YANMAR

DIESEL INBOARD SHOP MANUAL

ONE, TWO & THREE CYLINDER ENGINES

Contents

Quick Reference Data

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 dis-

cusses 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.

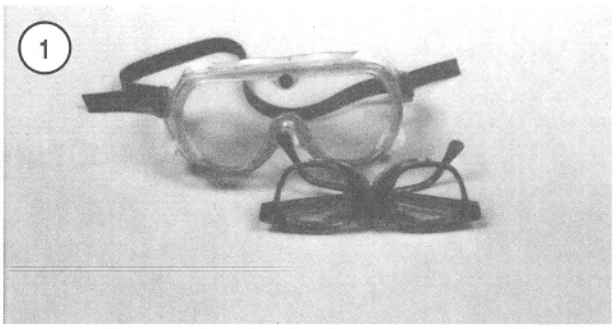
A CAUTION emphasizes areas where equipment damage could occur. Disregarding a CAUTION could cause permanent mechanical damage; however, personal injury is unlikely.

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.



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

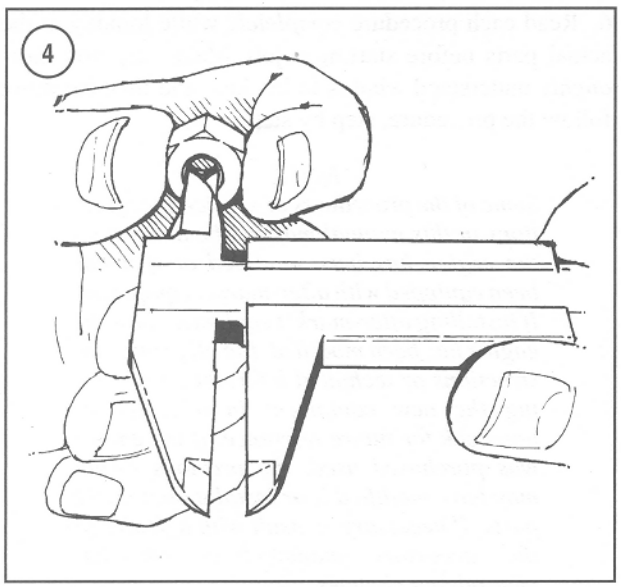
Some of the procedures or service specifications in this manual may not be accurate if the engine has been modified or if it has been equipped with after-market equipment. If installing after-market equipment or if the engine has been modified, file all printed instructions or technical information regarding 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.

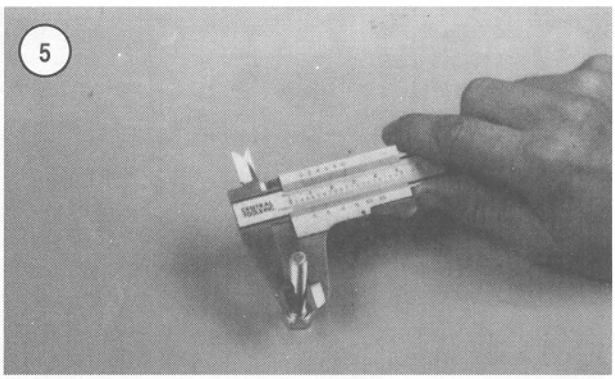
14. When assembling parts, make sure all shims and washers are replaced exactly where they were before removal.

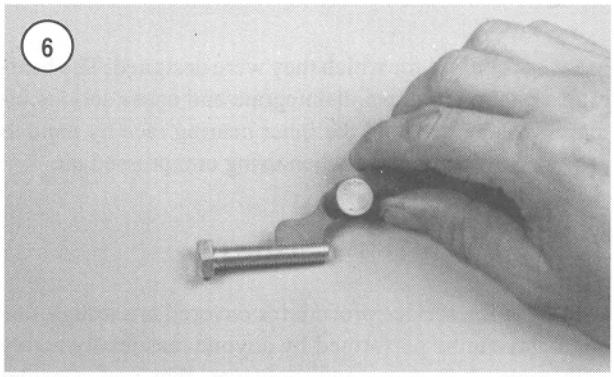
15. Whenever a rotating part contacts a stationary part, look for a shim or washer. Use new gaskets if there is any doubt about the condition of the old ones. A thin coat of silicone sealant on non-pressure-type gaskets may help them seal more effectively.

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.

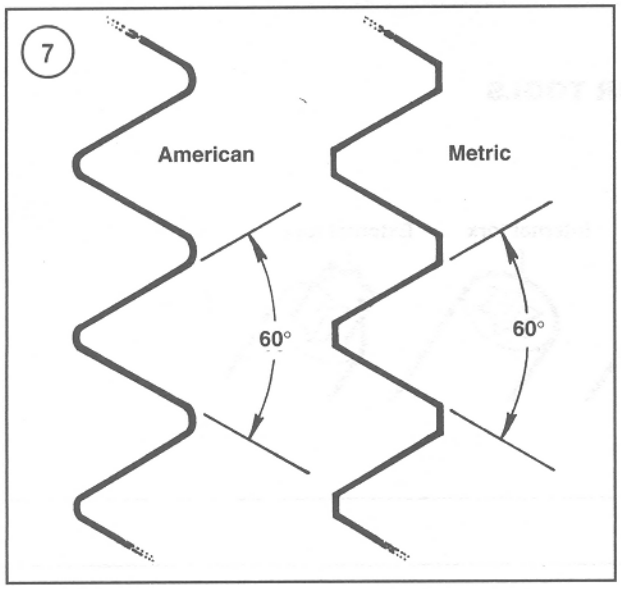
TORQUE SPECIFICATIONS

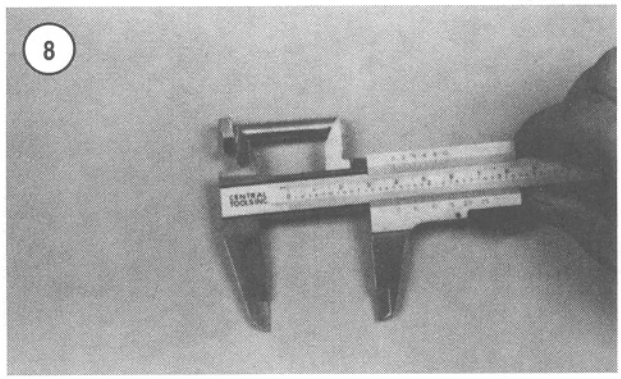
Torque specifications throughout this manual are given in Newton-meters (N•m) and foot-pounds (ft.-lb.).

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

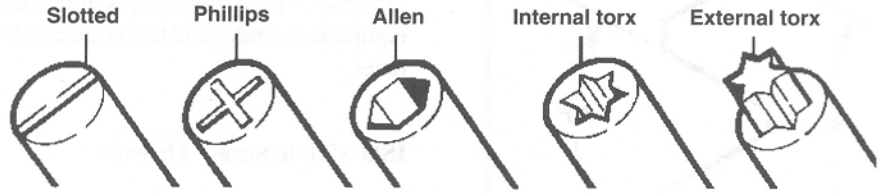
There are many different types of machine screws. **Figure 9** shows a number of screw heads requiring different types of turning tools. Heads are also designed to protrude above the metal (round) or to be slightly recessed in the metal (flat). See **Figure 10**.

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).

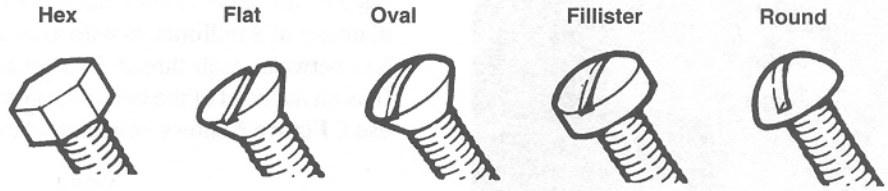
9

OPENINGS FOR TOOLS



10

MACHINE SCREWS



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.

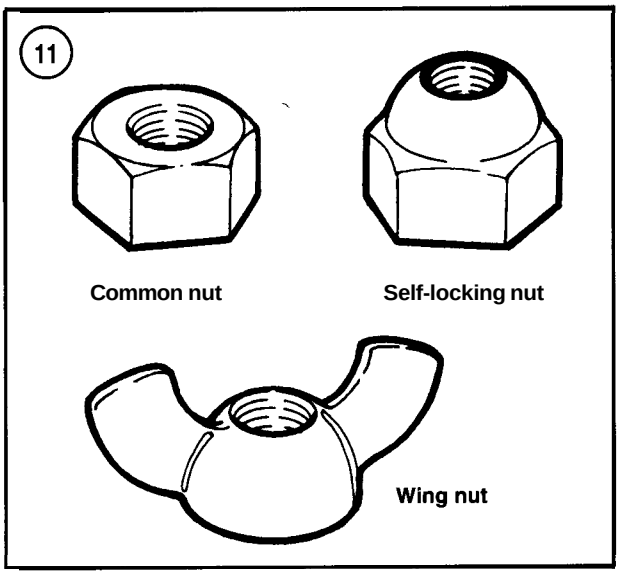
Figure 11 shows several types of nuts. The common nut is generally used with a lockwasher. Self-locking nuts have a nylon insert that prevents the nut from loosening; no lockwasher is required. Wing nuts are designed for fast removal by hand. Wing nuts are used for convenience in non-critical locations.

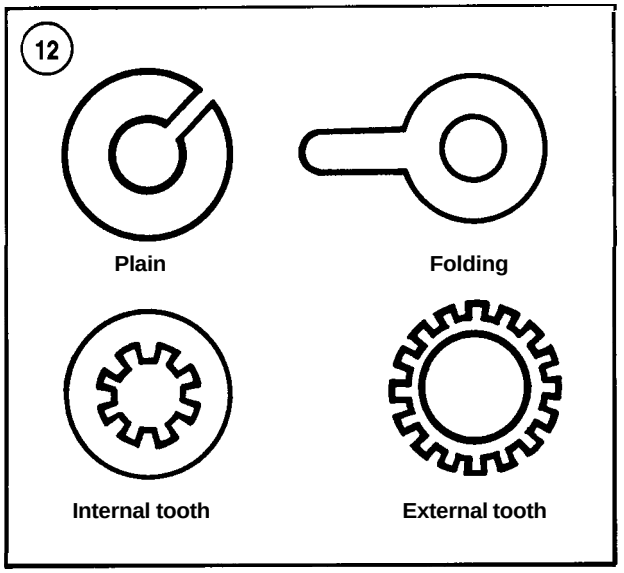
To indicate the size of a metric nut, manufacturers specify the diameter of the opening and the thread pitch. This is similar to bolt specifications, but without the length dimension. The measurement across two flats on the nut indicates the wrench size to be used.

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.

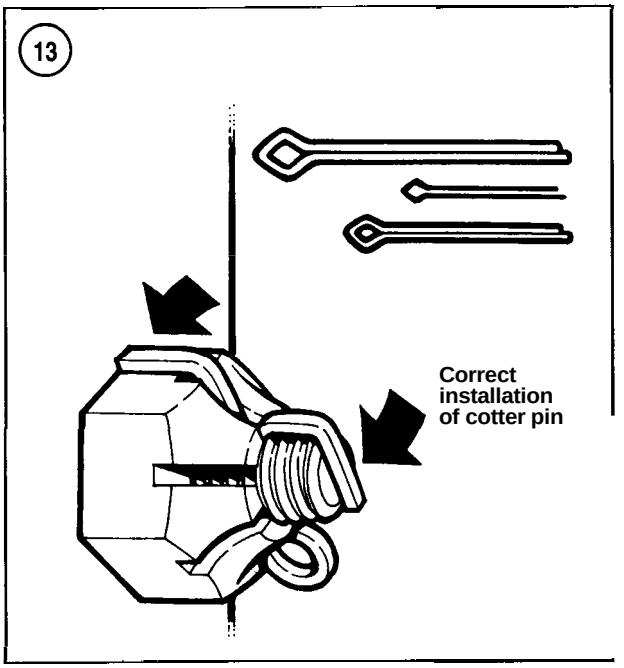




Washers

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.

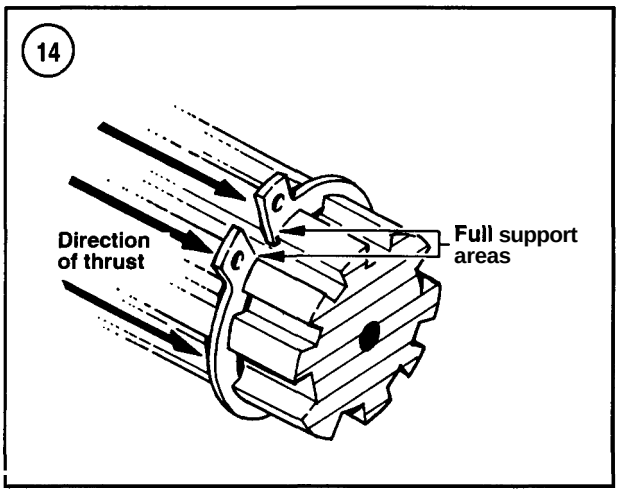
Do not reuse cotter pins, as their ends may break and allow the cotter pin to fall out and the fastener to loosen.

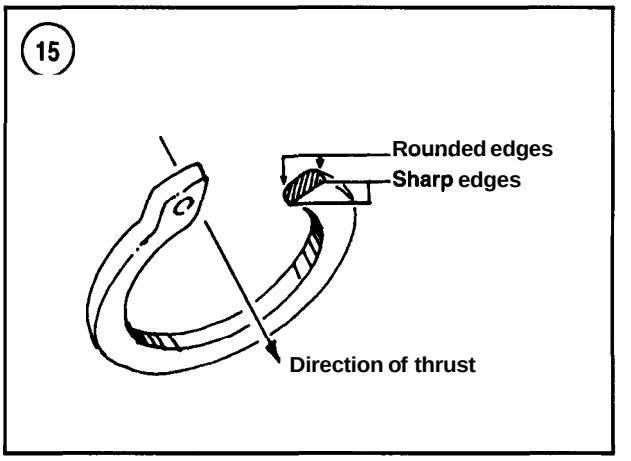
Circlips

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 theoend product is semi-solid. Grease is often classified by the type of thickener added; lithium soap is commonly used.

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-

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.

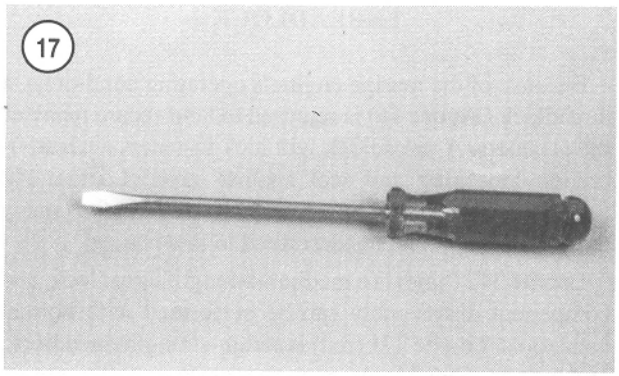
BASIC HAND TOOLS

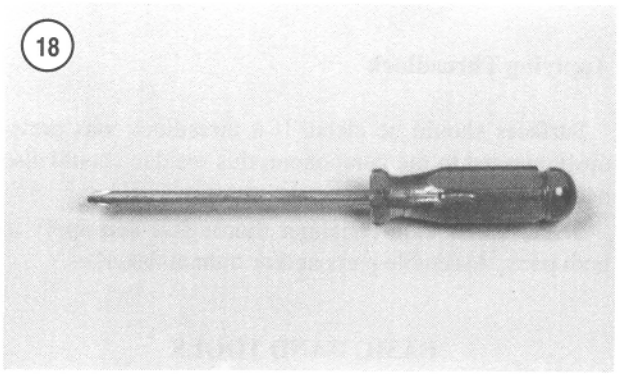
Many of the procedures in this manual can accomplished with simple hand tools and test equipment familiar to the average home mechanic. Keep tools clean and organized in a toolbox. After using a tool, wipe off dirt and grease and return the tool to its correct place. Wiping tools off is especially important 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.

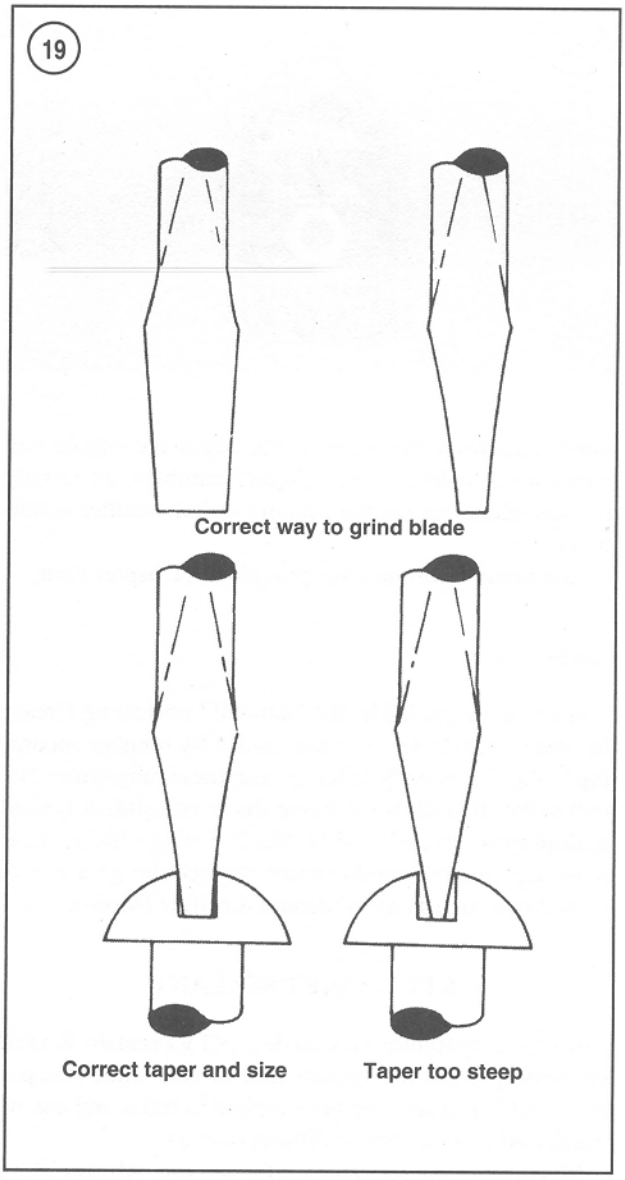
High-quality tools are essential; they are also more economical in the long run. Stay away from the advertised specials featured at some stores. These are usually a poor grade tool that can be sold cheaply. They are usually made of inferior material and are thick, heavy and clumsy. Their rough finish 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

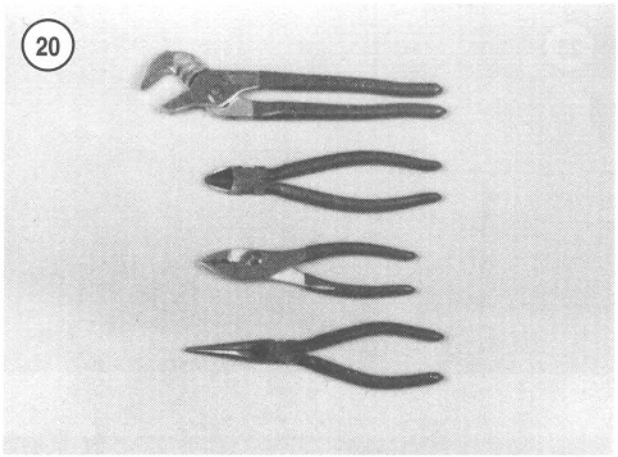
The screwdriver is a very basic tool, but if used improperly it will do more damage than good. The slot on a screw has a definite dimension and shape. Through improper use or selection, a screwdriver can damage the screw head, making removal of the screw difficult. A screwdriver must be selected to conform 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**).

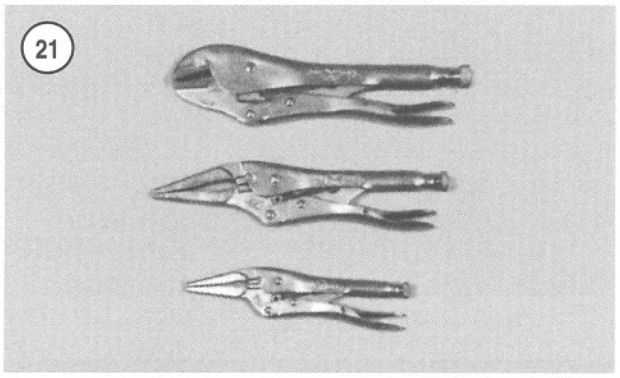
Note the following when selecting and using screwdrivers:

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.





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.

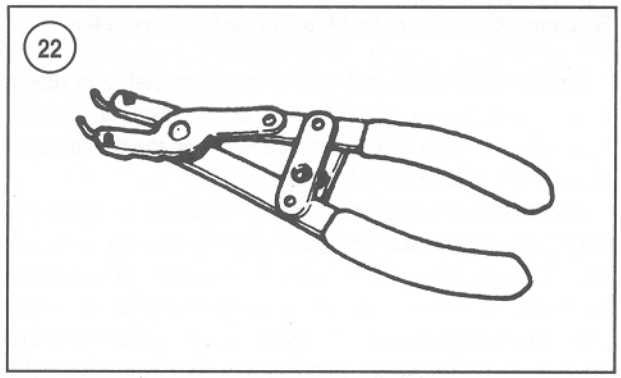
5. Because the working end of a screwdriver receives quite a bit of abuse, you should purchase screwdrivers with hardened tips. The extra money will be well spent.

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 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

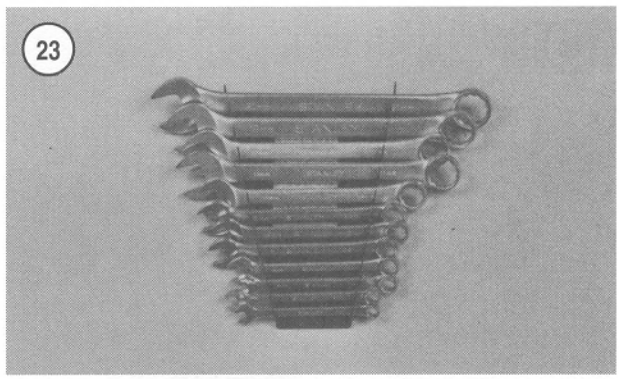
Circlip pliers (**Figure 22**) are used to remove circlips from shafts or within engine or suspension housings. When purchasing circlip pliers, there are two types. External pliers (spreading) are used to remove circlips that fit on the outside of a shaft. Internal pliers (squeezing) are used to remove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

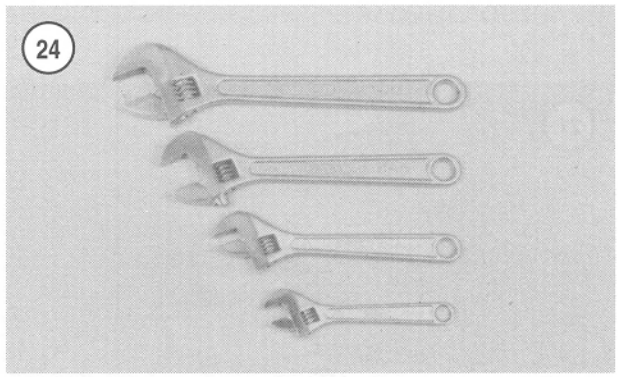
Combination wrenches (**Figure 23**) are open on one side and boxed on the other. Both ends are the same size.



Adjustable Wrenches

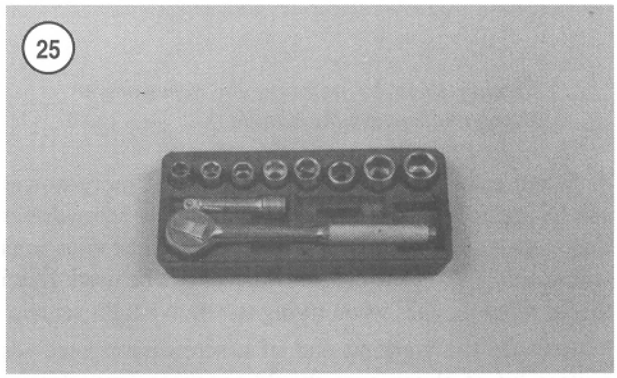
An adjustable wrench fits a variety of nuts or bolt heads (**Figure 24**). However, it can loosen and slip, causing damage to the nut and possibly causing injury. Use an adjustable wrench only when other wrenches are not available.

Adjustable wrenches come in various sizes.



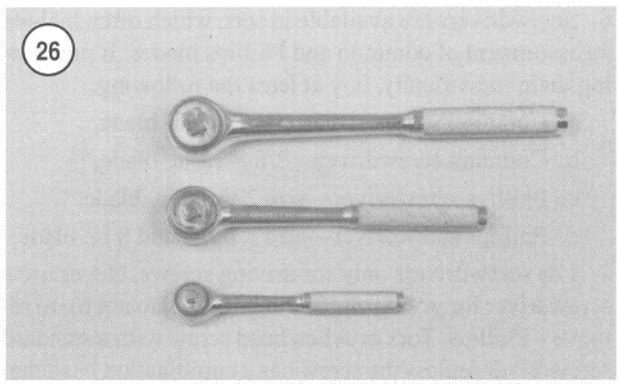
Socket Wrenches

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.



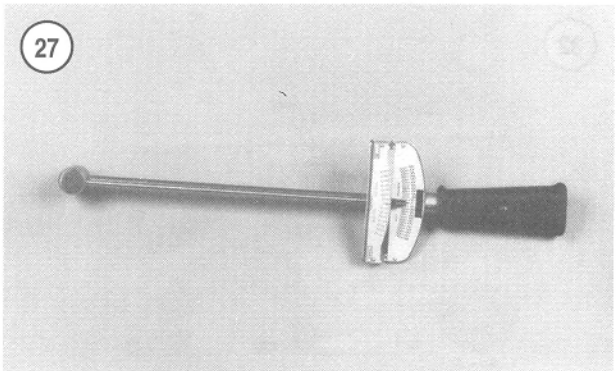
Torque Wrench

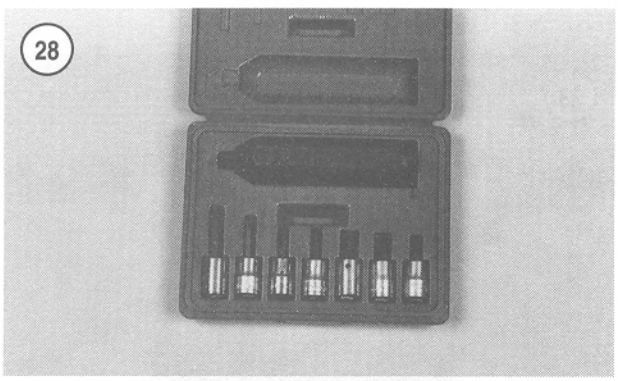
A torque wrench (**Figure 27**) is used with a socket to measure how tightly a nut or bolt is installed. Torque wrenches come in a wide price range and in different drive sizes. The drive size is the size of the square drive that mates with the socket.

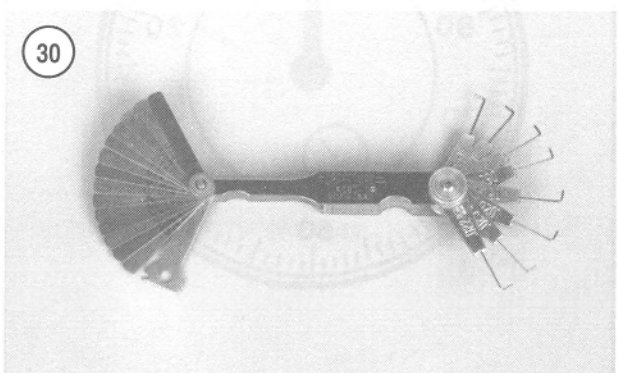


Impact Driver

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.







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.