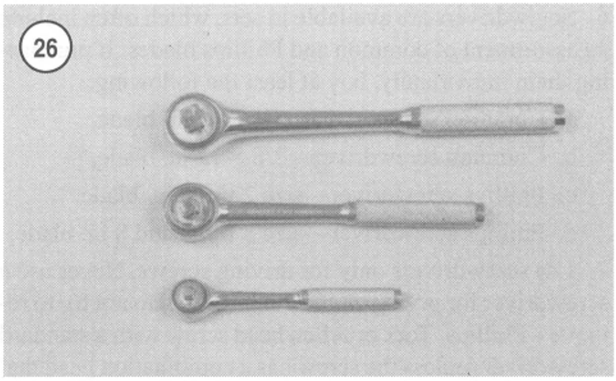
Impact Driver

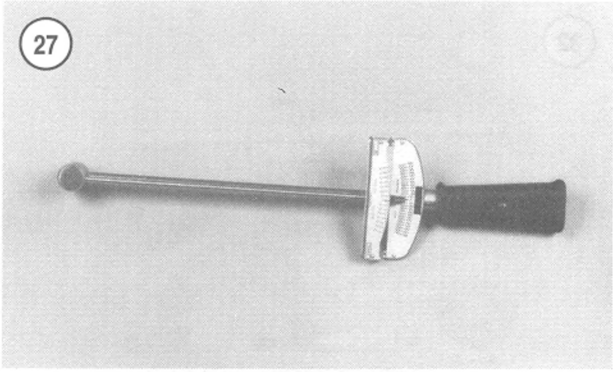
This tool makes removal of tight fasteners easy and eliminates damage to bolts and screw slots. Impact drivers and interchangeable bits (**Figure 28**) are available at most large hardware stores, tool suppliers and motorcycle dealers. Sockets can also be used with a hand-impact driver. However, make sure the socket is designed for impact use. Do not use regular hand sockets, as they may shatter.











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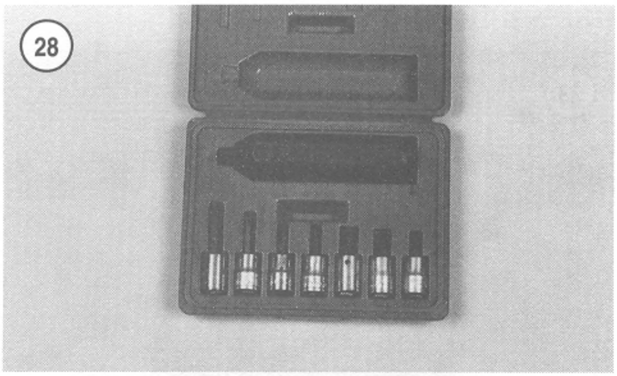

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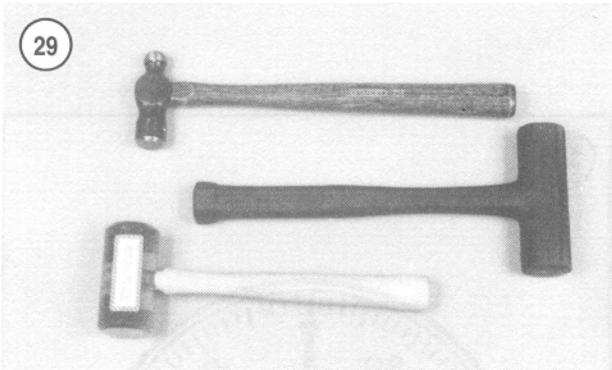

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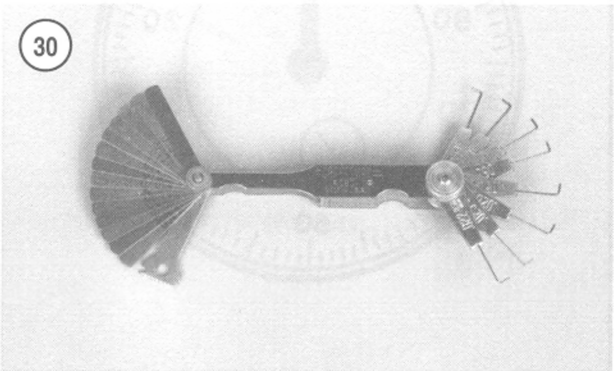

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Hammers

The correct hammer (**Figure 29**) is necessary for many types of repairs. Use only a hammer with a face (or head) made of rubber or plastic or the soft-faced type filled with leadshot. *Never* use a metal-faced hammer on engine or jet pump parts, as severe damage will result. Ball-peen or machinist's hammers are required if striking another tool, such as a punch or impact driver. When striking a hammer against a punch, cold chisel or similar tool, the face of the hammer should be at least 1/2 in. larger than the head of the tool. If it is necessary to strike hard against a steel part without damaging it, use a brass hammer. A brass hammer can be used because brass will give when striking a harder object.

When using hammers, note the following:

1. *Always* wear safety glasses.
2. Inspect hammers for damaged or broken parts. Repair or replace the hammer as required. Do *not* use a hammer with a taped handle.
3. Always wipe oil or grease off the hammer *before* using it.
4. The head of the hammer should always strike the object squarely. Do not use the side of the hammer or the handle to strike an object.
5. Always use the correct hammer for the job.

PRECISION MEASURING TOOLS

Measurement is an important part of service. When performing many of the service procedures in this manual, a number of measurements will be required. These include basic checks, such as engine compression and spark plug gap. Measurements will be required to determine the condition of the piston and cylinder bore, crankshaft runout and so on. When making these measurements, the degree of accuracy will dictate which tool is required. Precision measuring tools are expensive. If these tools are not available, it may be more worthwhile to have the checks made at a dealer. The following is a description of the measuring tools required during engine and transmission overhaul.

Feeler Gauge

A feeler gauge (**Figure 30**) is made of a piece of a flat or round hardened steel of a specified thickness. Wire gauges are used to measure spark plug gap. Flat gauges are used for all other measurements.

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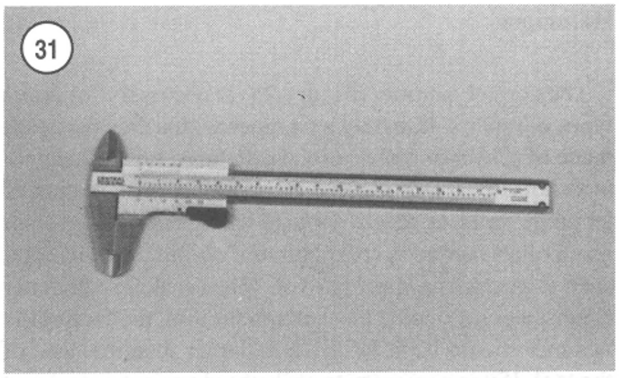

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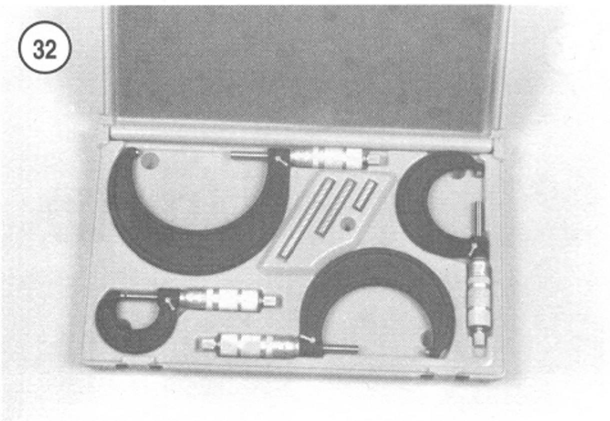

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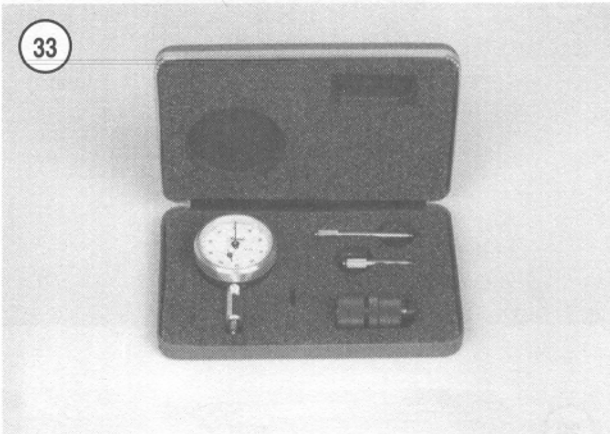

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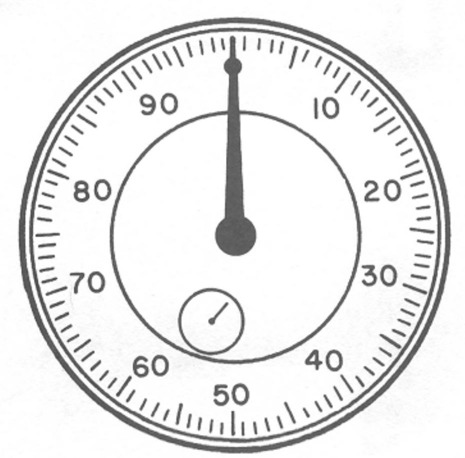


Vernier Caliper

This tool is used to obtain inside, outside and depth measurements. See **Figure 31**.

Outside Micrometers

One of the most accurate tools used for precision measurement is the outside micrometer. Outside micrometers are required to measure shim and bearing thickness and piston diameter. Outside micrometers are also used with a telescoping gauge to measure cylinder bore. Micrometers can be purchased individually or as a set (**Figure 32**).

Dial Indicator

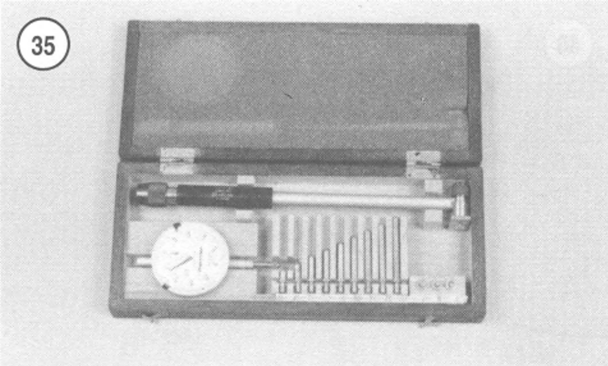
Dial indicators (**Figure 33**) are used to check crankshaft and drive shaft runout limits. Select a dial indicator with a continuous dial (**Figure 34**).

Cylinder Bore Gauge

The cylinder bore gauge is a very specialized precision tool. The gauge set shown in **Figure 35** is comprised of a dial indicator, handle and various length adapters to adapt the gauge to different bore sizes. The bore gauge can be used to make cylinder bore measurements such as bore size, taper and out-of-round. An outside micrometer must be used to calibrate the bore gauge.

Telescoping Gauges

Telescoping gauges (**Figure 36**) can be used to measure hole diameters from approximately 8 mm (5/16 in.) to 150 mm (6 in.). The telescoping gauge does not have a scale gauge for direct readings. An outside micrometer is required to determine bore dimensions.



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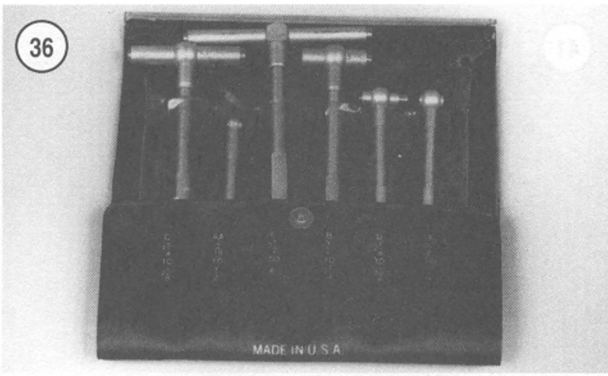

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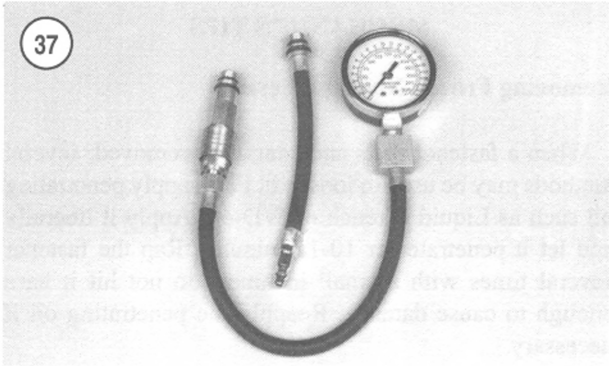

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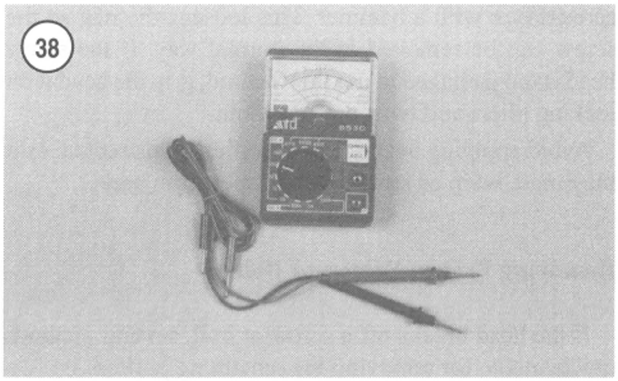

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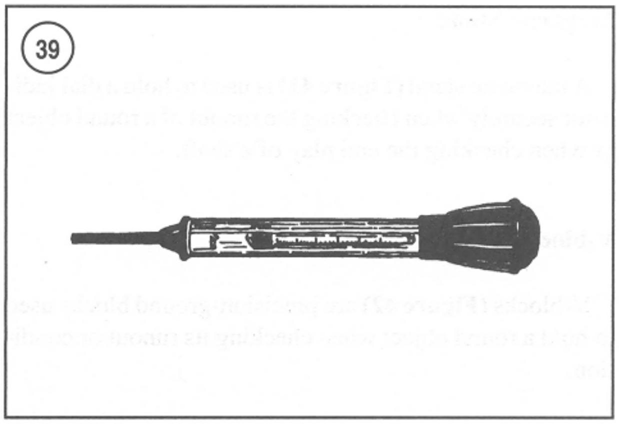

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Compression Gauge

An engine with low compression cannot be properly tuned and will not develop full power. A compression gauge (**Figure 37**) and adapter specifically designed for diesel applications is required to measure the high cylinder compression pressure (390-470psi [2700-3300kPa]). If these specialized tools are not available, refer compression testing to a qualified technician. See Chapter Three.

Multimeter or VOM

This instrument (**Figure 38**) is required for electrical system troubleshooting.

Battery Hydrometer

A hydrometer (**Figure 39**) is the used to check a battery's state of charge. A hydrometer measures the weight or density of the sulfuric acid in the battery's electrolyte in specific gravity.

Screw Pitch Gauge

A screw pitch gauge (**Figure 40**) determines the thread pitch of bolts, screws, studs, etc. The gauge is made up of a number of thin plates. Each plate has a thread shape cut on one edge to match one thread pitch. When using a screw pitch gauge to determine a thread pitch size, fit different blade sizes onto the bolt thread until both threads match.

Magnetic Stand

A magnetic stand (**Figure 41**) is used to hold a dial indicator securely when checking the runout of a round object or when checking the end play of a shaft.

V-blocks

V-blocks (**Figure 42**) are precision-ground blocks used to hold a round object when checking its runout or condition.

Surface Plate

A surface plate can be used to check the flatness of parts or to provide a perfectly flat surface for minor resurfacing of cylinder head or other critical gasket surfaces. While industrial quality surface plates are quite expensive, the home mechanic can improvise. A thick metal plate can be used as a surface plate. The surface plate shown in **Figure 43** has a piece of sandpaper glued to its surface that is used for cleaning and smoothing machined surfaces, such as the cylinder head.

NOTE
A local machine shop can fabricate a surface plate.

Expendable Supplies

Certain expendable supplies are also required. These include grease, oil, gasket cement, shop rags and cleaning solvent. Ask the dealer for the special locking compounds, silicone lubricants and lubricants that make vehicle maintenance simpler and easier.

WARNING
Having a stack of clean shop rags on hand is important when performing engine work. However, to prevent the possibility of fire, store solvent-soaked rags in a sealed metal container until they can be washed or discarded.

NOTE
To avoid absorbing solvent and other chemicals into the skin while cleaning parts, wear a pair of petroleum-resistant rubber gloves. These can be purchased through industrial supply houses or well-equipped hardware stores.

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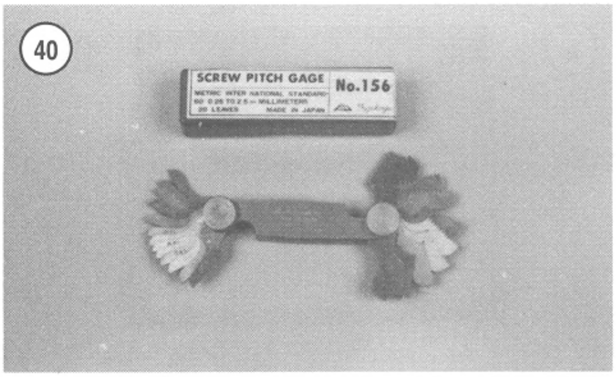

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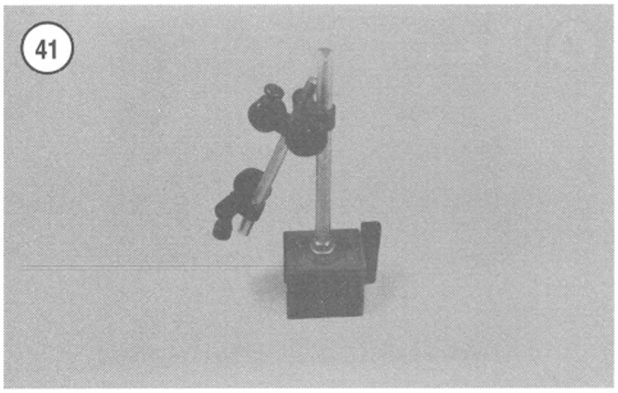


MECHANIC'S TIPS

Removing Frozen Nuts and Screws

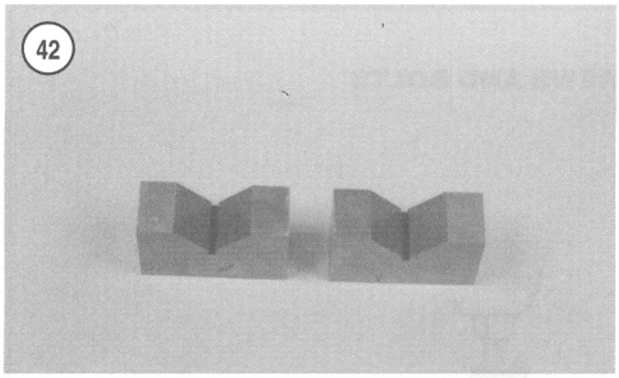
When a fastener rusts and cannot be removed, several methods may be used to loosen it. First, apply penetrating oil such as Liquid Wrench or WD-40. Apply it liberally and let it penetrate for 10-15 minutes. Rap the fastener several times with a small hammer; do not hit it hard enough to cause damage. Reapply the penetrating oil if necessary.

For frozen screws, apply penetrating oil as described, then insert a screwdriver in the slot and rap the top of the screwdriver with a hammer. This loosens the rust so the screw can be removed in the normal way. If the screw head is too damaged to use this method, grip the head with locking pliers and twist the screw out.

Avoid applying heat unless specifically instructed, as it may melt, warp or remove the temper from parts.

Removing Broken Screws or Bolts

If the head breaks off a screw or bolt, several methods are available for removing the remaining portion.



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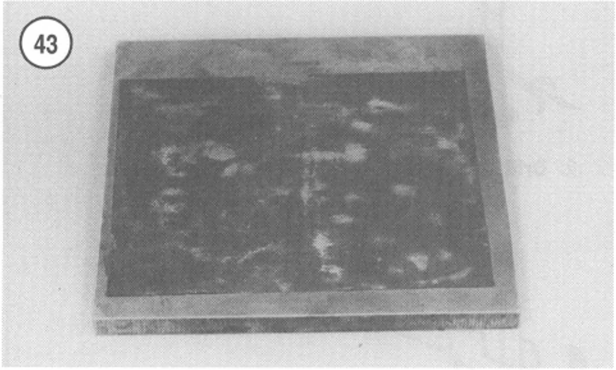

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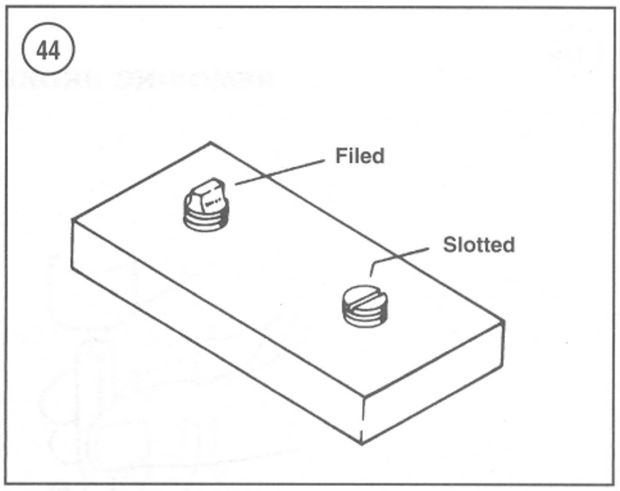

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If a large portion of the remainder projects out, try gripping it with locking pliers. If the projecting portion is too small, file it to fit a wrench or cut a slot in it to fit a screwdriver. See **Figure 44**.

If the head breaks off flush, use a screw extractor. To do this, centerpunch the remaining portion of the screw or bolt. Drill a small hole in the screw and tap the extractor into the hole. Back the screw out with a wrench on the extractor. See **Figure 45**.

Remedying Stripped Threads

Occasionally, threads are stripped through carelessness or impact damage. Often the threads can be repaired by running a tap (for internal threads on nuts) or die (for external threads on bolts) through the threads. See **Figure 46**. To clean or repair spark plug threads, a spark plug tap can be used.

NOTE
*Tap and dies can be purchased individually or in a set as shown in **Figure 47**.*

If an internal thread is damaged, it may be necessary to install a Helicoil (**Figure 48**) or some other type of thread insert. Follow the manufacturer's instructions when installing their insert.

If it is necessary to drill and tap a hole, refer to **Table 4** for metric tap and drill sizes.

Removing Broken or Damaged Studs

If a stud is broken or the threads severely damaged, perform the following. A tube of Loctite 271 (red), two nuts, two wrenches and a new stud will be required during this procedure.

1. Thread two nuts onto the damaged stud. Then tighten the two nuts against each other so that they are locked.

NOTE
If the threads on the damaged stud do not allow installation of the two nuts, remove the stud with a stud remover or a pair of locking pliers.

2. Turn the bottom nut counterclockwise and unscrew the stud.
3. Clean the threads with solvent or electrical contact cleaner and allow them to dry thoroughly.
4. Install two nuts on the top half of the new stud as in Step 1. Make sure they are locked securely.
5. Coat the bottom half of a new stud with Loctite 271 (red).
6. Turn the top nut clockwise and thread the new stud securely.
7. Remove the nuts and repeat for each stud as required.
8. Follow Loctite's directions on cure time before assembling the component.

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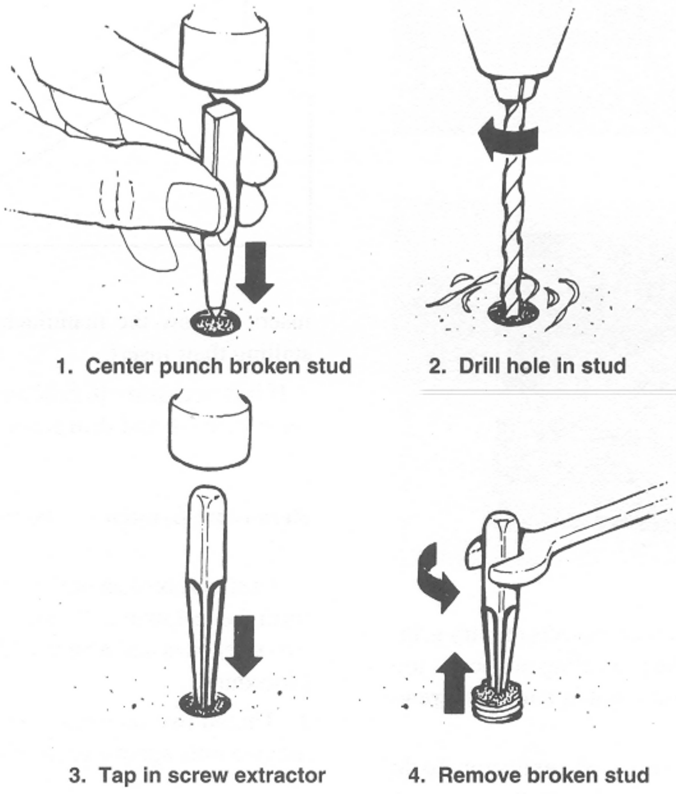
REMOVING BROKEN SCREWS AND BOLTS



BEARING REPLACEMENT

Bearings (**Figure 49**) are used throughout the engine to reduce power loss, heat and noise resulting from friction. Because bearings are precision-made parts, they must be maintained by proper lubrication and maintenance. If a bearing is damaged, it should be replaced immediately. However, if installing a new bearing, care should be taken to prevent damage to the new bearing. While bearing replacement is described in the individual chapters where applicable, the following should be used as a guideline.

NOTE
Unless otherwise specified, install bearings with the manufacturer's mark or number facing outward.

Bearing Removal

While bearings are normally removed only when damaged, there may be times when it is necessary to remove a bearing that is in good condition. Improper bearing removal will damage the bearing and possibly the shaft or case half. Note the following when removing bearings.

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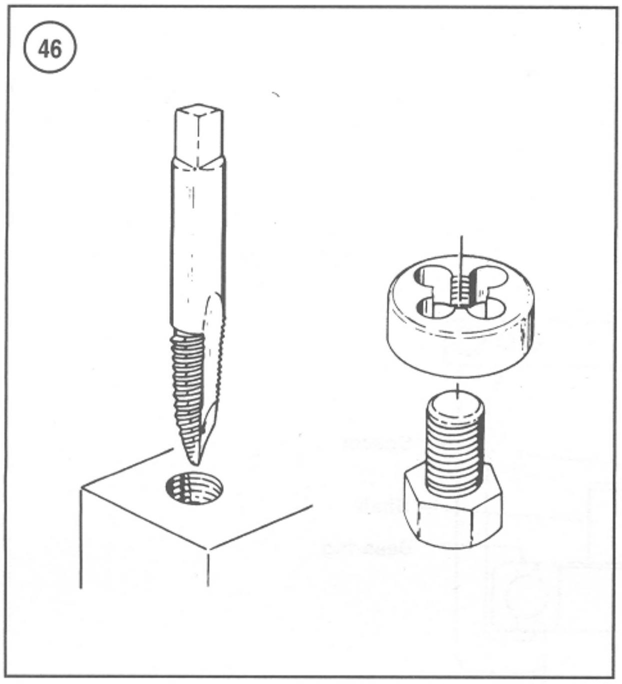

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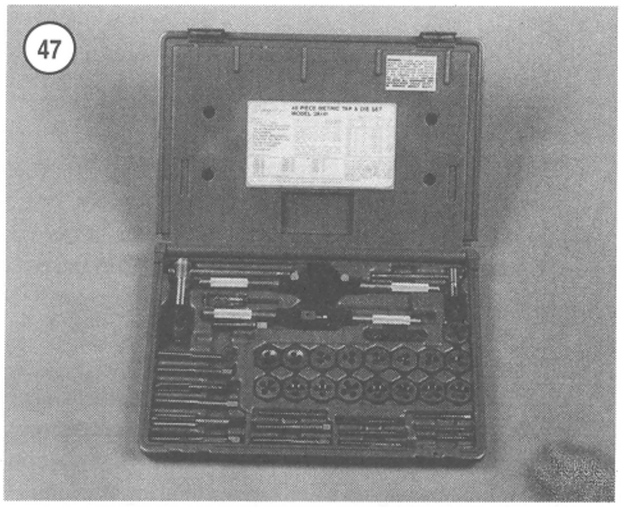

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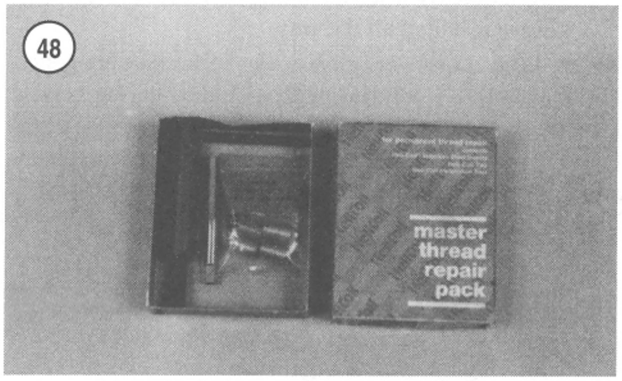

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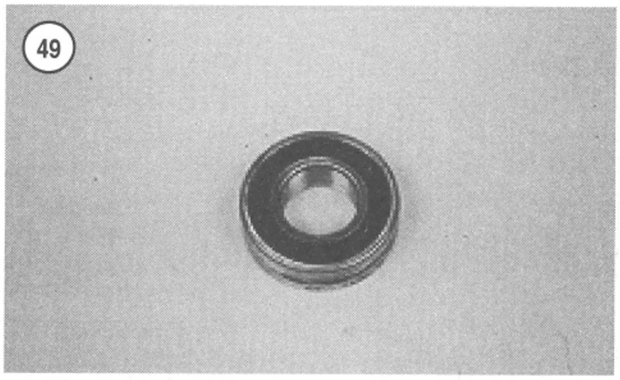
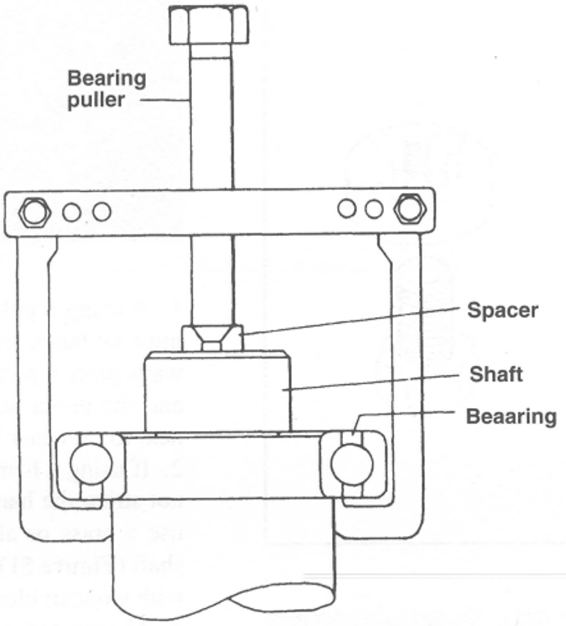


1. If using a puller to remove a bearing on a shaft, care must be taken so that shaft damage does not occur. Always place a piece of metal between the end of the shaft and the puller screw. In addition, place the puller arms next to the inner bearing race. See **Figure 50**.
2. If using a hammer to remove a bearing on a shaft, do not strike the hammer directly against the shaft. Instead, use a brass or aluminum rod between the hammer and shaft (**Figure 51**). In addition, support both bearing races with wooden blocks as shown in **Figure 51**.
3. The most ideal method of bearing removal is with a hydraulic press. However, certain procedures must be followed or damage may occur to the bearing, shaft or bearing housing. Note the following if using a press:
   a. Always support the inner and outer bearing races with a suitable size wood or aluminum ring (**Figure 52**). If only the outer race is supported, pressure applied against the bearings and/or the inner race will damage them.
   b. Always make sure the press ram (**Figure 52**) aligns with the center of the shaft. If the ram is not centered, it may damage the bearing and/or shaft.
   c. The moment the shaft is free of the bearing, it will drop to the floor. Secure the shaft to prevent it from falling.

Bearing Installation

1. When installing a bearing in a housing, pressure must be applied to the *outer* bearing race (**Figure 53**). When installing a bearing on a shaft, pressure must be applied to the *inner* bearing race (**Figure 54**).
2. When installing a bearing as described in Step 1, some type of driver will be required. Never strike the bearing directly with a hammer or the bearing will be damaged. A piece of pipe or a socket with an outer diameter that matches the bearing race will be required. **Figure 55** shows the correct way to use a socket and hammer when installing a bearing.

50



3. Step 1 describes how to install a bearing in a case half and over a shaft. However, when installing a bearing over a shaft and into a housing at the same time, a snug fit will be required for both outer and inner bearing races. In this situation, a spacer must be installed underneath the driver tool so that pressure is applied evenly across *both* races. See **Figure 56**. If the outer race is not supported as shown in **Figure 56**, the balls will push against the outer bearing track and damage it.

Shrink Fit

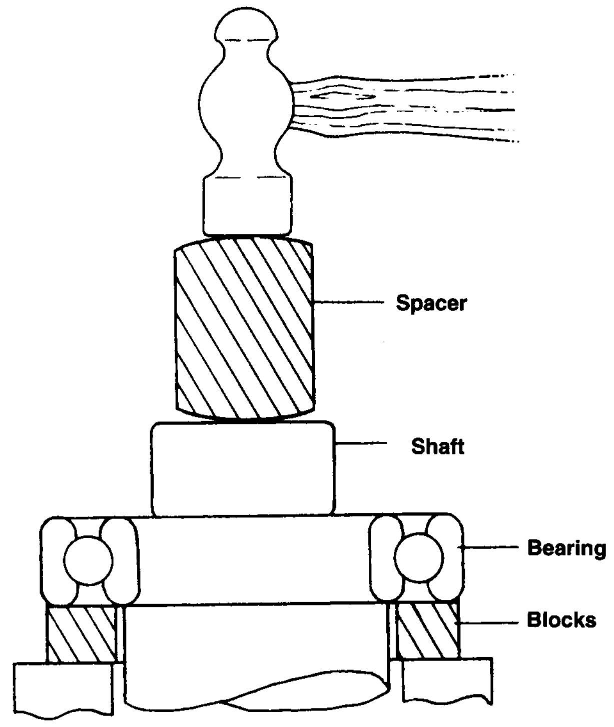
1. *Installing a bearing over a shaft*—If a tight fit is required, the bearing inside diameter will be smaller than the shaft. In this case, driving the bearing on the shaft using normal methods may cause bearing damage. Instead, the bearing should be heated before installation. Note the following:
   a. Secure the shaft so that it can be ready for bearing installation.
   b. Clean the bearing surface on the shaft of all residue. Remove burrs with a file or sandpaper.
   c. Fill a suitable pot or beaker with clean mineral oil. Place a thermometer (rated higher than 120° C [248° F]) in the oil. Support the thermometer so it does not rest on the bottom or side of the pot.
   d. Remove the bearing from its wrapper and secure it with a piece of heavy wire bent to hold it in the pot. Hang the bearing in the pot so that it does not touch the bottom or sides of the pot.
   e. Turn the heat on and monitor the thermometer. When the oil temperature rises to approximately 120° C (248° F), remove the bearing from the pot and quickly install it. If necessary, place a socket on the inner bearing race and tap the bearing into place. As the bearing cools, it will tighten on the shaft so work quickly when installing it. Make sure the bearing is installed all the way.

2. *Installing a bearing in a housing*—Bearings are generally installed in a housing with a slight interference fit. Driving the bearing into the housing using normal methods may damage the housing or cause bearing damage. Instead, the housing should be heated before the bearing is installed. Note the following:

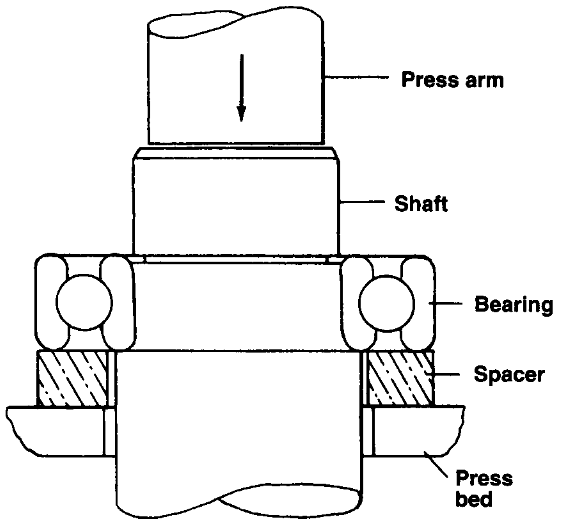
CAUTION

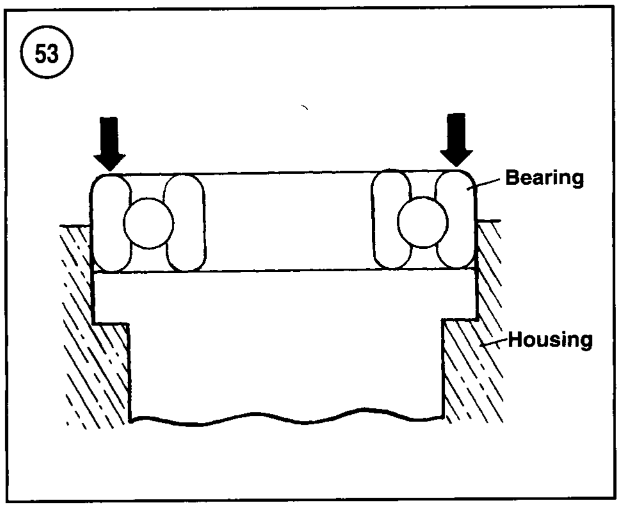
Before heating the housing in this procedure to remove the bearings, wash the housing thoroughly with detergent and water. Rinse

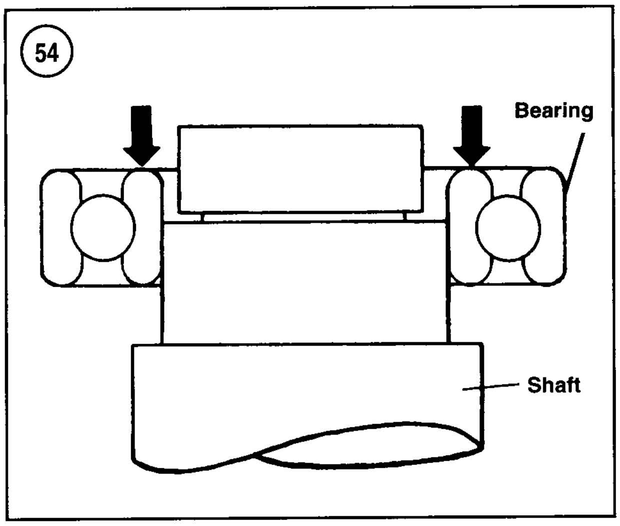
51

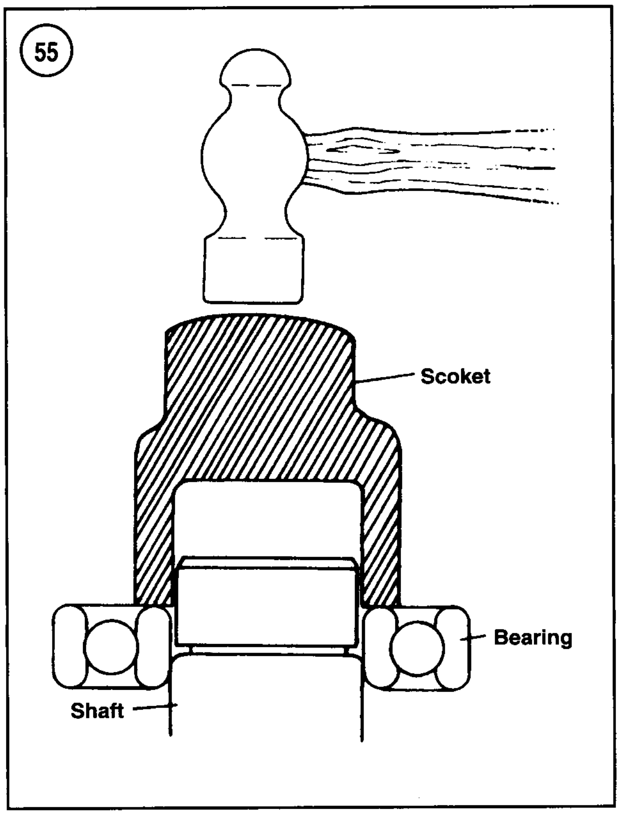

Spacer
Shaft
Bearing
Blocks

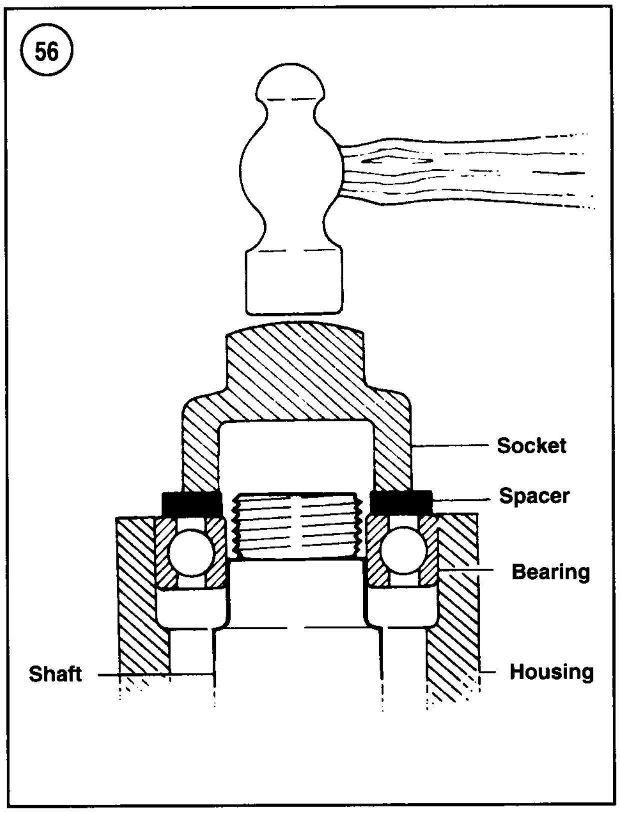
52


Press arm
Shaft
Bearing
Spacer
Press bed







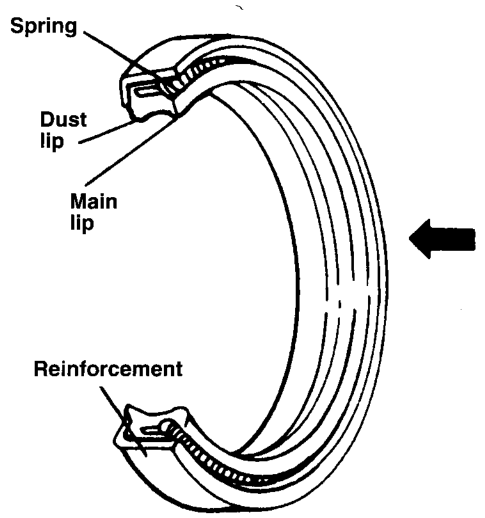


and rewash the housing as required to remove all traces of oil and other chemical deposits.

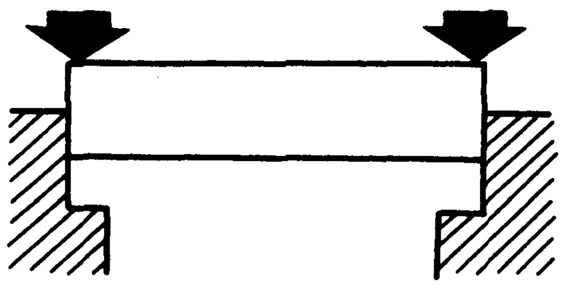
a. The housing must be heated to a temperature of approximately 212° F (100° C) in an oven or on a hot plate. Check to see that it is at the proper temperature by dropping tiny drops of water on the case; if they sizzle and evaporate immediately, the temperature is correct. Heat only one housing at a time.

CAUTION
Do not heat the housing with a torch (propane or acetylene)—never bring a flame into contact with the bearing or housing. The direct heat will destroy the case hardening of the bearing and will likely warp the housing.

57



58



b. Remove the housing from the oven or hot plate and hold onto the housing with a kitchen potholder, heavy gloves or heavy shop cloths—*it is hot.*

NOTE
A suitable size socket and extension works well for removing and installing bearings.

c. Hold the housing with the bearing side down and tap the bearing out. Repeat for all bearings in the housing.
d. Prior to heating the bearing housing, place the new bearing in a freezer, if possible. Chilling a bearing will slightly reduce its outside diameter, while the heated bearing housing assembly will be slightly larger due to heat expansion. This will make bearing installation much easier.

NOTE
Always install bearings with the manufacturer's mark or number facing outward.

e. While the housing is still hot, install the new bearing(s) into the housing. Install the bearings by hand, if possible. If necessary, lightly tap the bearing(s) into the housing with a socket placed on the outer bearing race. *Do not* install new bearings by driving on the inner bearing race. Install the bearing until it seats completely.

SEALS

Seals (**Figure 57**) are used to contain oil, water, grease or combustion gasses in a housing or shaft. Improper removal of a seal can damage the housing or shaft. Improper installation of the seal can damage the seal. Note the following:

1. Prying is generally the easiest and most effective method of removing a seal from a housing. However, always place a rag underneath the pry tool to prevent damage to the housing.
2. Pack grease in the seal lips before the seal is installed.
3. Always install seals so that the manufacturer's numbers or marks face out.
4. Install seals with a socket placed on the outside of the seal as shown in **Figure 58**. Make sure the seal is driven squarely into the housing. Never install a seal by hitting against the top of the seal with a hammer.

Tables 1-4 are on the following pages.

Table 1 YANMAR MODELS

Model	Number of cylinders	Displacement	Horsepower /rpm	Transmission	Transmission ratio (forward gear)
1GM	1	293 cc (17.9 cu. in.)	6.5 hp/3400 rpm	KM2A	2.21, 2.62 or 3.22
1GM10	1	318 cc (19.4 cu. in.)	8 hp/3400 rpm	KM2C or KM2P	2.21, 2.62 or 3.22
2GM	2	586 cc (35.7 cu. in.)	13 hp/3400 rpm	KM2A	2.21, 2.62 or 3.22
2GMF	2	586 cc (35.7 cu. in.)	13 hp/3400 rpm	KM2A	2.21, 2.62 or 3.22
2GM20	2	636 cc (38.8 cu. in.)	16 hp/3400 rpm	KM2C or KM2P	2.21, 2.62 or 3.22
2GM20F	2	636 cc (38.8 cu. in.)	16 hp/3400 rpm	KM2C or KM2P	2.21, 2.62 or 3.22
3GM	3	879 cc (53.6 cu. in.)	20 hp/3400 rpm	KBW10D	2.14, 2.63 or 2.83
3GMF	3	879 cc (53.6 cu. in.)	20 hp/3400 rpm	KBW10D	2.14, 2.63 or 2.83
3GMD	3	879 cc (53.6 cu. in.)	20 hp/3400 rpm	KM3A	2.36, 2.61 or 3.20
3GM30	3	954 cc (58.2 cu. in.)	24 hp/3400 rpm	KM3A or KM3P	2.36, 2.61 or 3.20
3GM30F	3	954 cc (58.2 cu. in.)	24 hp/3400 rpm	KM3A or KM3P	2.36, 2.61 or 3.20
3HM	3	1126 cc (68.7 cu. in.)	27 hp/3200 rpm	KBW10E	2.14 or 2.83
3HMF	3	1126 cc (68.7 cu. in.)	27 hp/3200 rpm	KBW10E	2.14 or 2.83
3HM35	3	1282 cc (78.2 cu. in.)	30 hp/3200 rpm	KBW10E	2.14 or 2.83
3HM35F	3	1282 cc (78.2 cu. In.)	30 hp/3200 rpm	KBW10E	2.14 or 2.83

Table 2 DECIMAL AND METRIC EQUIVALENTS

Fractions	Decimal in.	Metric mm	Fractions	Decimal in.	Metric mm
1/64	0.015625	0.39688	33/64	0.515625	13.09687
1/32	0.03125	0.79375	17/32	0.53125	13.49375
3/64	0.046875	1.19062	35/64	0.546875	13.89062
1/16	0.0625	1.58750	9/16	0.5625	14.28750
5/64	0.078125	1.98437	37/64	0.578125	14.68437
3/32	0.09375	2.38125	19/32	0.59375	15.08125
7/64	0.109375	2.77812	39/64	0.609375	15.47812
1/8	0.125	3.1750	5/8	0.625	15.87500
9/64	0.140625	3.57187	41/64	0.640625	16.27187
5/32	0.15625	3.96875	21/32	0.65625	16.66875
11/64	0.171875	4.36562	43/64	0.671875	17.06562
3/16	0.1875	4.76250	11/16	0.6875	17.46250
13/64	0.203125	5.15937	45/64	0.703125	17.85937
7/32	0.21875	5.55625	23/32	0.71875	18.25625
15/64	0.234375	5.95312	47/64	0.734375	18.65312
1/4	0.250	6.35000	3/4	0.750	19.05000
17/64	0.265625	6.74687	49/64	0.765625	19.44687
9/32	0.28125	7.14375	25/32	0.78125	19.84375
19/64	0.296875	7.54062	51/64	0.796875	20.24062
5/16	0.3125	7.93750	13/16	0.8125	20.63750
21/64	0.328125	8.33437	53/64	0.828125	21.03437
11/32	0.34375	8.73125	27/32	0.84375	21.43125
23/64	0.359375	9.12812	55/64	0.859375	22.82812
3/8	0.375	9.52500	7/8	0.875	22.22500
25/64	0.390625	9.92187	57/64	0.890625	22.62187
13/32	0.40625	10.31875	29/32	0.90625	23.01875
27/64	0.421875	10.71562	59/64	0.921875	23.41562
7/16	0.4375	11.11250	15/16	0.9375	23.81250
29/64	0.453125	11.50937	61/64	0.953125	24.20937
15/32	0.46875	11.90625	31/32	0.96875	24.60625
31/64	0.484375	12.30312	63/64	0.984375	25.00312
1/2	0.500	12.70000	1	1.00	25.40000

Chapter Two

Troubleshooting

Every internal combustion engine requires an uninterrupted supply of fuel, air, ignition and adequate compression. If any of these are lacking, the engine will not run.

Troubleshooting is a relatively simple matter if it is done logically. The first step in any troubleshooting procedure is to define the symptoms as fully as possible and then localize the problem. Subsequent steps involve testing and analyzing those areas that could cause the symptoms. A haphazard approach may eventually solve the problem, but it can be costly in terms of wasted time and unnecessary parts replacement.

When all else fails, go back to basics—simple solutions often solve complex-appearing problems.

Never assume anything. Do not overlook the obvious. If the engine suddenly quits when running or refuses to start, check the easiest and most accessible areas first. Make sure there is fuel in the tank and that the wiring is properly connected.

Be familiar with the engine compartment and engine components so a quick visual check is possible. Learning to recognize and describe symptoms accurately will make repairs easier. If a technician is required, saying that it will not run is not the same as saying that it quit at full throttle and would not restart.

Identify as many symptoms as possible to aid in diagnosis. Note whether the engine lost power gradually or all at once, what color smoke (if any) came from the exhaust, etc.

After defining the symptoms, test and analyze those areas that could cause the problem(s). Many problems can be analyzed without expensive test equipment. A few simple checks can keep a small problem from turning into a large one. They can also avoid a large repair bill and time lost while the boat sits in a shop's service department.

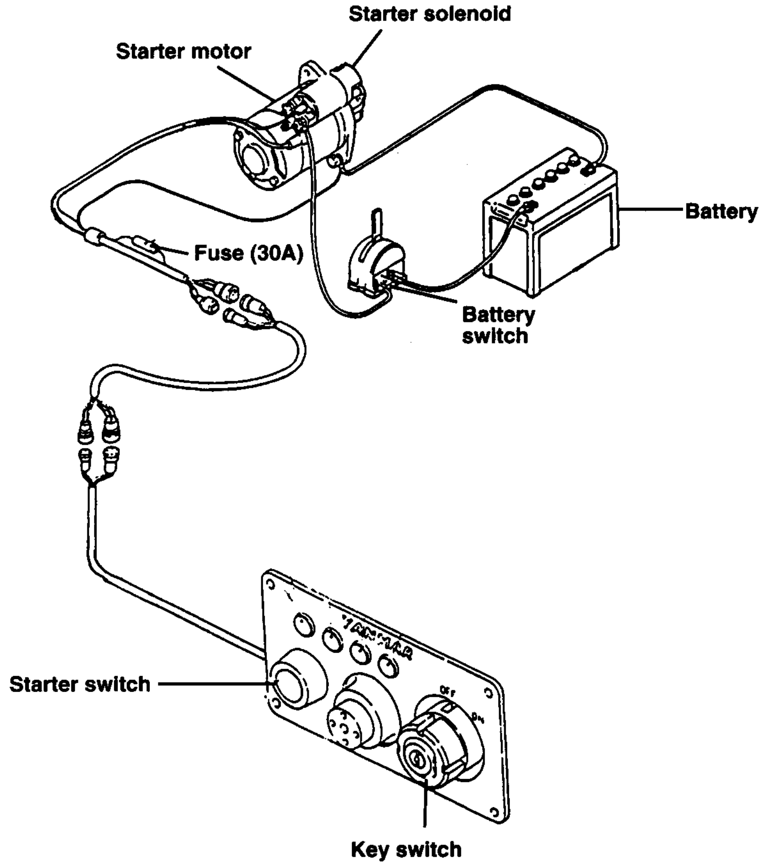
On the other hand, be realistic and do not attempt repairs beyond your abilities or with makeshift tools. Marine service departments also tend to charge heavily for putting together a disassembled engine or other components that may have been abused. Some shops will not even accept such a job. Use common sense and do not get in over your head or attempt a job without the proper tools.

Proper lubrication, maintenance and periodic tune-ups as described in Chapter Three will reduce the necessity for troubleshooting. Even with the best care, however, every marine engine is prone to problems that will eventually require troubleshooting.

If installing replacement parts, do not use automotive parts. While marine components, such as starters and alternators, may appear to be the same as automotive components, they are not. Marine components have been designed to withstand the unique requirements of marine

1

STARTING CIRCUIT (TYPICAL)



service, as well as to provide a measure of safety that is not required of automotive service. For example, a marine starter is flashproofed to prevent possible ignition of fuel vapor in the bilge. The use of an automotive starter as a replacement can result in an explosion or fire, which may cause death, serious injury or boat damage.

This chapter contains brief descriptions of each major operating system and troubleshooting procedures to be used. The troubleshooting procedures analyze common symptoms and provide logical methods of isolation. These are not the only methods. There may be several approaches to a problem, but all methods used must have one thing in common to be successful—a logical, systematic approach.

Troubleshooting diagrams for individual systems are provided within this chapter. A master troubleshooting chart (**Table 1**) is provided at the end of this chapter.

STARTING SYSTEM

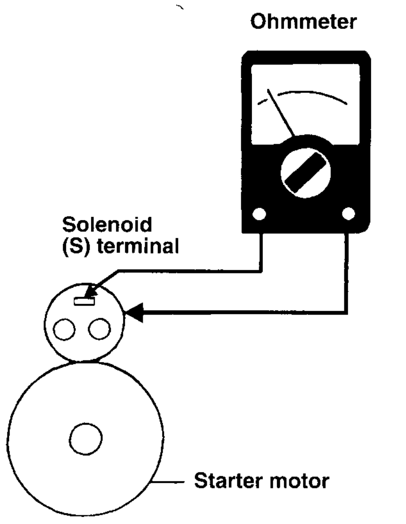
The starting system consists of the battery, starter motor, starter solenoid, starter switch, key switch, fuse and connecting wiring. See **Figure 1**, typical.

Starting system problems are relatively easy to find. In many cases, the trouble is a loose or dirty connection.

Starting System Operation

The battery switch, if used, and the key switch must be in the ON positions so battery current is available to the starter circuit. When the start switch on the instrument panel is pushed, battery current flows to the starter solenoid, which mechanically engages the starter with the engine flywheel. The solenoid also directs current to the starter motor, which rotates the engine flywheel to start

2



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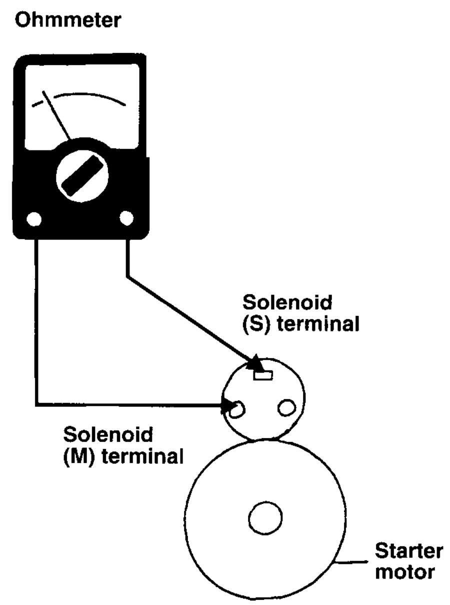


the engine. Once the engine has started and the start switch is released, the slave solenoid is de-energized. Without current to hold the solenoid in position, the starter motor overrunning clutch disengages the starter pinion from the flywheel.

On-Boat Testing

Two of these procedures require a fully charged 12-volt battery, to be used as a booster, and a pair of jumper cables. Use the jumper cables as outlined in *Jump Starting*, Chapter Nine, following all of the precautions noted. Disconnect the wiring harness and leads at the rear of the alternator before connecting a booster battery for these tests. This will protect the alternator from possible damage.

Slow running starter

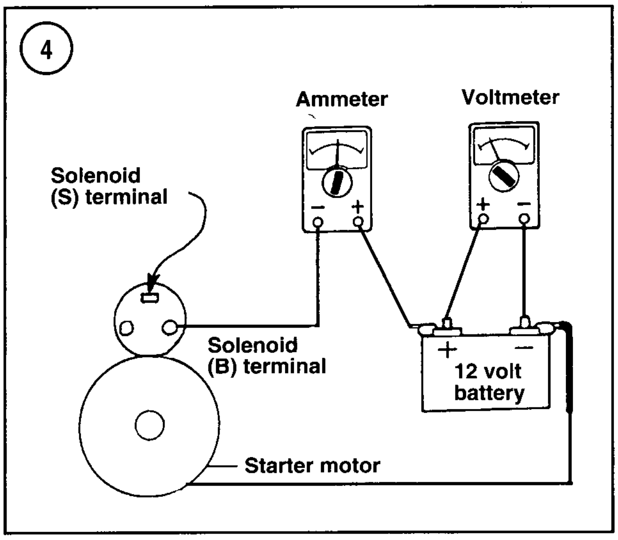
1. Connect the 12-volt booster battery to the engine's battery with jumper cables. Listen to the starter running speed as the engine is cranking. If the starter running speed sounds normal, check the battery for loose or corroded connections or a low charge. Clean and tighten the connections as required. Recharge the battery if necessary.
2. If starter running speed does not sound normal, clean and tighten all starter solenoid connections and the battery ground on the engine.
3. Repeat Step 1. If the starter running speed is still too slow, replace the starter.

Starter solenoid clicks, starter does not run

1. Clean and tighten all starter and solenoid connections. Make sure the terminal eyelets are securely fastened to the wire strands and are not corroded.
2. Remove the battery terminal clamps. Clean the clamps and battery posts. Reinstall the clamps and tighten them securely.
3. If the starter still does not run, connect the 12-volt booster battery to the engine's battery with the jumper cables. If the starter still does not run, replace it.

Starter solenoid chatters (no click), starter does not run

1. Check the S terminal wire connection at the starter solenoid. Clean and tighten if necessary.
2. Disconnect the S terminal wire at the starter solenoid. Connect a jumper wire between this terminal and the positive battery post.
3. Try starting the engine. If the engine starts, check the key switch, starter switch and the system wiring for an



open circuit or a loose connection. If the engine does not start, replace the starter solenoid.

Starter spins but does not rotate flywheel

1. Remove the starter. See Chapter Nine.
2. Check the starter pinion gear. If the teeth are chipped or worn, inspect the flywheel ring gear for the same problem. Replace the starter and/or ring gear as required.
3. If the pinion gear is in good condition, disassemble the starter and check the armature shaft for corrosion. See *Brush Replacement*, Chapter Nine, for the disassembly procedure. If no corrosion is found, the starter drive mechanism is slipping. Replace the starter with a new or rebuilt marine unit.

Starter will not disengage when start switch is released

This problem is usually caused by a sticking solenoid or defective start switch, but the pinion may jam on the flywheel ring gear on an engine with many hours of operation.

NOTE
A low battery or loose or corroded battery connections can also cause the starter to remain engaged with the flywheel ring gear. Low voltage at the starter can cause the contacts inside the solenoid to chatter and weld together, resulting in the solenoid sticking in the ON position.

Loud grinding noises when starter runs

This can be caused by improper meshing of the starter pinion and flywheel ring gear or by a broken overrunning clutch mechanism.

1. Remove the starter. See Chapter Nine.
2. Check the starter pinion gear. If the teeth are chipped or worn, inspect the flywheel ring gear for the same problem. Replace the starter and/or ring gear as required.
3. If the pinion gear is in good condition, the overrunning clutch mechanism in the starter may be defective. Replace the starter with a new or rebuilt marine unit.

Starter Solenoid Resistance Tests

Check the starter solenoid using the following resistance tests:

CAUTION
Disconnect the negative battery cable before performing resistance tests.

1. Refer to **Figure 2** and connect an ohmmeter lead to the S terminal of the solenoid. Connect the remaining ohmmeter lead to the metal body of the solenoid. The ohmmeter should indicate approximately one ohm or less. Replace the solenoid if the ohmmeter indicates infinite resistance (no continuity).
2. Refer to **Figure 3** and connect an ohmmeter lead to the S terminal of the solenoid. Connect the remaining ohmmeter lead to the M terminal of the solenoid. The ohmmeter should indicate approximately one ohm or less. Replace the solenoid if the ohmmeter indicates infinite resistance (no continuity).

Starter Motor No-Load Current Draw Test

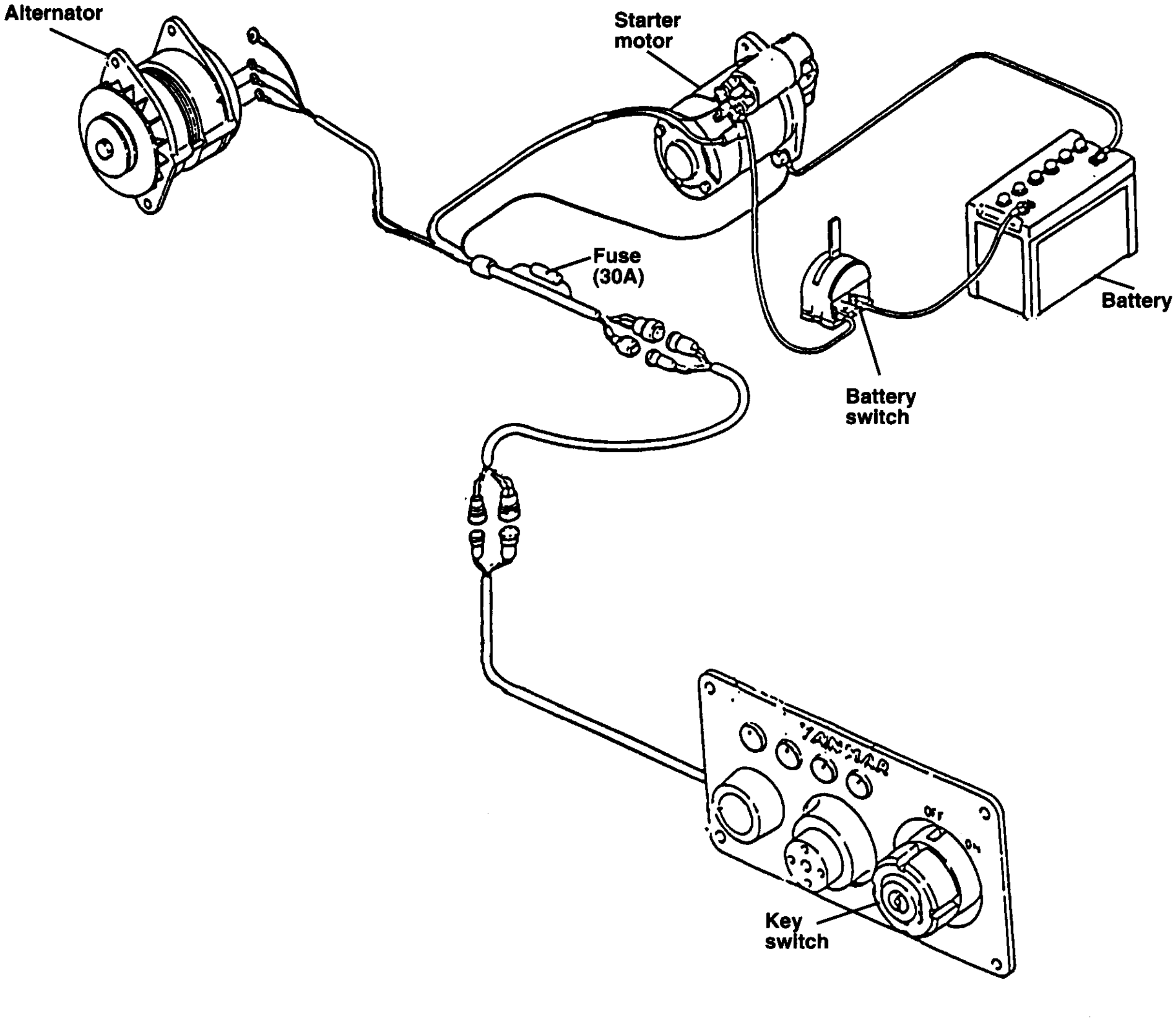
If troubleshooting indicates that the starter motor may be defective, use the following starter motor no-load current draw test to determine if the starter motor is in acceptable operating condition.

To perform the test, the following equipment is needed: an ammeter capable of measuring 0-100 amps, a voltmeter, a vibration tachometer and a fully charged 12-volt battery. Minimum battery capacity is 70 amp-hours for one- and two-cylinder engines and 100 amp-hours for three-cylinder engines.

1. Remove the starter motor from the engine. Securely fasten the motor in a vise or other suitable holding fixture.
2. Using a heavy gauge jumper cable, connect the ammeter in series with the positive battery terminal (**Figure 4**). Connect a voltmeter to the battery.

5

CHARGING SYSTEM (TYPICAL)



3. Hold a vibration-type tachometer against the starter frame.
4. To operate the starter motor, connect a wire between the positive battery terminal and the S terminal on the starter solenoid.
5. Note the starter rpm, current draw and battery voltage while the motor is running, then disconnect the wire to the S terminal on the solenoid.
6. If the starter motor does not perform within the specifications listed in **Table 3**, repair or replace the motor as described in Chapter Nine.

CHARGING SYSTEM

The charging system consists of the alternator, voltage regulator, battery, key switch, instrument panel warning light, connecting wiring and fuse.

A belt driven by the engine crankshaft pulley turns the alternator, which produces electrical energy to charge the battery. As engine speed varies, the voltage output of the alternator varies. The regulator maintains the voltage to the electrical system within safe limits. The warning light on the instrument panel signals if charging is not taking place.

All models use a Hitachi alternator with an internal transistorized voltage regulator attached to the rear alternator housing. Alternator output is 35 amps (model LR135-05) or 55 amps (model LR155-20). **Figure 5** shows components of the charging circuit.

Charging system troubles are generally caused by a defective alternator, voltage regulator, battery or an inoperative charge lamp. They may also be caused by something as simple as incorrect drive belt tension.

The following are symptoms of problems that may be encountered.

1. *Battery discharges frequently*—This can be caused by a drive belt that is slightly loose. Grasp the alternator pulley with both hands and try to turn it. If the pulley can be turned without moving the belt, the drive belt is too loose. As a rule, keep the belt tight enough so that it can be deflected only about 1/2 in. under moderate thumb pressure applied between the pulleys. The battery may also be at fault; test the battery condition as described in Chapter Nine.
2. *Charging system warning lamp does not light when key switch is turned ON*—This may indicate a defective key switch, battery, voltage regulator or warning lamp. Try to start the engine. If it doesn't start, check the key switch and battery. If the engine starts, remove and test the warning lamp bulb. If the problem persists, the alternator brushes may not be making contact. Perform the System Circuitry Test in this chapter.
3. *Charging system warning lamp flashes on and off*—This usually indicates that the charging system is working intermittently. Check drive belt tension first, then check all electrical connections in the charging circuit. As a last resort, check the alternator.
4. *Charging system warning lamp comes on and stays on*—This usually indicates that no charging is taking place. First check drive belt tension, then the battery condition. Check all wiring connections in the charging system. If this does not locate the problem, check the alternator and voltage regulator as described in this chapter.
5. *Battery requires frequent addition of water or lamp requires frequent replacement*—The alternator is probably overcharging the battery. The voltage regulator is most likely at fault.
6. *Excessive noise from the alternator*—Check for loose mounting brackets and bolts. The problem may also be worn bearings or, in some cases, lack of lubrication. If an alternator whines, a shorted diode may be the problem.

CHARGING SYSTEM TESTS

The alternator is equipped with an internal transistorized regulator. The transistorized regulator contains excitation and sensing circuits. The regulator controls output voltage by switching the alternator rotor current on and off. A rectifier consisting of a set of diodes converts alternating current to direct current.

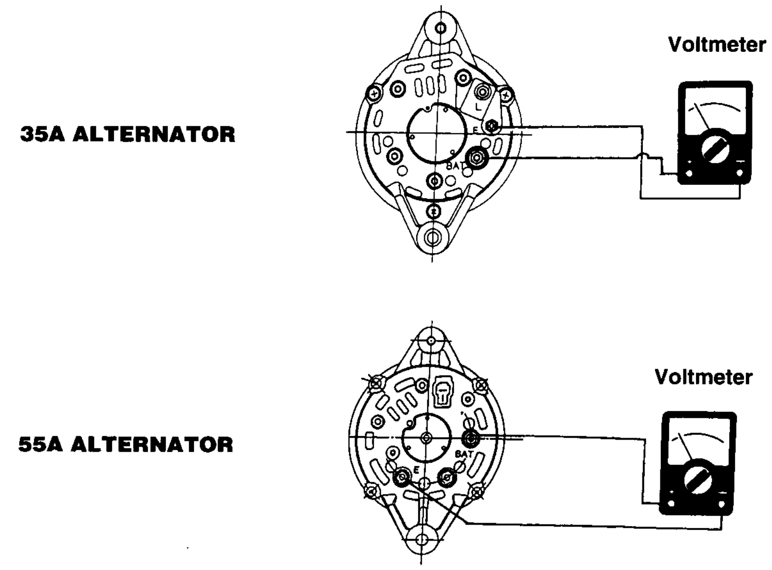
Alternator Regulated Voltage Test

This test checks the regulated voltage output of the alternator. All wires connected to the alternator for normal operation must be connected.

1. Check the alternator drive belt tension. See Chapter Three.
2. Check the battery terminals and cables for corrosion and/or loose connections. Disconnect the negative battery cable, then the positive battery cable. Clean the cable clamps and battery terminals, if necessary, then reconnect the cables.
3. Check all wiring connections between the alternator and engine to make sure they are clean and tight.
4. Connect the positive lead of a voltmeter to the BAT terminal of the alternator. Connect the negative voltmeter lead to the E terminal of the alternator. See **Figure 6.**
5. Move the engine wire harness back and forth while observing the voltmeter scale. The meter should indicate a steady battery voltage reading (approximately 12 volts).

6

VOLTAGE OUTPUT TEST



If the reading varies or if no reading is obtained, check for poor connections or damaged wiring.

6. Turn the key switch ON. Run the engine from idle up to 2,500 rpm and note the voltmeter reading. If the voltmeter does not indicate 14.2-14.8 volts, remove the alternator and have it bench tested by a dealership or qualified specialist.

Alternator Current Output Test

This test checks the current output of the alternator. All wires connected to the alternator for normal operation must be connected. Refer to **Figure 7** for this procedure.

1. Check the alternator drive belt tension. See Chapter Three.
2. Disconnect the negative battery cable.
3. Disconnect the wire from the BAT terminal on the alternator.
4. Connect the positive lead of a 0-100 amp DC ammeter to the BAT terminal and the negative lead to the disconnected wire.
5. Reconnect the negative battery cable.
6. Make sure the engine control is in the stop position.
7. Turn on all accessories and crank the engine for 15-20 seconds to remove any surface charge from the battery.
8. Turn off all accessories.
9. Connect a tachometer to the engine. Connect a carbon pile load device to the battery terminals.
10. Start the engine and run at 2,500 rpm. Adjust the carbon pile to obtain maximum alternator output. The ammeter should read the rated amperage according to the alternator model identified on the data plate on the alternator (**Figure 8**). Model LR135 alternators should produce 35 amps, and model LR155 alternators should produce 55 amps.

FUEL SYSTEM

Refer to Chapter Seven for a description of fuel system operation. A diagram of a typical fuel system is shown in **Figure 9**.

Be aware that diesel fuel injection systems require clean fuel that meets the fuel requirements specified by the engine manufacturer. Many fuel problems are a result of contaminated fuel or fuel not approved by the engine manufacturer. Refer to Chapter Three.

NOTE

Engine components outside the fuel system can also cause some of the following engine symptoms. Be sure to check other engine components that can also cause the symptoms.

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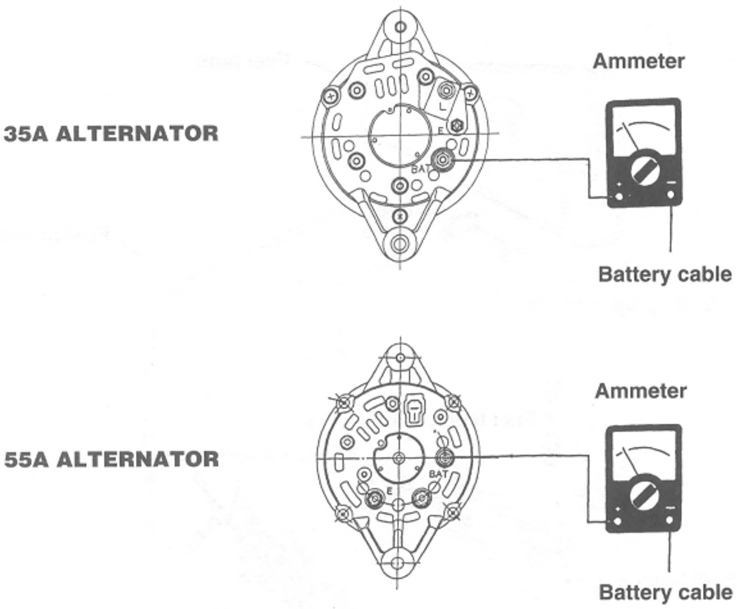
CURRENT OUTPUT TEST



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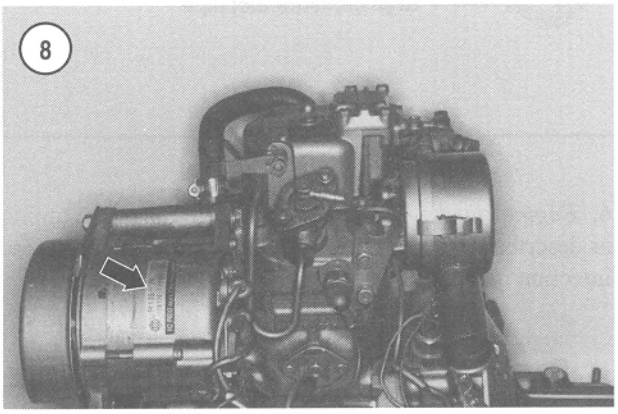

NOTE
If the fuel injection pump or a fuel injector is suspected, have it checked by a diesel engine service shop before purchasing replacement parts.

When troubleshooting the fuel system, refer to the following symptoms and possible causes:

1. *Engine will not start*—Check for an empty fuel tank, incorrect fuel or water in the fuel. Bleed the fuel system as described in Chapter Seven to be sure that fuel is routed to the fuel injection pump and to locate any restrictions, such as the fuel filter, or defective components, such as the fuel transfer pump. Check for proper operation and adjustment of the speed control mechanism, including the stop lever. Refer to Chapter Seven. Check the fuel injection timing as directed in Chapter Seven.
2. *Engine stops suddenly*—Check for an empty fuel tank, incorrect fuel or water in the fuel. Bleed the fuel system as directed in Chapter Seven to be sure that fuel is routed to the fuel injection pump and to locate any restrictions, such as the fuel filter, or defective components, such as the fuel transfer pump. Check for the proper operation and adjustment of the speed control mechanism, including the stop lever.
3. *Engine speed decreases unexpectedly*—Check for water in the fuel. Check for a clogged fuel filter element. Bleed the fuel system as described in Chapter Seven to remove air in the fuel. Check for clogged or defective fuel injection pump or fuel injector.
4. *Engine will not run under full load*—Check for a clogged fuel filter element. Check for a defective fuel transfer pump. Check for a clogged or defective fuel injection pump. Check the speed control mechanism.
5. *Engine misfires*—Check for water in the fuel. Check for a clogged fuel filter element. Bleed the fuel system as

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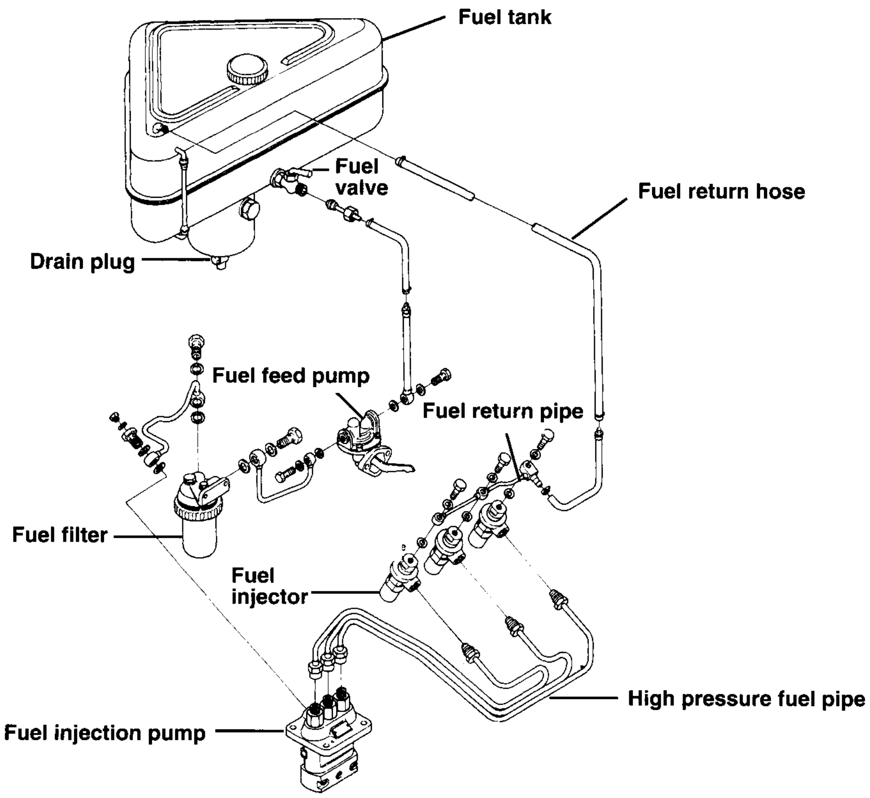
FUEL INJECTION SYSTEM



described in Chapter Seven to remove air in fuel. Check for a clogged or defective fuel injection pump or fuel injector.

WARNING
Wear goggles and protective clothing when performing the next procedure. Diesel injectors can spray with sufficient force to penetrate the skin. Have a fire extinguisher rated for fuel and electrical fires on hand.

To identify a faulty fuel injector on multicylinder engines, loosen the fuel injector fuel line nut with the engine running to reduce fuel pressure (only slight loosening is required). If the engine runs worse, the injector is operating satisfactorily. If the engine runs the same, the injector or the fuel injection pump is not operating properly. If no fuel appears at the fuel line, the fuel injection pump is defective.

6. *Engine knocks*—Check the fuel injection pump timing as described in Chapter Seven. Check for a defective fuel injection pump.

COOLING SYSTEM

The engine may be equipped with a seawater cooling system or freshwater cooling system. Refer to Chapter Eight for identification and description of the cooling system.

Engine Overheating

A problem in the cooling system generally causes engine overheating; however, other engine problems can also cause overheating. Note the possible causes in the following list:

1. *Loose pump drive belt (except 1GM models)*—A loose drive belt prevents the circulating pump from operating at the proper speed.

2. *Loose hose or pipe connections*—Air may be drawn into the suction side of the system.

3. *Worn or defective water pump*—A worn or defective pump may not provide sufficient cooling water.

4. *Dirty cooling system*—Debris in the cooling system prevents adequate heat transfer to the cooling water.

5. *Defective or incorrect thermostat*—A defective thermostat may stay closed or not open sufficiently to allow hot water to leave the engine. An incorrect thermostat may open at a temperature higher than specified, thereby raising the temperature of the cooling water in the engine. Conversely, a thermostat that stays open and doesn't close or opens at a low temperature will cause the engine to run at less than optimum temperature.

ENGINE EXHAUST SMOKE

The engine should emit colorless exhaust smoke or smoke that appears no more than a light haze. If the exhaust smoke is black, white or blue, an engine problem exists.

Blue Smoke

Blue exhaust smoke indicates that oil is burning during the combustion process. Look for a condition that allows oil to enter the combustion chamber, such as a broken piston, broken or stuck piston rings, a damaged cylinder wall, worn valves or guides, a defective crankcase vent, or an overfilled oil sump.

White Smoke

Unburned fuel causes white exhaust smoke. The unburned fuel may be due to retarded fuel injection timing or insufficient compression pressure. Low compression pressure may be caused by a damaged cylinder gasket, broken piston rings, leaking valves or incorrectly adjusted valves. Raw, unburned fuel may be due to incorrect fuel (low cetane rating) or a defective injector.

NOTE
White smoke may also be due to coolant leaking into the combustion chamber.

Black Smoke

Black exhaust smoke results from excess fuel (rich) that forms soot when burned. Either excess fuel or insufficient air can cause black smoke. Some possible causes are a defective fuel injection pump, poor injector spray pattern, low injection opening pressure, clogged air intake, restricted exhaust system or low compression pressure.

ENGINE NOISES

Often the first evidence of an internal engine problem is a strange noise. That knocking, clicking or tapping sound never heard before may be warning of impending trouble.

While engine noises can indicate problems, they are difficult to interpret correctly; inexperienced mechanics can be seriously misled by them.

Remember that diesels are much noisier than gasoline engines and have a normal clatter at idle, especially when cold. It is necessary to become accustomed to these normal noises in order to detect possible problem-associated noises.

Professional mechanics often use a special stethoscope for isolating engine noises. The home mechanic can do nearly as well with a sounding stick, which can be an ordinary piece of dowel, a length of broom handle or a section of small hose. Place one end in contact with the area in question and the other end near the ear to hear sounds emanating from that area. There are many strange sounds coming from even a normal engine. If possible, have an experienced mechanic help sort out the noises.

Clicking or Tapping Noises

Clicking or tapping noises usually come from the valve train and indicate excessive valve clearance. A sticking valve may also sound like a valve with excessive clearance. In addition, excessive wear in valve train components can cause similar engine noises.

Knocking Noises

A heavy, dull knocking is usually caused by a worn main bearing. The noise is loudest when the engine is working hard, such as accelerating at low speed. It is possible to isolate the trouble to a single bearing by disabling the fuel injectors on multicylinder engines one at a time. By disabling the fuel injector nearest the bearing, the knock will be reduced or disappear.

Worn connecting rod bearings may also produced a knock, but the sound is usually more metallic. As with a main bearing, the noise is worse during acceleration. It may increase in transition from acceleration to coasting. Disabling the fuel injectors will help isolate this knock as well.

A double knock or clicking usually indicates a worn piston pin. Disabling fuel injectors on multicylinderengines will isolate this to a particular piston; however, the noise will increase when the affected piston is reached.

A loose flywheel and excessive crankshaft end play also produce knocking noises. While similar to main bearing noises, they are usually intermittent, not constant, and they do not change when fuel injectors are disabled. If caused by a loose flywheel or coupling, the noise is generally heard at idle or during rapid deceleration. It is a good idea to recheck flywheel/coupler bolt torque whenever accessible.

Some mechanics confuse piston pin noise with piston slap (excessive piston clearance). The double knock will distinguish piston pin noise. Piston slap will always be louder when the engine is cold.

ENGINE TROUBLESHOOTING

These procedures assume the starter cranks the engine over normally. If not, refer to the *Starting System* section of this chapter.

Engine Will Not Start

This can be caused by the fuel system or by insufficient compression pressure. Refer to troubleshooting in the *Fuel System* section of this chapter. Refer to Chapter Three and check valve adjustment. Check for low compression pressure by performing a compression pressure check as described in Chapter Three. Repair the engine as required to obtain the correct compression pressure.

Engine Misses

This can be caused by the fuel system. Refer to troubleshooting in the *Fuel System* section of this chapter. Sticking intake or exhaust valves can also cause the engine to misfire.

Engine Stops Suddenly

This can be caused by engine seizure, a governor malfunction or a problem in the fuel system. Attempt to start the engine to determine if the engine rotates freely. Refer to Chapter Three to check governor adjustment or to Chapter Seven to repair the governor. If a fuel system problem is suspected, refer to troubleshooting in the *Fuel System* section of this chapter.

Engine Will Not Run Under Load

Refer to troubleshooting in the *Fuel System* section in this chapter.

Low Oil Pressure

Low engine oil pressure may be caused by leakage in the oil circuit, excessive bearing clearance, a clogged oil filter, a loose oil regulator valve or incorrect oil viscosity. Low oil pressure may also be caused by engine overheating or oil dilution by fuel in the crankcase.

Verify low oil pressure by performing the oil pressure test described in this chapter.

If the engine is overheating, refer to troubleshooting in the *Cooling System* section in this chapter.

COOLING SYSTEM

The temperature warning lamp should signal cooling system problems before there is any damage. If the engine is stopped at the first indication of trouble, serious damage is unlikely.

With standard cooling systems in which seawater is drawn into the engine, circulated and then expelled, cooling system problems are generally mechanical—a defective pump or thermostat, a loose or broken drive belt or passages plugged with contamination.

Closed cooling systems are more complex in that they use a heat exchanger, which transfers heat from the engine coolant to seawater without the two coming in contact. The closed portion of the cooling system is pressurized (like an automotive cooling system) and uses a 50/50 mixture of ethylene glycol antifreeze and pure soft water. Check this system periodically to make sure it can hold pressure up to 13 psi.

Heat exchangers used in closed cooling systems collect salt, lime and other contaminants in their passages, leading to a gradual decrease in cooling efficiency. For this reason, they should be removed every two years and the seawater passages cleaned with a wire brush and compressed air.

LUBRICATION SYSTEM

Refer to **Figure 10, Figure 11** and **Figure 12** for lubrication system diagrams. A rotor type oil pump receives oil

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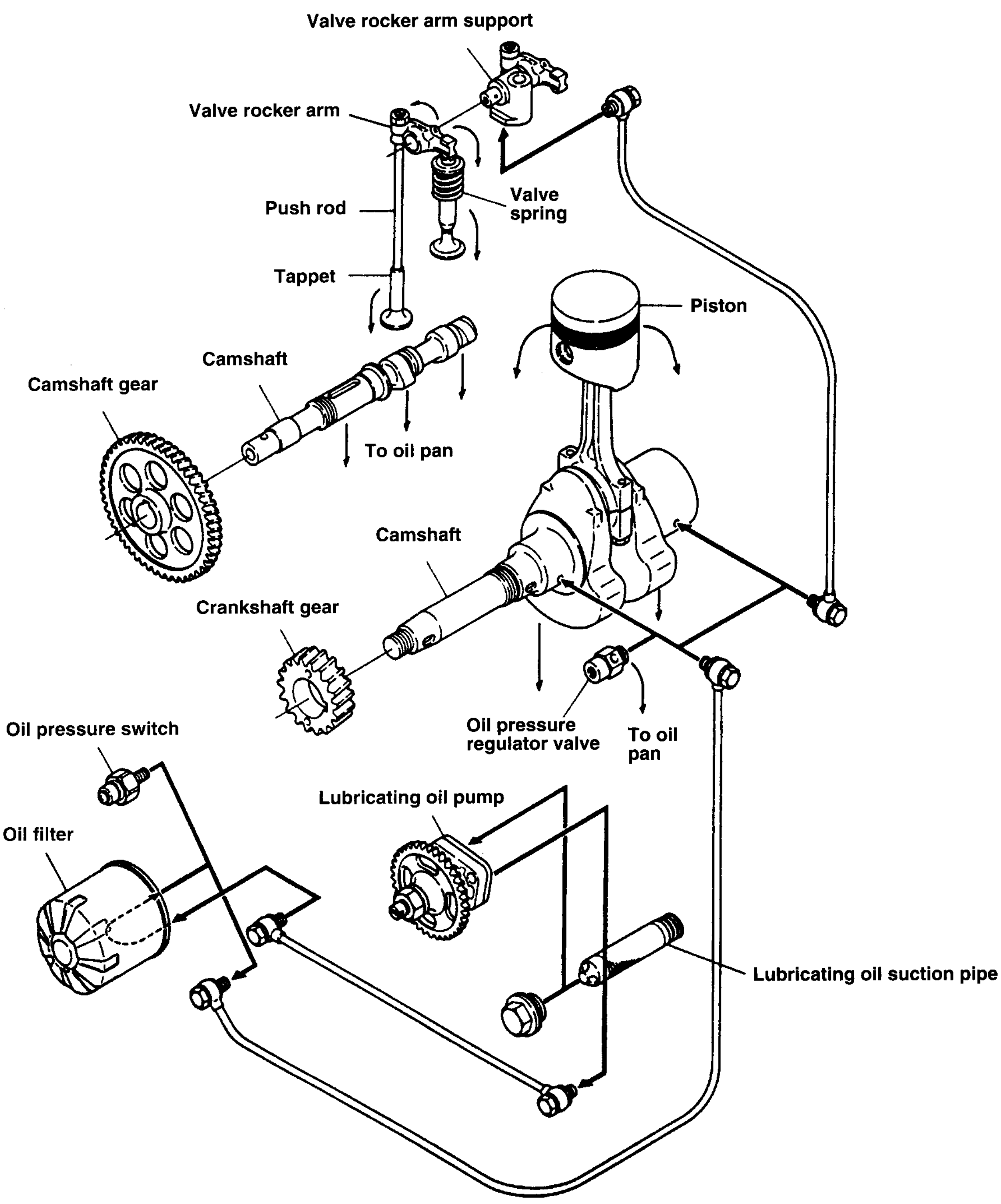
LUBRICATION SYSTEM (1GM AND 1GM10 MODELS)



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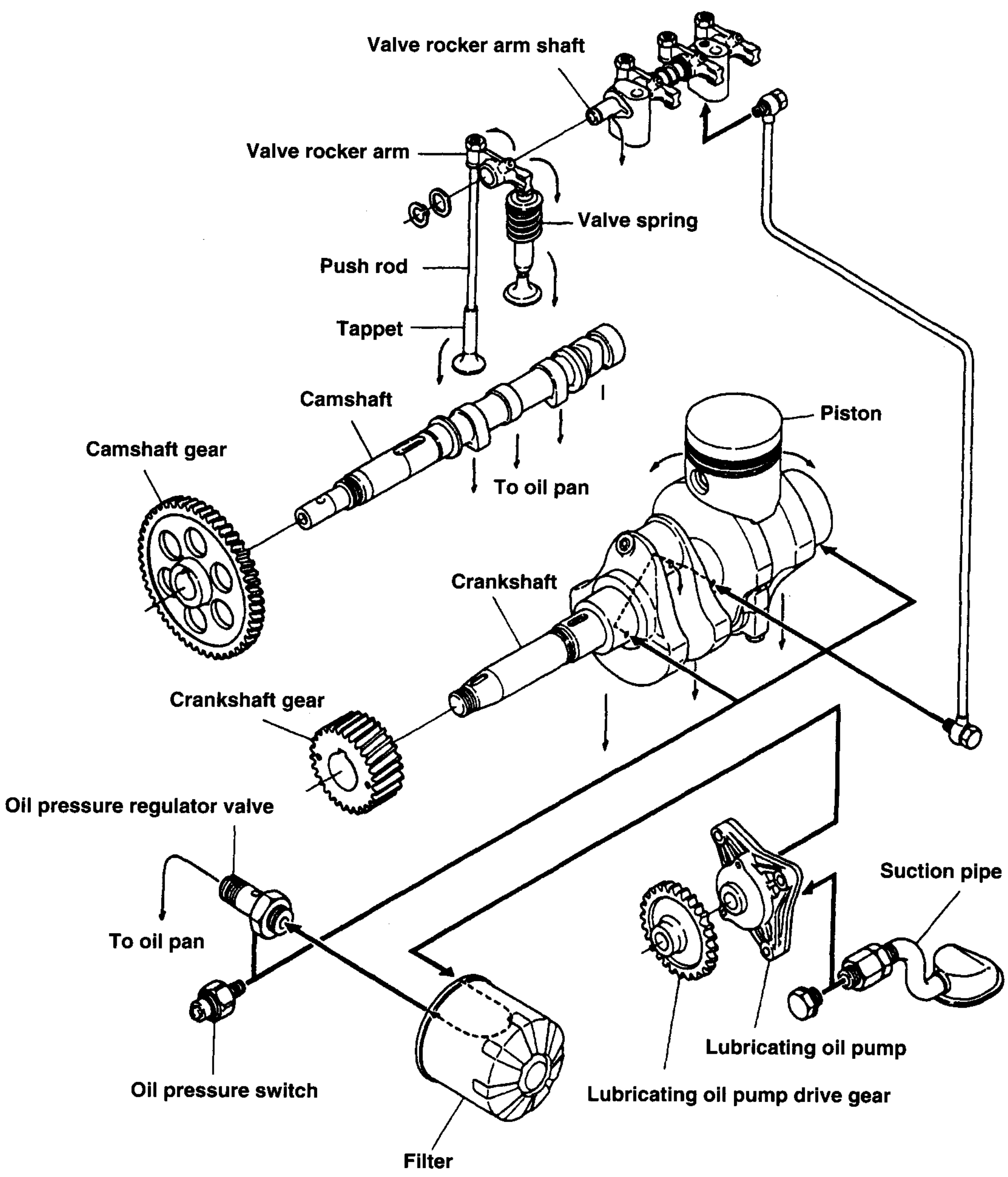
LUBRICATION SYSTEM (2GM AND 2GM20 MODELS)



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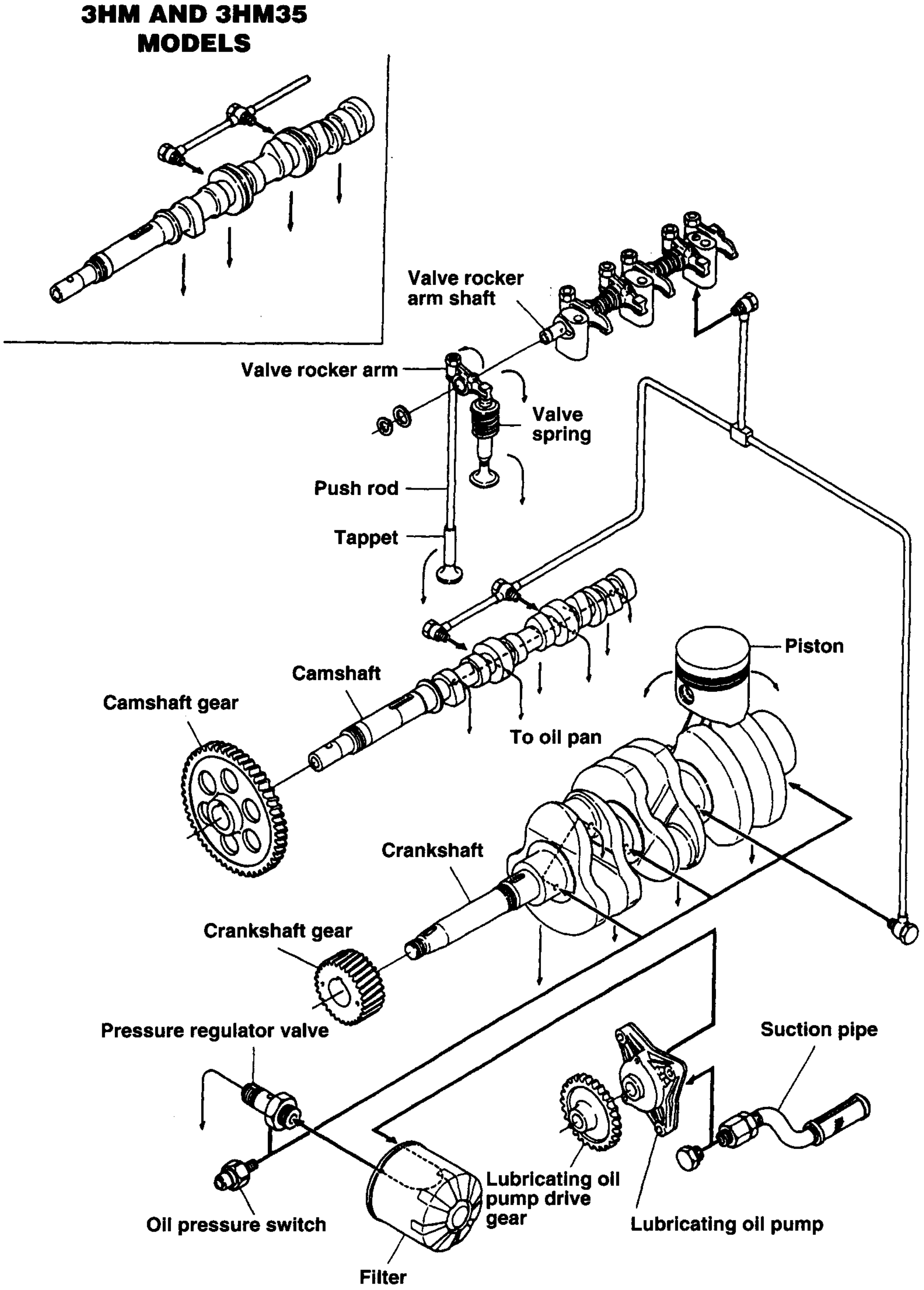
LUBRICATION SYSTEM (3GM, 3GM30, 3HM AND 3HM35 MODELS)



from a pickup located in the oil pan, then forces oil to the necessary engine components. The oil pump is driven by the crankshaft gear.

An oil pressure relief valve regulates oil pressure at 300-400 kPa (43-57 psi). When oil pressure exceeds the desired pressure, the relief valve opens and expels oil into the timing gearcase. A low oil pressure warning light on the instrument panel and a warning alarm buzzer activate if oil pressure is below 9.8 kPa (1.4 psi).

Refer to Chapters Five, Six and Nine for service procedures.

Oil Pressure Test

The engine is equipped with an oil pressure warning light and alarm that are activated if low oil pressure occurs. To verify low oil pressure, perform the following oil pressure test.

1. Disconnect the wire lead from the oil pressure sender (**Figure 13**, typical).

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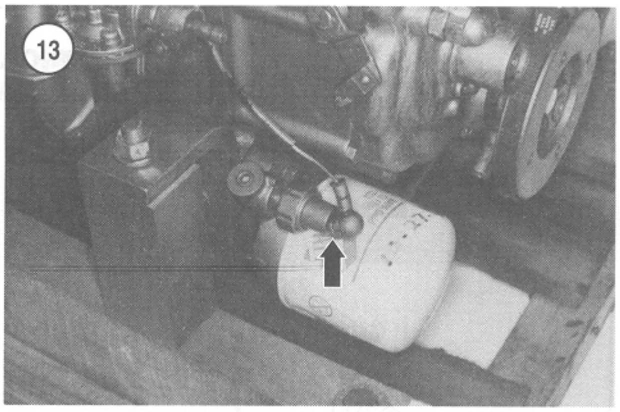


2. Remove the oil pressure sender.
3. Connect a suitable oil pressure gauge.
4. Start the engine and note the oil pressure reading at idle and wide open throttle.
5. Compare the gauge readings with the specifications in **Table 3**.

Table 1 ENGINE TROUBLESHOOTING

Trouble	Probable cause	Correction
Engine cranks slowly	Battery faulty or low charge	Charge or replace battery
	Faulty starter motor	Repair or replace starter motor
	Incorrect engine oil viscosity	Replace with proper engine oil
Engine will not crank	Discharged battery	Charge or replace battery
	Corroded battery terminals	Clean terminals
	Loose connection in starting circuit	Clean and tighten all connections
	Defective starting switch	Replace switch
	Starting motor brushes dirty	Clean or replace brushes
	Jammed starter drive gear	Loosen starter motor to free gear
	Faulty starter motor	Replace motor
	Seized engine	Inspect and repair
Engine will not start	Empty fuel tank	Fill tank with proper fuel
	Dirty or plugged fuel filter	Clean fuel filters
	Air in injection lines	Bleed air in injection lines
	Faulty fuel feed pump	Repair fuel feed pump
	Faulty fuel injection pump	Repair fuel injection pump
	Faulty governor	Repair governor
	Misadjusted controls	Adjust speed and stop controls
	Improper fuel injection timing	Adjust fuel injection timing
	Poor valve seating	Check for broken or weak valve springs, warped stems, carbon and gum deposits and insufficient tappet clearance
	Damaged cylinder head gasket	Check for leaks around gasket when engine is cranked; if a leak is found, replace gasket
	Worn or broken piston rings	Replace worn or broken rings; check cylinders for out-of-round and taper
Engine stops suddenly	Empty fuel tank	Fill fuel tank
	Air in fuel lines	Bleed fuel lines

(continued)

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.

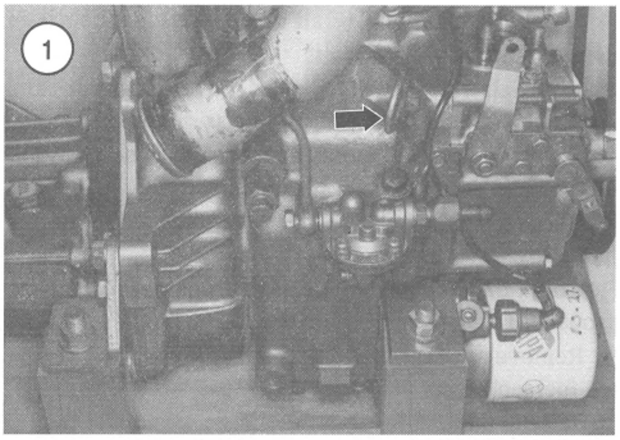
6. Move the speed control lever to the MEDIUM SPEED position.
7. Allow the engine to warm for approximately five minutes before applying full load to the engine.

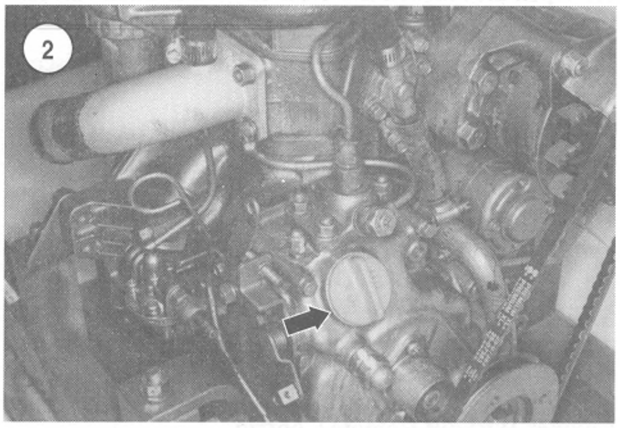
STOPPING THE ENGINE

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.





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.

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).

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

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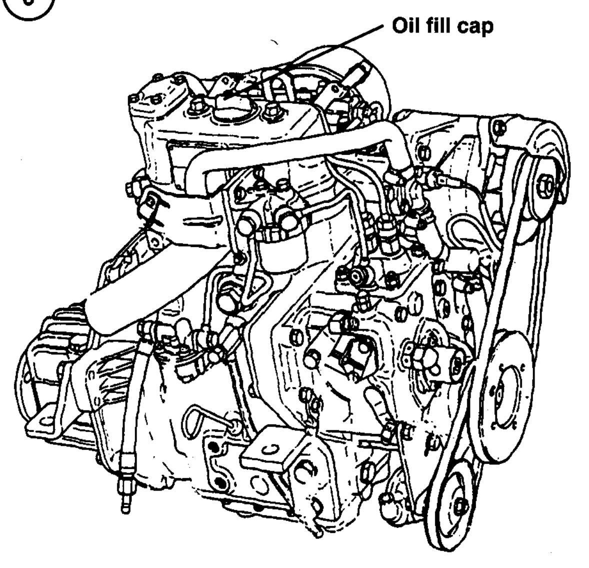

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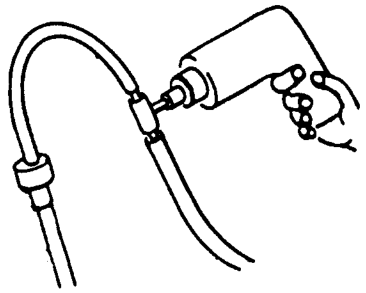


criteria that engine oils must meet to attain a diesel engine oil classification of CA, CB, CC or CD. The classification system ranges from CA for light diesel engine service to CD for severe diesel engine service. Yanmar specifies engine oils with classification CB or CC for use in the Yanmar diesel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

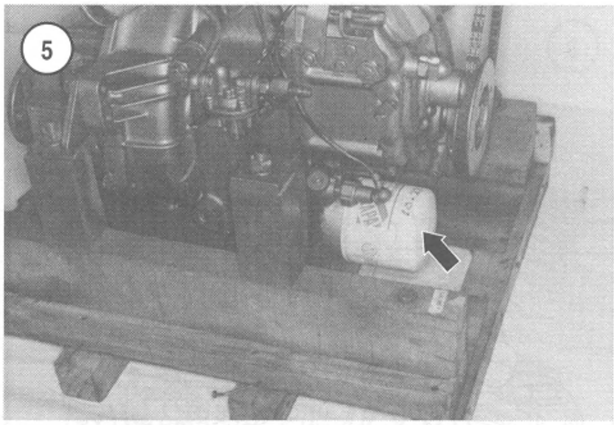
NOTE

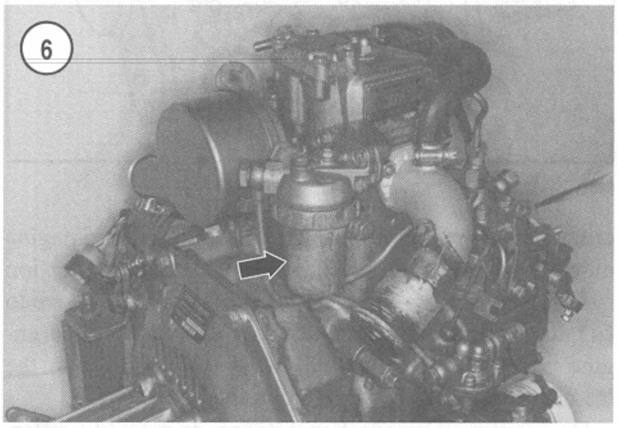
Never dispose of motor oil in the trash, on the ground, down a storm drain or overboard. Many service stations accept used *motor oil and waste haulers provide curb-side used motor oil collection. Do not combine other fluids with motor oil to be recycled. To locate a recycler, contact the American Petroleum 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 am 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

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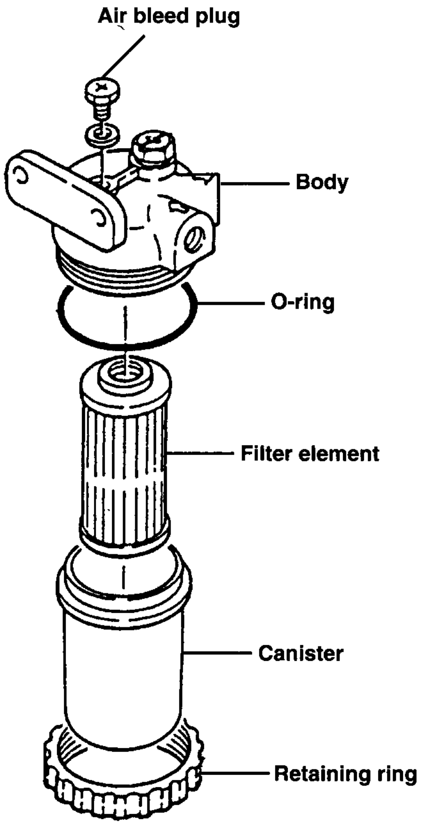


fuel and maintain the fuel filter and fuel system components to prevent a fuel system malfunction.

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.

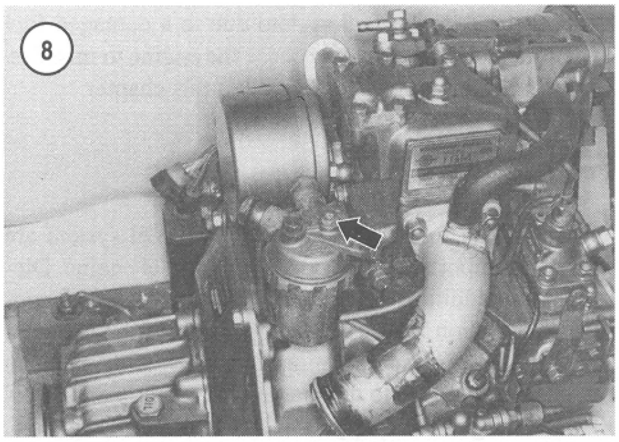
After every 50 hours of operation, or more frequently if necessary, remove and disassemble the fuel filter and clean the inside of the fuel bowl and filter element. The filter body contains a replaceable element. Replace the element after every 250 hours of operation or more frequently if dirt clogs 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

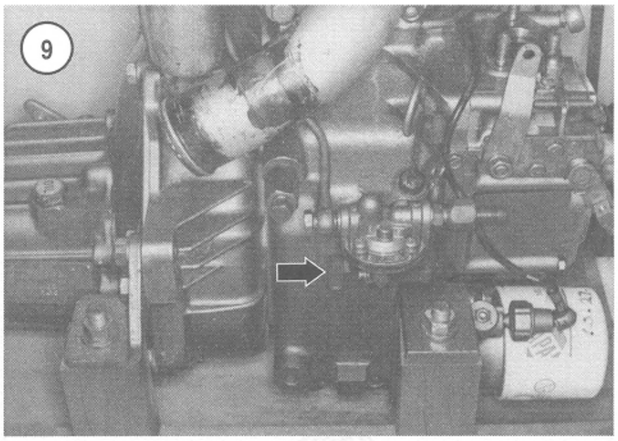
An air filter (A, **Figure 10**, typical) removes airborne dirt and debris. Within the air filter canister is a reuseable polyurethane filter element. Clean the filter element after every 250 hours of operation or more frequently if the engine operates in a dirty environment. Inspect the filter element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

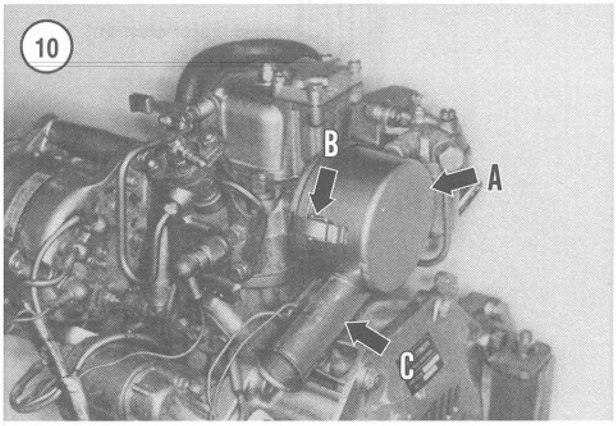
Use the following procedure to remove and clean the filter element:

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.

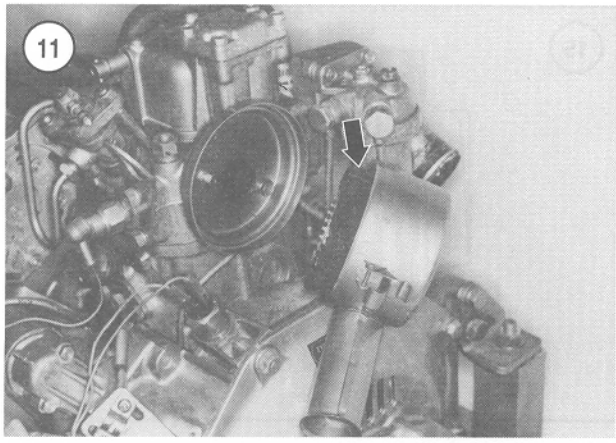
5. Reassemble and reinstall the filter by reversing the removal procedure.

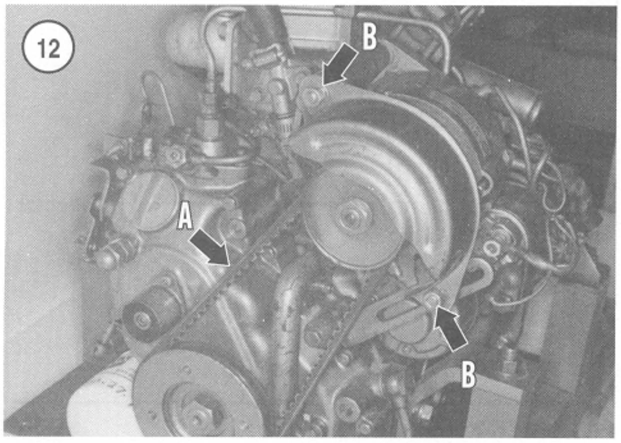
NOTE

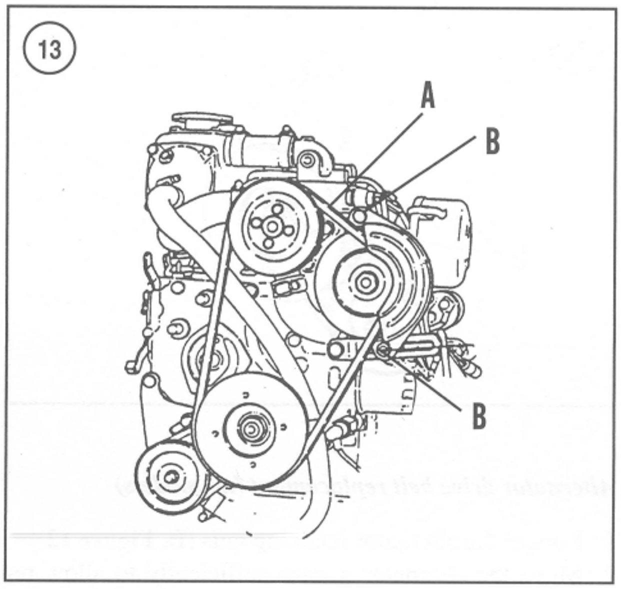
*Be sure the intake tube (C, **Figure 10**) of the canister points slightly downward and not upward; otherwise, water can enter the tube and run into the filter.*

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.

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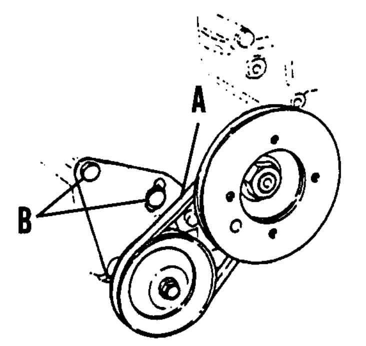

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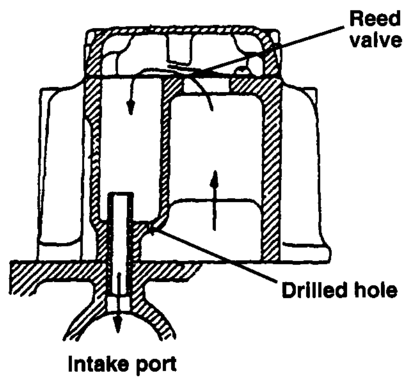

Alternator drive belt replacement (all models)

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.

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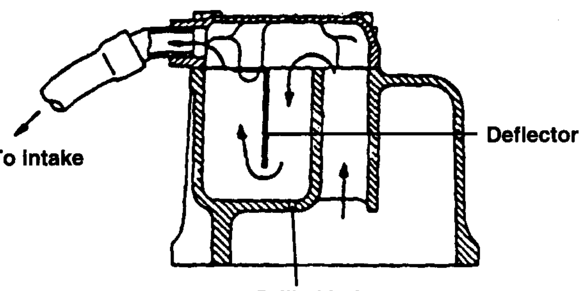

Seawater pump drive belt replacement (2GM, 2GM20, 3GM, 3GM30, 3HM and 3HM35 models)

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.

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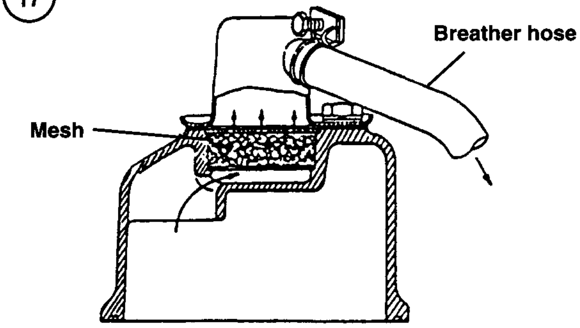


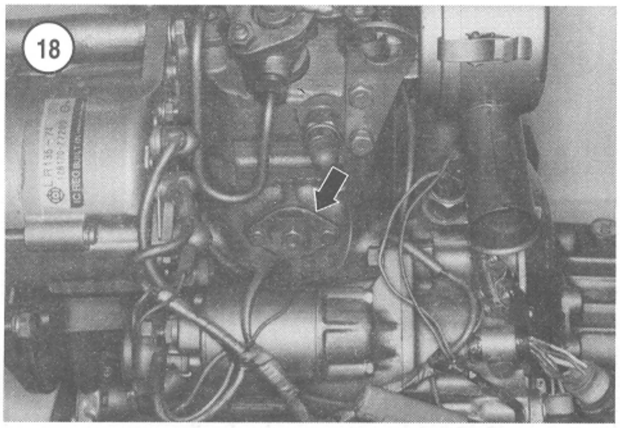
Crankcase Breather

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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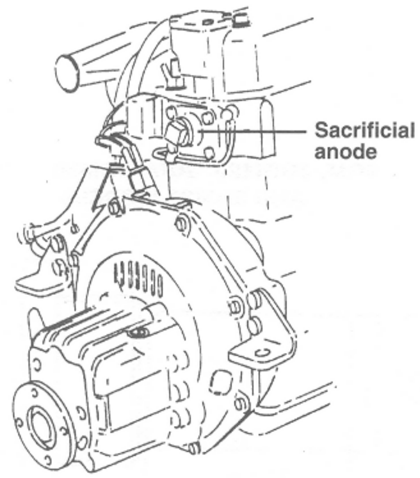

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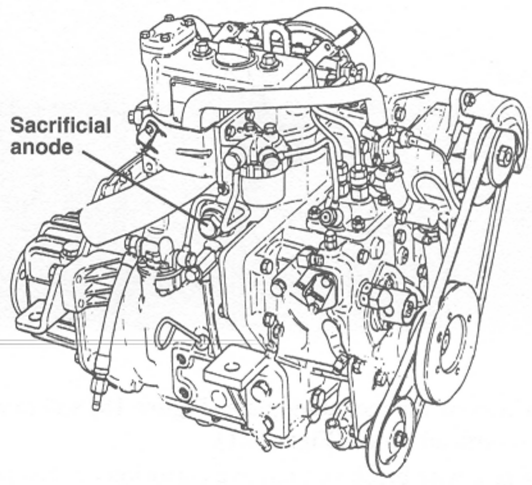

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sure. The reed valve closes when the piston moves up in the cylinder. This creates a negative pressure in the crankcase, which helps the piston rings seal against the cylinder bore. A hole in the breather chamber routes oil back to the crankcase; however,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

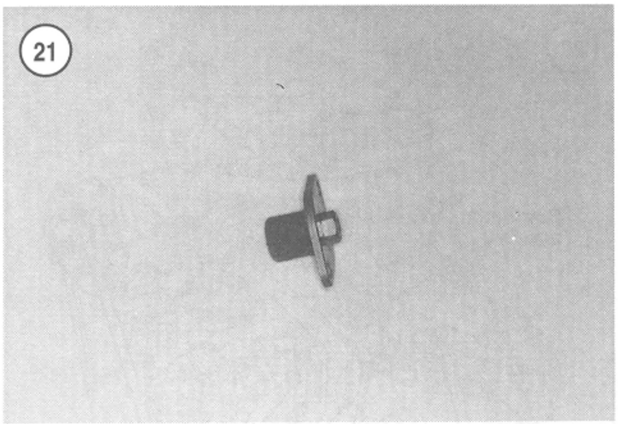
Check the condition of the anodes periodically and frequently. Replace any anode that is corroded to 50 percent of its original size.

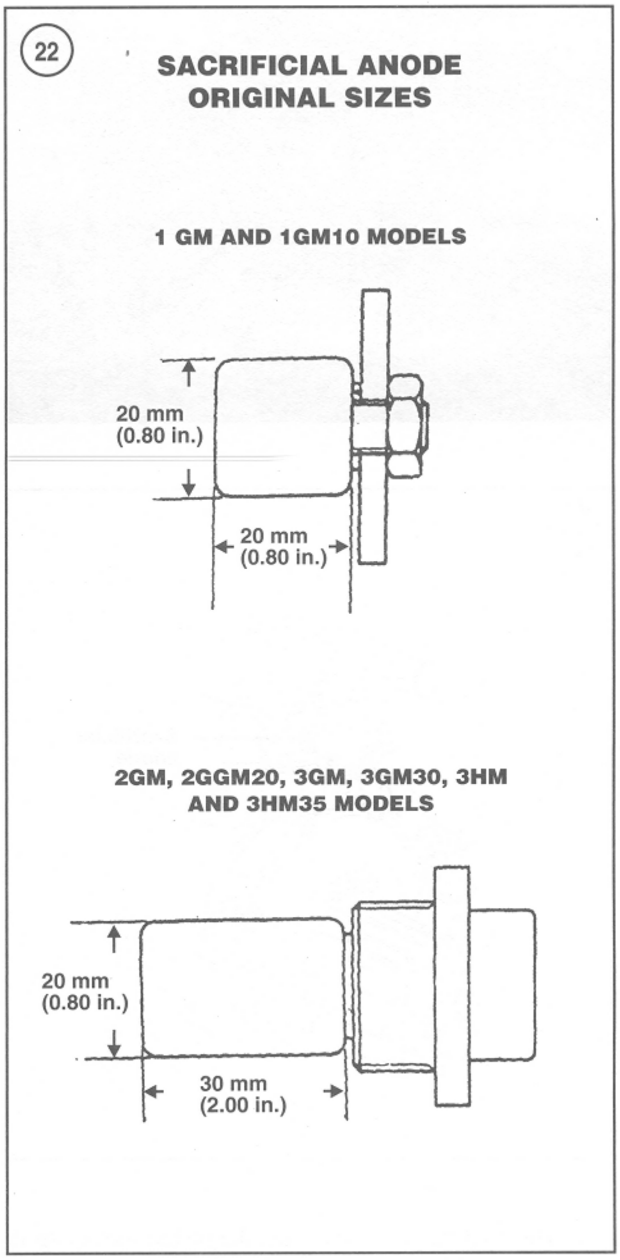
Engine models 1GM and 1GM10 are equipped with a single sacrificial anode that is attached to a plate located on the cylinder block (**Figure 18**). A threaded type sacrificial anode is used on 2GM, 2GM20, 3GM, 3GM30, 3HM and 3HM35 model engines. One anode is located in the cylinder head (**Figure 19**),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

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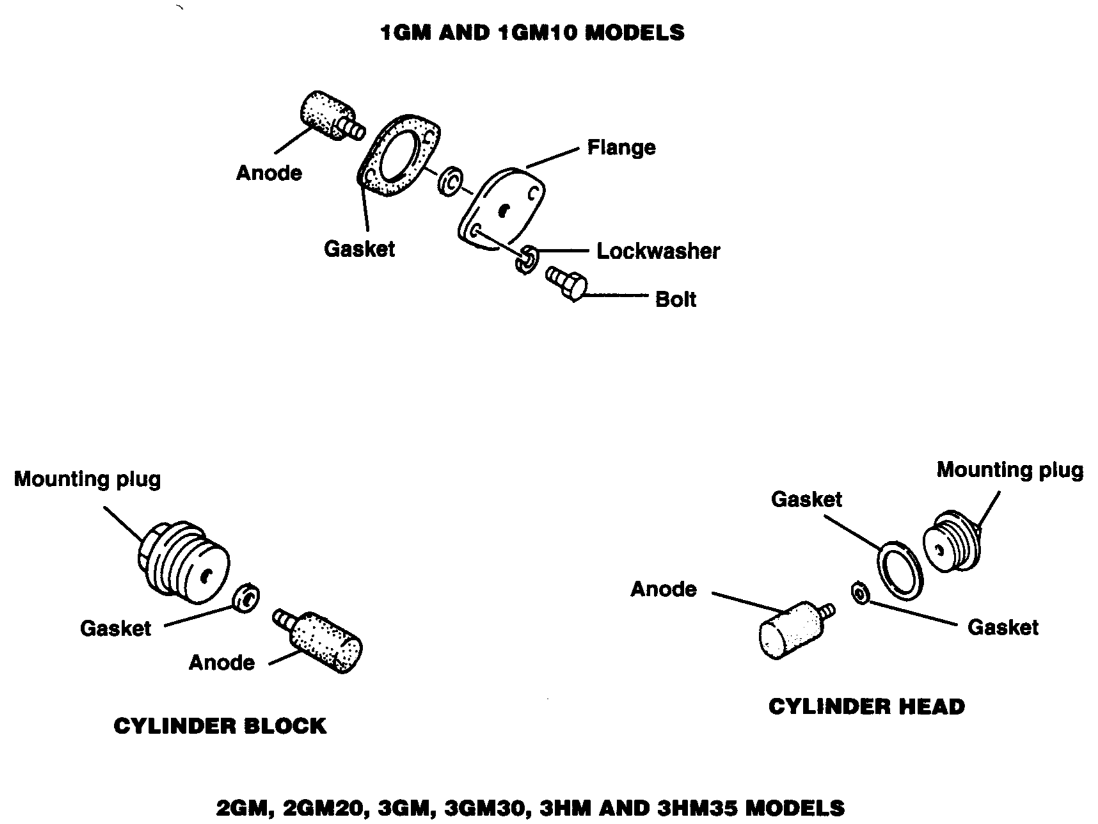
ANODE MOUNTINGS



(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.

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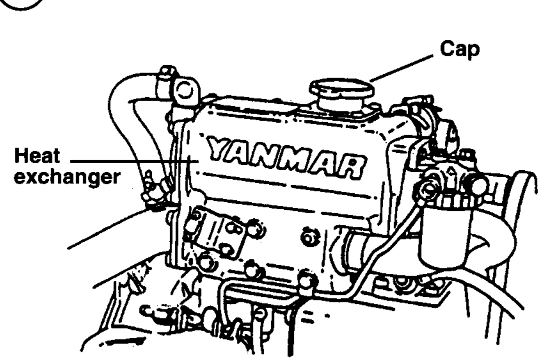


Check/Fill Coolant (Equipped With a Remote Reservoir)

Refer to **Figure 26**.

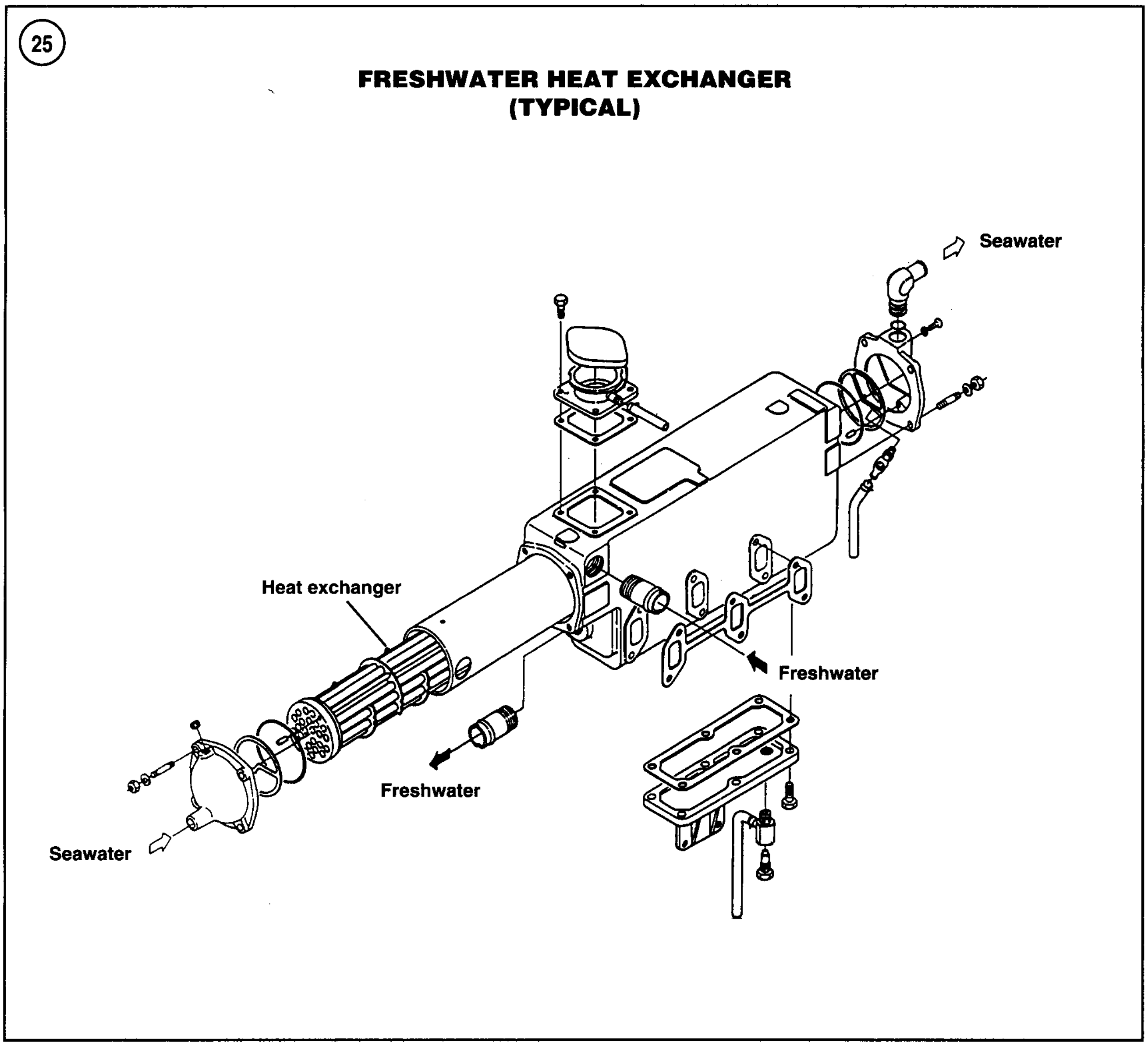
1. Check the level of the coolant in the remote reservoir tank (**Figure 26**) when the engine is cold. The coolant level should be between the marks on the tank.
2. If the coolant level is low, but the tank is not dry, add coolant to the tank. Refer to the following section for the proper coolant mixture.

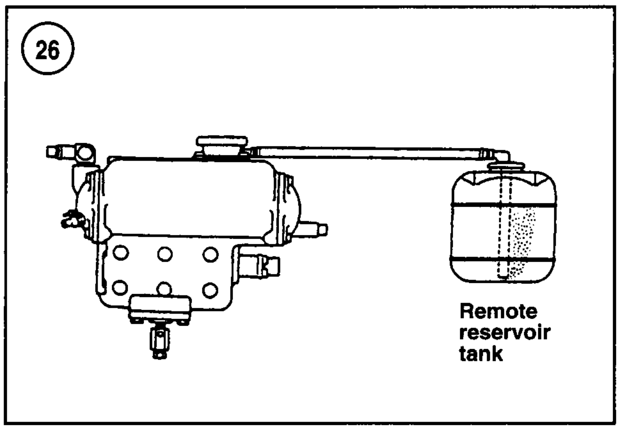
WARNING
*Do not remove the pressure fill cap (**Figure 24**) from the pressurized cooling system when the engine is hot.*

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.





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.

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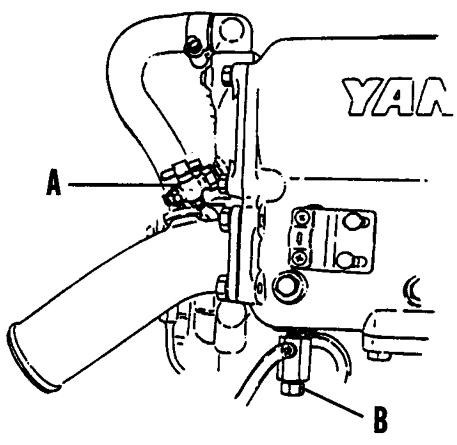

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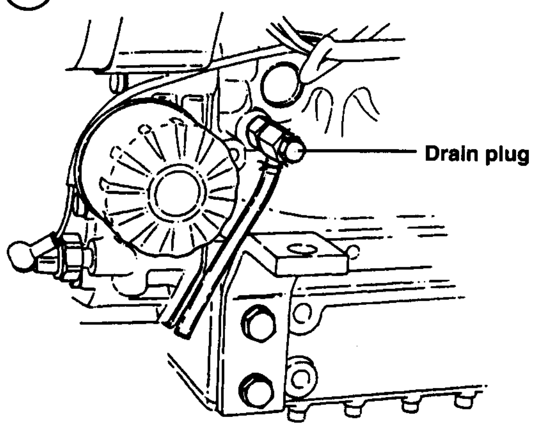

BATTERY

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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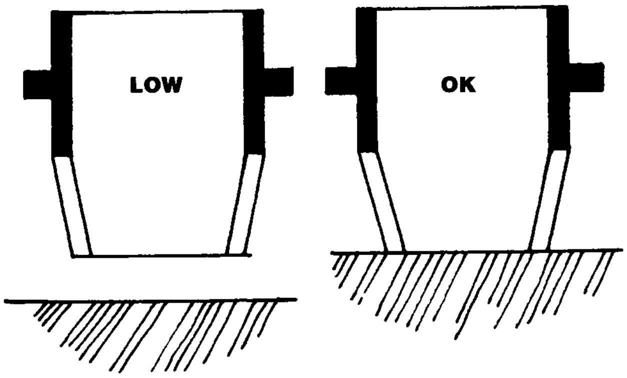
BATTERY CUTAWAY VIEW



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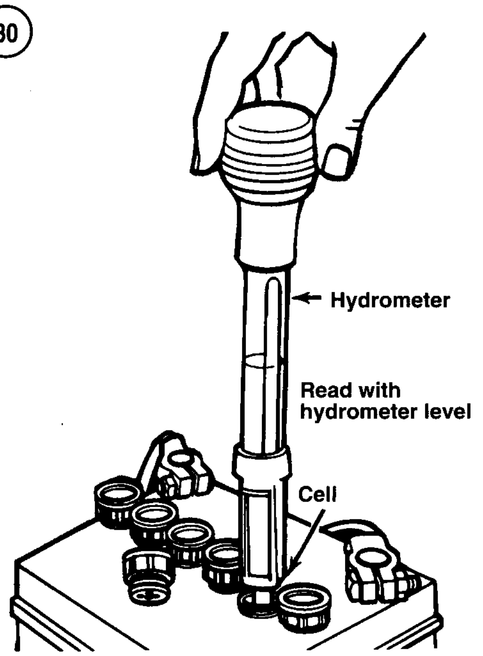


ENGINE TUNE-UP

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.

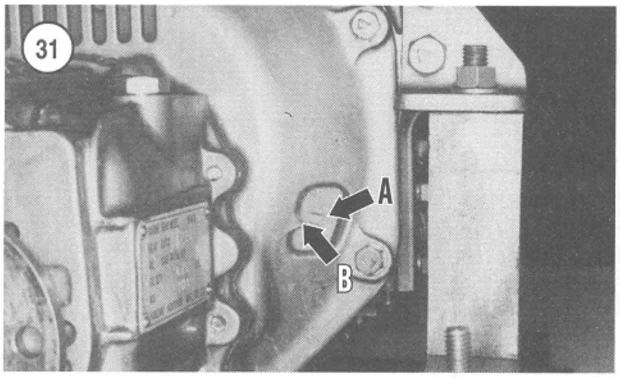
Careful and accurate adjustment is crucial to a successful engine tune-up. Each procedure in this section must be performed exactly as described and in the order presented.

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).

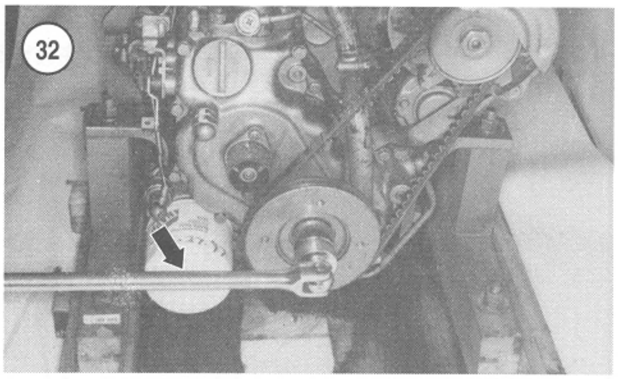
A compression reading that is below the desired compression pressure indicates that engine repair is required because of worn or broken rings, leaky or sticking valves or a combination of all.

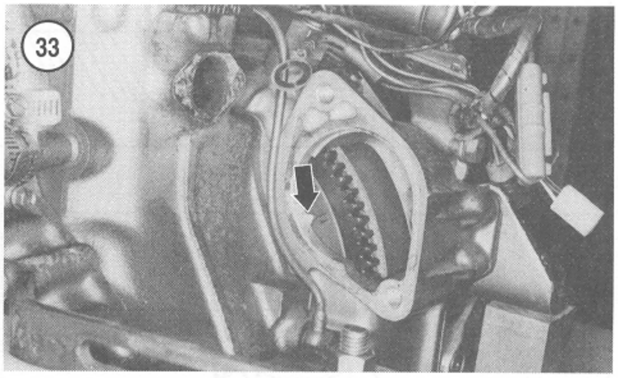
If the compression test readings are lower than desired, isolate the cause by performing a wet compression test. Remove the precombustion chamber (refer to Chapter Seven). Perform the wet compression test in the same way as the dry test, except pour approximately one tablespoon of heavy engine oil (at 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

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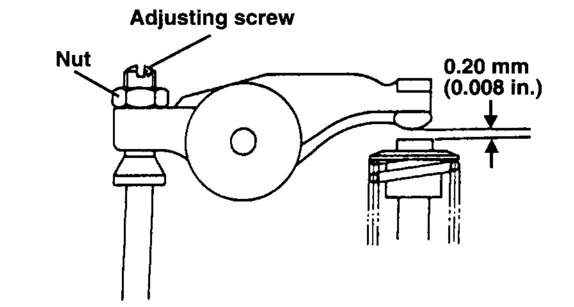
VALVE CLEARANCE ADJUSTMENT (ALL MODELS)



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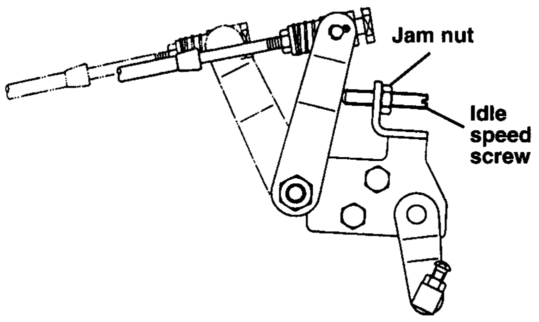
IDLE SPEED ADJUSTMENT (1GM AND 1GM10 MODELS)



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**).

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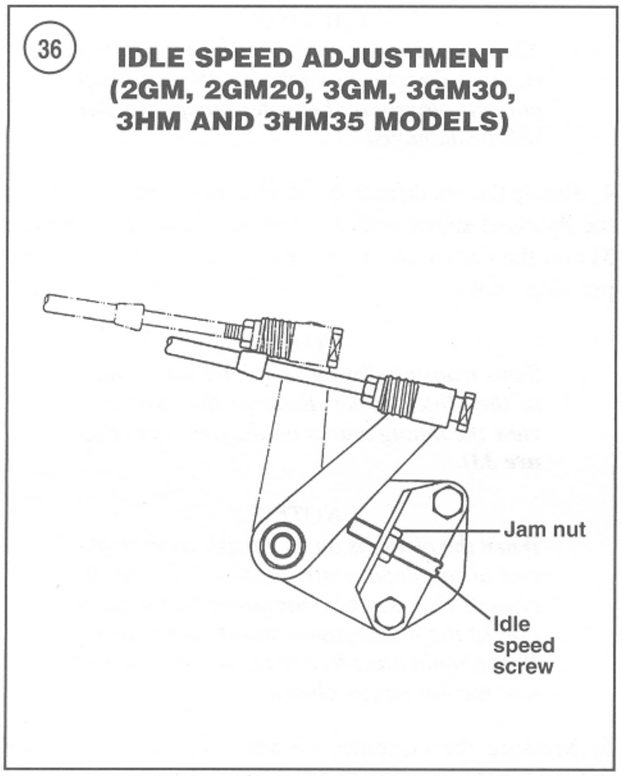

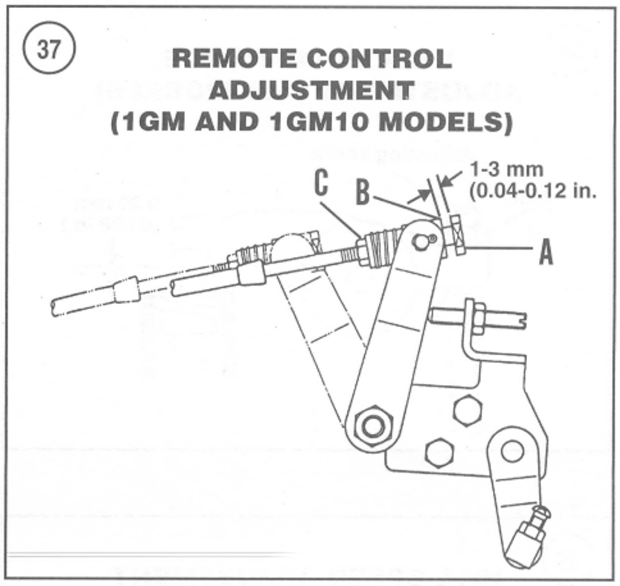

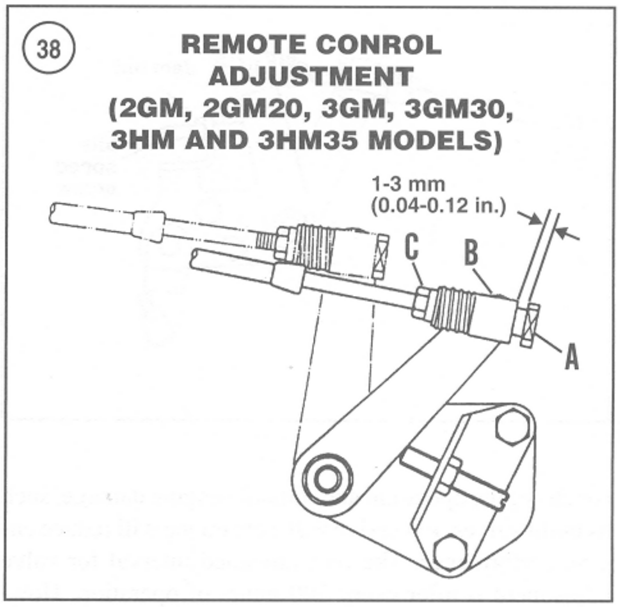

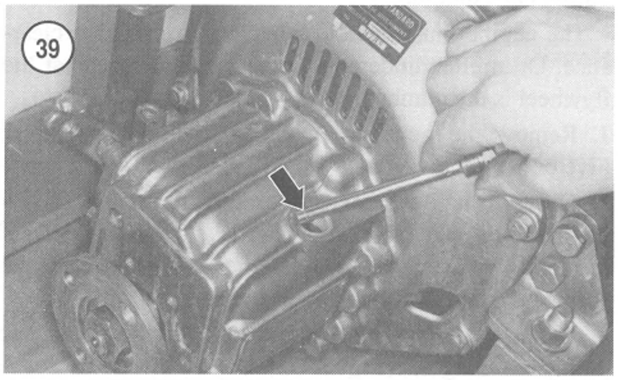

4. Adjust the idle speed screw until the engine idles at 825-875 rpm, then retighten the locknut.

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)

Chapter Four

Lay-up and Fitting Out

LAY-UP

Boats that are stored for more than a month require careful preparation for the lay-up. This is necessary to prevent the engine from freezing. A thorough service will also minimize damage from corrosion or fuel system contamination. Begin the service, if possible, while the boat is still in the water.

If the boat has been removed from the water, a supply of cooling water must be made available to the engine. This can be accomplished using a water hose attached to the water pump inlet. Always start the water flow before starting the engine.

CAUTION
Some of the following steps require water for the cooling system. The boat must be in the water, or a source of water must be connected to the seawater cooling pump.

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.

1. Run the engine until it reaches normal operating temperature.
2. Change the engine oil and filter as described in Chapter Three.
3. Use a suitable engine fogging oil as instructed by the oil manufacturer.
4. Thoroughly inspect the engine, including the cooling and fuel systems. Perform service work that will protect against damage during extended storage, such as replacing hoses and gaskets. Make a list of problems that should be corrected before the boat is returned to service.
5. If the engine is equipped with freshwater cooling, flush and change the freshwater coolant as described in Chapter Three.
6. Drain the seawater cooling system as described in this chapter. Be sure to drain or blow out all portions of the system.

NOTE
In some instances, such as to prevent rust formation, it may be desirable to fill the seawater cooling system with an antifreeze solution. Refer to the following section in this chapter.

7. If the seawater cooling system was drained, remove the seawater pump impeller as described in Chapter Eight. Lubricate the impeller with dishwashing soap, then install the impeller in the pump housing. Assemble the pump, but do not tighten the cover retaining screws.

NOTE
Make a highly visible sign as a reminder that the seawater pump is inoperable. Attach the sign to the controls.

8. Apply lubricant to the control cables and all linkage pivot points.
9. Loosen belt tension for the pump and alternator drive belts.
10. Seal or cover all engine openings to prevent the entrance of water, dirt or debris. Make a list of all the sealed locations to be sure they are all uncovered when returning the engine to service.
11. Wipe any dirt or corrosion off the engine and transmission, then use a rag to apply oil or a rust inhibitor to all engine surfaces.
12. Fill the fuel tank so less condensation will form. Add a good-quality antibacterial additive (biocide) and fuel stabilizer to the fuel tank.
13. Remove the battery from the boat. Tape the vent holes closed and clean the battery case with a baking soda solution to remove any traces of corrosion and acid, then rinse with cold water. Check the electrolyte level in each cell and top off with distilled water as required. Cover the terminals with a light coat of petroleum jelly. Store the battery in a cool, dry place.

NOTE
Remove the battery from storage every 30-45 days. Check electrolyte level and slow-charge for five or six hours at 6 amperes.

COOLING SYSTEM DRAINING

The engine seawater cooling system must be properly drained for storage during the winter months in areas where temperatures fall below 32° F (0° C). If it is not, the engine block or cooling system may be cracked by the expansion of frozen water.

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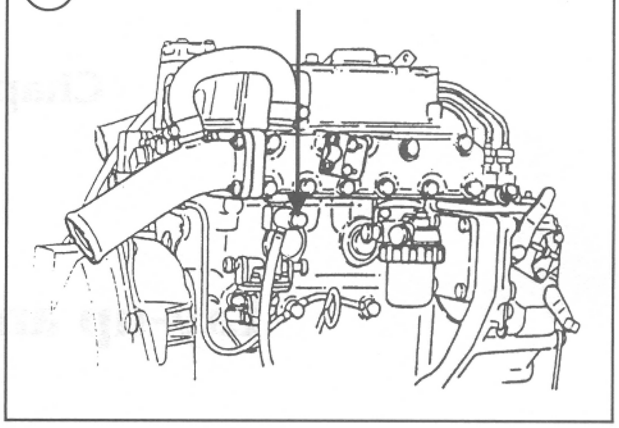

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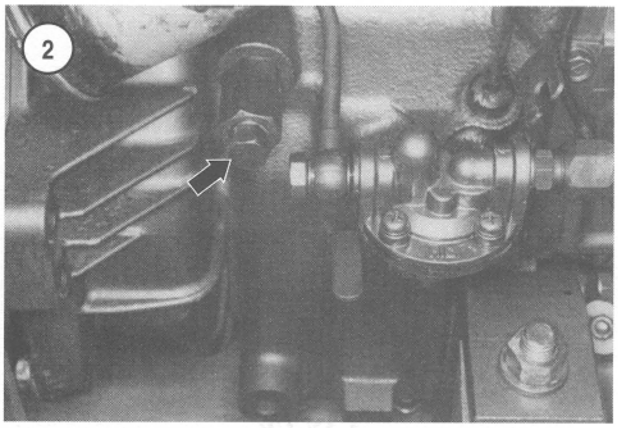


The following procedures are designed to help prevent unnecessary engine damage during winter storage.

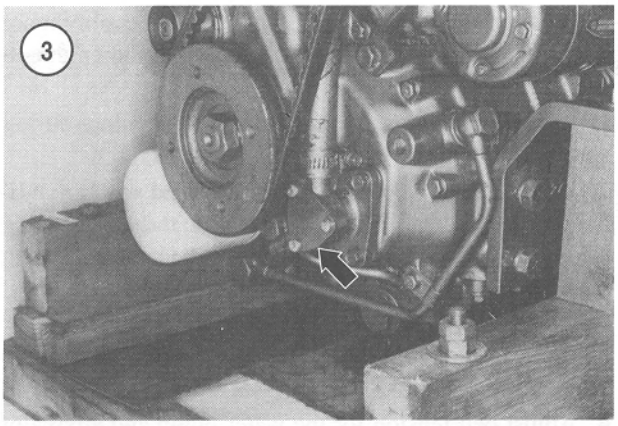
To ensure that the cooling system is completely drained, it may be necessary to readjust the position of the engine to drain all water.

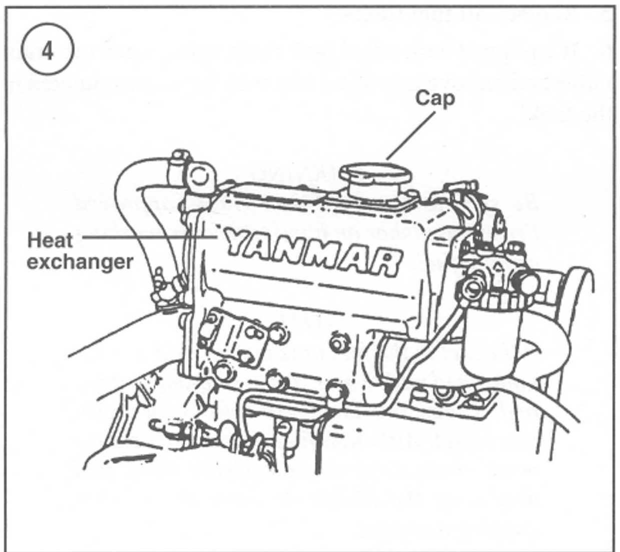
It is possible that some water will remain in the system. Filling it with an antifreeze solution will protect the seawater cooling system.

Seawater Cooling System

1. Place a suitable container under each drain, if space permits. This will prevent water from draining into the bilge.

NOTE
If no water flows from a drain, check the drain to make sure it is not obstructed or plugged.





2. On 3GM, 3GM30, 3HM and 3HM35 engines, open the drain on the underside of the exhaust manifold (**Figure 1**, typical).

3. Open the drain on the cylinder block (**Figure 2**, typical).

4. Remove the lower end of all cooling system hoses from the engine, pump and exhaust manifold. Lower the hoses and allow them to completely drain. Reconnect the hoses and clamp securely.

NOTE
On 1GM and 1GM10 engines, access is restricted to the upper water pump cover screw. If a suitable tool is not available, it may be necessary to remove the crankshaft pulley for access to all of the water pump cover screws.

5. Loosen the cover screws on the seawater pump (**Figure 3**, typical) and drain any water in the pump. If the gasket is damaged, remove the cover and install a new gasket and the cover.
6. Allow the cooling system to drain completely, then close all drains.

Adding antifreeze

The following procedure pertains to seawater cooling systems and is designed to provide additional protection against damage due to freezing temperatures while the boat is in storage.

CAUTION
Do not run the engine after performing the storage service procedure that follows. Before returning the boat to service, drain the seawater cooling system as described in this chapter.

1. Refer to Chapter Eight to remove the thermostat and gasket. Discard the gasket.
2. Make sure the seacock or water inlet to the seawater pump is closed.
3. Pour a 50/50 solution of pure soft water and ethylene glycol antifreeze through the thermostat hole into the engine until the cylinder head, block and manifold are full.
4. Reinstall the thermostat with a new gasket.

Freshwater (Closed) Cooling System

The freshwater section of a cooling system need not be drained during winter months, provided it is filled with a 50/50 solution of pure soft water and ethylene glycol antifreeze. However, if draining the freshwater cooling system is necessary, use the following procedure.

Note that the following procedures address the freshwater and seawater sections of the cooling system separately. If the freshwater portion is not being drained, follow the draining procedure for the seawater section.

Freshwater (closed) cooling section

1. Place containers under the drains, if space permits. This will prevent coolant from draining into the bilge.
2. Remove the pressure fill cap from the heat exchanger (**Figure 4**).

WARNING
Ethylene glycol is an environmental toxic waste that cannot be legally flushed down a drain or poured on the ground. Put it in suit-

able containers and dispose of it according to local regulations. Make sure to wipe up any spills and cover any containers of antifreeze. Keep antifreeze out of the reach of children and animals.

3. Open the drain on the underside of the exhaust manifold (**Figure 1**).
4. Open the drain on the engine block (**Figure 2**, typical).
5. Allow the freshwater section to drain completely.
6. On models equipped with a remote reservoir, disconnect the hose to the engine and drain the coolant from the reservoir. Reconnect the hose.
7. Close the drain plugs.
8. If refilling the freshwater section, refer to Chapter Three for the filling procedure.

Seawater cooling section

Refer to the following procedure to drain the seawater section.

1. Place a suitable container under the drain, if space permits. This will prevent water from draining into the bilge.

NOTE
If no water flows from the drain, check the drain to make sure it is not obstructed or plugged.

2. Open the drain on the underside of the exhaust manifold end cap (**Figure 2**).
3. Allow the water to drain completely, then close the drain.
4. Loosen the cover screws on the seawater pump (**Figure 3**) and drain any water in the pump. If the gasket is damaged, remove the cover and install a new gasket and the cover.
5. Remove the lower end of the cooling system hoses from the pump and exhaust manifold. Lower the hoses and allow them to completely drain. Then reconnect the hoses and clamp securely.

NOTE
It is possible that undrained water may remain. Protect the seawater cooling section by filling it with an antifreeze solution.

FITTING OUT

Preparing the boat for use after storage is easier if the engine was properly prepared before storage. Refer to the list of needed work that was to be performed before returning the engine to service. If there is other work to be done, determine if the work is easier, and possibly more economical, if performed before returning the engine to service.

1. Remove all covers placed over engine openings during lay-up.
2. If the seawater cooling system is filled with an antifreeze solution, drain the antifreeze from the system using the draining procedure described for the seawater cooling system or the procedure for the seawater section if equipped with a freshwater (closed) cooling system.
3. If left loose during lay-up, tighten the seawater pump cover screws (**Figure 3**).
4. Adjust belt tension for the water pump and alternator drive belts as described in Chapter Three.
5. Replace all fuel filters.
6. If equipped with a fuel tank drain valve, open the drain valve and remove any water that may have accumulated in the tank.

WARNING
Be sure to have a Coast Guard-approved fire extinguisher on hand whenever working around fuel.

NOTE
If the fuel in the fuel tank is dirty, old or contaminated with water, drain or pump out the fuel. Clean the tank and refill with fresh, clean fuel. Although fuel filters will remove most contaminants, excessively dirty fuel may clog the filters or enter the engine, causing damage.

7. Bleed the fuel system as described in Chapter Seven.
8. Check the battery electrolyte level and fill if necessary. Make certain the battery has a full charge; recharge if necessary. Clean the battery terminals and install the battery, making sure the cables are connected properly. Cover the battery terminals with a light coat of petroleum jelly.
9. Check the crankcase oil level. Add oil, if necessary. If the oil was not changed at time of lay-up or if the engine has been in storage for an extended period of time, change the oil and oil filter.
10. Move the engine control to the STOP position. Position the decompression lever in the ON position. Engage the starter and crank the engine for 30 seconds. This procedure will pump engine oil to the engine bearings and other engine parts.
11. On engines equipped with a freshwater cooling system, check the coolant. If the coolant is contaminated or has reached its scheduled replacement time, drain, flush and refill the freshwater cooling system.

12. Thoroughly inspect the engine. Check for leakage, rust or corrosion that will affect engine operation. Check all hoses for deterioration and clamps for tightness.
13. Check all through-hull fittings.
14. Make sure water is available to the cooling system.
15. Operate all engine controls to be sure they operate properly and smoothly.
16. Start and run engine. Check for oil and water leaks. Check engine operation.
17. Tune-up engine as described in Chapter Three.

Chapter Five

Single-Cylinder Engines

This chapter covers the Yanmar 1GM and 1GM10 single-cylinder, diesel engines.

The engine consists of a cast-iron cylinder block, containing a full-length water jacket around the cylinder.

The crankshaft rotates counterclockwise as viewed from the flywheel. Two main bearings support the crankshaft, with the front bearing providing the thrust surfaces. The crankshaft gear drives the rotor-type oil pump located in the lower front of the engine block.

The camshaft is gear driven and located in the engine block above the crankshaft. One end of the camshaft is supported by a ball bearing (front), and the other rides directly in the block (rear). In addition to operating the valves, the camshaft operates the fuel transfer pump and has an actuating lobe for the injection pump attached at the front.

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

Engine specifications (**Table 1**) and tightening torques (**Table 2**) are located at the end of this chapter.

DIESEL ENGINE FUNDAMENTALS

Diesel engines are compression ignition engines, as opposed to gasoline engines, which are identified as spark ignition engines. The intake, compression, ignition, expansion and exhaust cycle occur in the same sequence for compression ignition engines as for spark ignition engines. The major differences are how the fuel is introduced into the combustion chamber and how the ignition is accomplished.

The principle of operation for compression ignition engines is to compress air in the cylinder without fuel; as the pressure increases, so does the temperature. The temperature of the compressed air is sufficient to ignite the diesel fuel injected into the cylinder. To achieve the required high-compression pressure/temperature, diesel engines have compression ratios between 16:1 and 22:1. These high compression ratios raise the cylinder air temperature to approximately 1000° F. Diesel fuel will ignite at approximately 750° F. Therefore, diesel fuel injected into the cylinder will immediately begin to burn.

A high-pressure fuel delivery system is necessary to inject fuel into the cylinder. The injector pressure must be higher than air pressure in the cylinder, and the fuel must be forced through the small openings in the fuel injector to properly atomize the fuel. Refer to Chapter Seven for fuel and governor system operation.

Refer to **Figure 1**. During the intake stroke, air is drawn into the cylinder.

During the compression stroke, the air is compressed to raise its temperature. The seal between the piston and the

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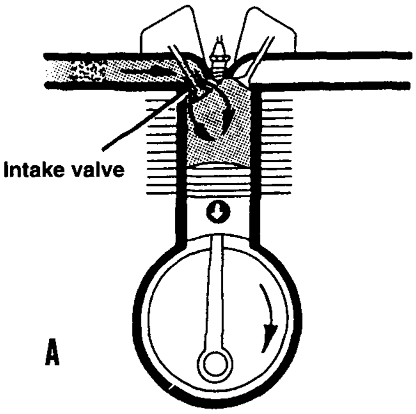
4-STROKE DIESEL ENGINE PRINCIPLES



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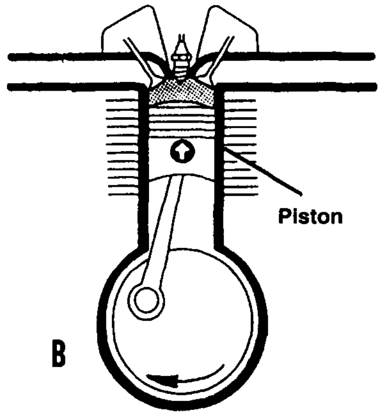

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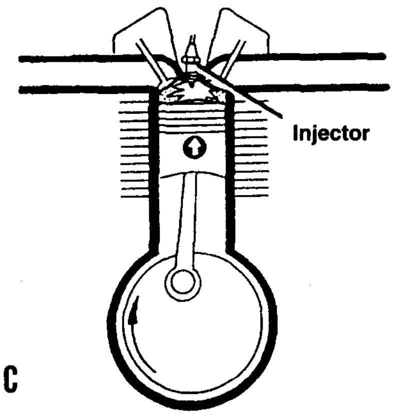
As the piston travels downward, the exhaust valve closes and the intake valve opens, allowing air to be drawn into the cylinder. When the piston reaches the bottom of its travel (BDC), the intake valve closes and remains closed for the next 1 1/2 revolutions of the crankshaft.

When the crankshaft continues to rotate, the piston moves upward, compressing the air.



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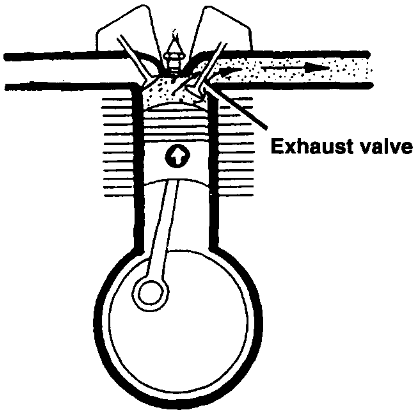
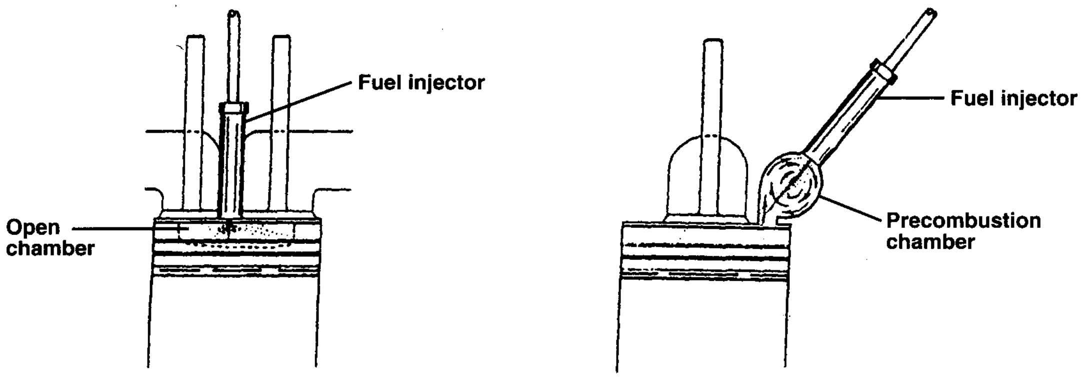


D

As the piston almost reaches the top of its travel, the injector sprays fuel into the combustion chamber. The fuel is ignited by the heat of compression. The piston continues to top dead center (TDC) and is pushed downward by the expanding gases.

When the piston almost reaches BDC, the exhaust valve opens and remains open until the piston is near TDC. The upward travel of the piston forces the exhaust gases out of the cylinder. After the piston has reached TDC, the exhaust valve closes and the cycle repeats.

2



cylinder must not permit compression leakage, which could lower the temperature of the compressed air. Also, the cylinder must not contain fuel that could ignite prematurely during compression.

Near the end of the compression stroke, fuel is injected into the cylinder and ignited by compressed air. Fuel injection continues during several degrees of crankshaft rotation, depending upon desired speed and load. Expansion of the air caused by the burning fuel pushes the piston down on the expansion (power) stroke.

The exhaust valve opens just before the piston reaches the bottom of travel. The exhaust valve remains open as the piston moves upward pushing burned (exhausted) gasses from the cylinder.

Different combustion chamber designs may be used on diesel engines to accomodate specific engine operating criteria. An open combustion chamber (direct injection) design is illustrated in **Figure 2**. The fuel and air are confined to one area. Usually the piston crown is concave to form the combustion chamber and provide turbulence required for mixing the fuel with the compressed air. The shape of the combustion chamber and the shape of the injection spray pattern are matched so that fuel will be distributed evenly throughout the chamber.

The Yanmar engines covered in this manual are equipped with a precombustion chamber for each cylinder (**Figure 2**). The precombustion chamber increases combustion efficiency, which produces greater power with reduced emmissions. Combustion first occurs in the precombustion chamber when hot, compressed air enters the precombustion chamber just as fuel is injected. Combustion continues as the fuel and air are mixed and forced from the precombustion chamber into the engine cylinder. Additional mixing and ignition are completed in the cylinder.

ENGINE SERIAL NUMBER AND CODE

The engine serial number and model designation are located on a plate attached to the rocker cover (**Figure 3**). The engine serial number is also stamped on the side of the cylinder block (**Figure 4**).

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

REPLACEMENT PARTS

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

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

ENGINE REMOVAL PRECAUTIONS

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

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

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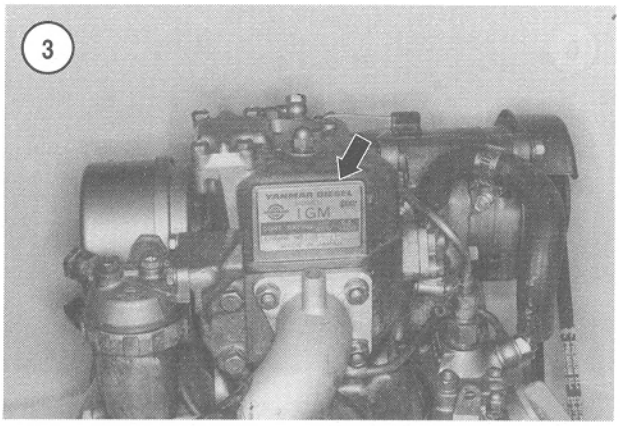

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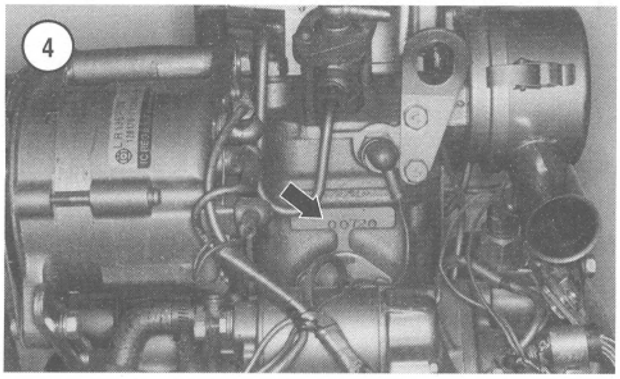

1. Never place any part of your body where a moving or falling engine may trap, cut or crush you.
2. If you must push the engine during removal, use a board or similar tool to keep your hands out of danger.
3. Make sure the hoist is designed to lift engines and has enough load capacity for your engine.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

Removal/Installation

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

1. Disconnect the negative battery cable.
2. Close the seacock and drain the cooling system as described in Chapter Four.
3. Disconnect the intake water hose from the seawater cooling pump.
4. Close the fuel shutoff valve and disconnect the fuel line and the fuel return line.
5. Disconnect the remote control cables.
6. Disconnect the electrical wiring harness connectors.
7. Disconnect the electrical wires from the electric starter motor and solenoid that will interfere with engine removal.
8. Detach the exhaust system.
9. Detach the driveshaft from the transmission output flange.
10. Remove the engine retaining bolts.
11. Remove the engine and transmission.
12. Remove the transmission from the engine as described in Chapter Ten.
13. Engine installation is the reverse of removal, plus the following:
    a. Tighten the engine mounting bolts securely.
    b. Securely tighten the output flange-to-driveshaft bolts.
    c. Bleed the fuel system at the fuel filter as described under Fuel Filter in Chapter Three.

5

VALVE COVER

Refer to **Figure 5**.

To remove the valve cover, proceed as follows:

1. Make sure the decompression lever is in the OFF position.
2. Unscrew the retaining nut (**Figure 6**).
3. Remove the valve cover.
4. Remove the gasket.
5. Clean the gasket surfaces on the valve cover and cylinder head.
6. Reverse the removal steps to install the valve cover. Be sure to install the breather pipe (19, **Figure 5**).

BREATHER ASSEMBLY

A reed-type breather is located in the valve cover. Refer to Chapter Three for a description of breather operation.

To service the reed portion of the breather, remove the breather cover (**Figure 7**). The reed (**Figure 8**) should lie flat. Replace the reed if it is split, cracked or otherwise damaged.

Check the oil return hole (**Figure 9**) inside the breather chamber in the valve cover. If the hole is obstructed, remove the valve cover and clean out the hole.

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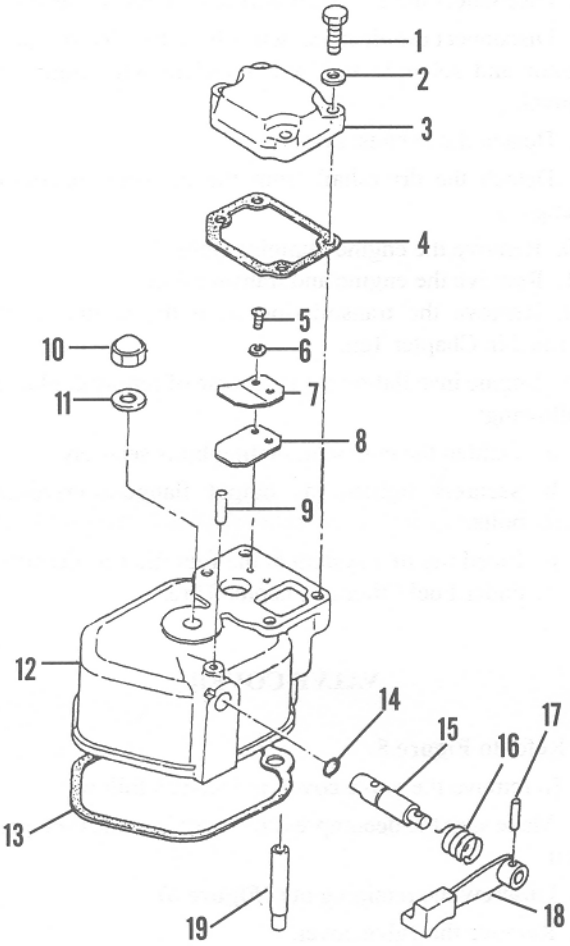
VALVE COVER ASSEMBLY



1. Bolt
2. Washer
3. Breather cover
4. Gasket
5. Screw
6. Washer
7. Valve stop
8. Breather valve reed
9. Pin
10. Nut
11. Washer
12. Valve cover
13. Gasket
14. O-ring
15. Decompression shaft
16. Spring
17. Pin
18. Decompression lever
19. Pipe

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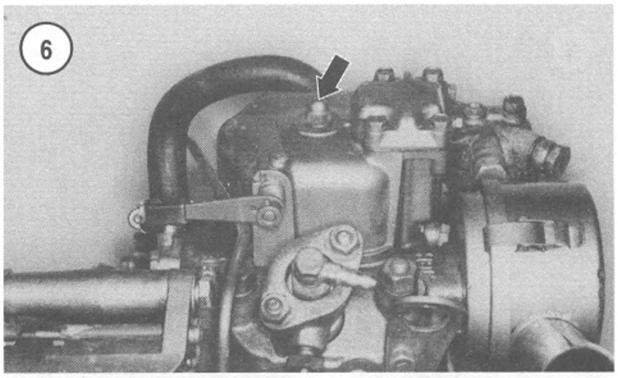

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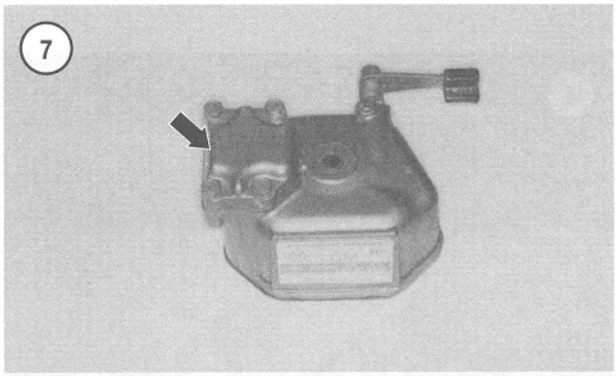

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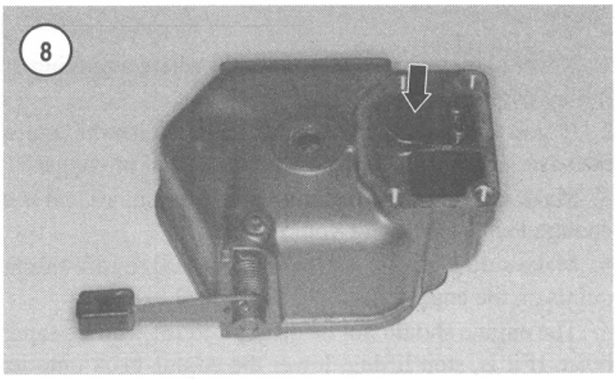

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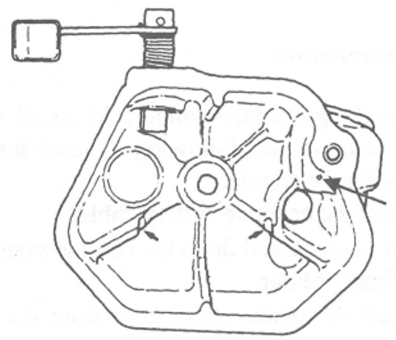

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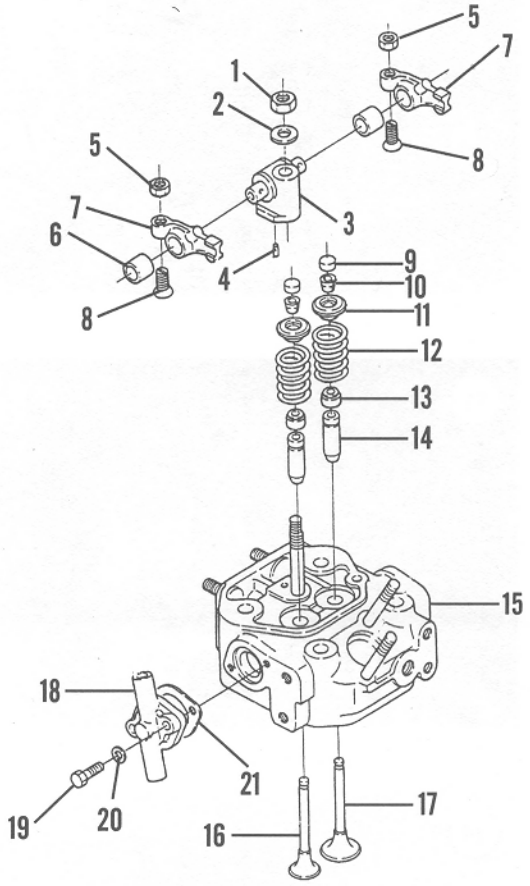
CYLINDER HEAD



1. Nut
2. Washer
3. Rocker shaft stand
4. Pin
5. Nut
6. Bushing
7. Rocker arm
8. Adjuster
9. Wear cap
10. Keys
11. Valve spring retainer
12. Valve spring
13. Valve seal
14. Valve guide
15. Cylinder head
16. Exhaust valve
17. Intake valve
18. Thermostat housing
19. Bolt
20. Washer
21. Gasket

DECOMPRESSION MECHANISM

The decompression mechanism on the valve cover forces the exhaust valve open to reduce compression pressure in the cylinder. Reducing compression pressure enables the starter to rotate the crankshaft faster during starting.

If the mechanism must be repaired, proceed as follows:

1. Remove the valve cover as previously described.

NOTE
*The lever retaining pin (17, **Figure 5**) is tapered. Drive the pin out toward top of lever.*

2. Using a suitable punch, drive out the retaining pin.
3. Remove the shaft assembly from the valve cover.
4. Inspect the mechanism and replace any damaged parts.
5. Reverse the removal procedure to reassemble the decompression mechanism. Note the following:

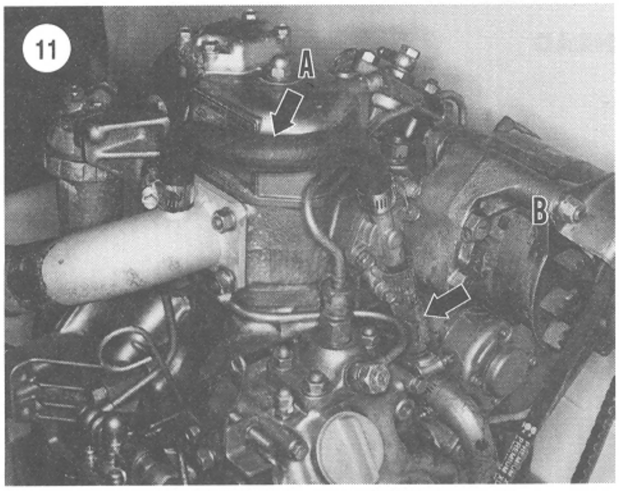
   a. The straight end of the spring must sit behind the lug on the valve cover. Position the hooked spring end on top of the lever.

   b. The shaft and lever must be properly assembled or the taper pin and tapered holes in the shaft and lever will not align. The cutout portion of the shaft must be down when the lever points toward the pulley end of the engine.

CYLINDER HEAD

Removal

In some instances, it may be possible to remove the cylinder head for service without removing the engine. If engine removal is necessary, refer to the previous engine removal procedure. Refer to **Figure 10** for an exploded view of the cylinder head assembly.



To remove the cylinder head, proceed as follows:

1. Disconnect the negative battery cable.
2. If not previously performed, drain the cooling system as described in Chapter Four.
3. Remove the alternator as described in Chapter Nine.
4. If not previously disconnected, detach the exhaust hose from the exhaust elbow.
5. Loosen the hose clamps and remove the water hose (A, **Figure 11**) from the exhaust elbow and thermostat housing.
6. Remove the exhaust elbow.
7. Disconnect the lower water hose (B, **Figure 11**) from the thermostat housing.
8. Disconnect the wire lead from the water temperature sender (**Figure 12**).
9. Remove the air cleaner and the air cleaner base (**Figure 13**).
10. Remove the fuel injector and precombustion chamber as described in Chapter Seven.
11. Remove the valve cover as previously described.
12. Remove the rocker arm stand retaining nut (A, **Figure 14**), then remove the rocker assembly (B).
13. Remove the push rods (**Figure 15**) and mark them so they can be reinstalled in their original positions.
14. Detach the oil line fitting (**Figure 16**) from the cylinder head.
15. Unscrew the cylinder head retaining nuts (**Figure 17**) in a crossing pattern.
16. Remove the cylinder head and head gasket.

Inspection

1. If service to the valves or rocker arm assembly is required, refer to the *Valves* and *Rocker Shaft Assembly* sections.