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# 1

## GENERAL INFORMATION, SAFETY AND TOOLS

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# 1-2 GENERAL INFORMATION, SAFETY AND TOOLS

## HOW TO USE THIS MANUAL

This manual is designed to be a handy reference guide to maintaining and repairing your Yamaha Outboard. We strongly believe that regardless of how many or how few years' experience you may have, there is something new waiting here for you.

This manual covers the topics that a factory service manual (designed for factory trained mechanics) and a manufacturer owner's manual (designed more by lawyers than boat owners these days) covers. It will take you through the basics of maintaining and repairing your outboard, step-by-step, to help you understand what the factory trained mechanics already know by heart. By using the information in this manual, any boat owner should be able to make better informed decisions about what they need to do to maintain and enjoy their outboard.

Even if you never plan on touching a wrench (and if so, we hope that we can change your mind), this manual will still help you understand what a mechanic needs to do in order to maintain your engine.

### Can You Do It?

If you are not the type who is prone to taking a wrench to something, NEVER FEAR. The procedures provided here cover topics at a level virtually anyone will be able to handle. And just the fact that you purchased this manual shows your interest in better understanding your outboard.

You may even find that maintaining your outboard yourself is preferable in most cases. From a monetary standpoint, it could also be beneficial. The money spent on hauling your boat to a marina and paying a tech to service the engine could buy you fuel for a whole weekend of boating. And, if you are really that unsure of your own mechanical abilities, at the very least you should fully understand what a marine mechanic does to your boat. You may decide that anything other than maintenance and adjustments should be performed by a mechanic (and that's your call), but if so you should know that every time you board your boat, you are placing faith in the mechanic's work and trusting him or her with your well-being, and maybe your life.

It should also be noted that in most areas a factory-trained mechanic will command a hefty hourly rate for off site service. If the tech comes to you this hourly rate is often charged from the time they leave their shop to the time that they return home. When service is performed at a boat yard, the clock usually starts when they go out to get the boat and bring it into the shop and doesn't end until it is tested and put back in the yard. The cost savings in doing the job yourself might be readily apparent at this point.

Of course, if even you're already a seasoned Do-It-Yourselfer or a Professional Technician, you'll find the procedures, specifications, special tips as well as the schematics and illustrations helpful when tackling a new job on a motor.

■ To help you decide if a task is within your skill level, procedures will often be rated using a wrench symbol in the text. When present, the number of wrenches designates how difficult we feel the procedure to be on a 1-4 scale. For more details on the wrench icon rating system, please refer to the information under Skill Levels at the beginning of this manual.

### Where to Begin

Before spending any money on parts, and before removing any nuts or bolts, read through the entire procedure or topic. This will give you the overall view of what tools and supplies will be required to perform the procedure or what questions need to be answered before purchasing parts. So read ahead and plan ahead. Each operation should be approached logically and all procedures thoroughly understood before attempting any work.

### Avoiding Trouble

Some procedures in this manual may require you to "label and disconnect . . ." a group of lines, hoses or wires. Don't be lulled into thinking you can remember where everything goes — you won't. If you reconnect or install a part incorrectly, the motor may operate poorly, if at all. If you hook up electrical wiring incorrectly, you may instantly learn a very expensive lesson.

A piece of masking tape, for example, placed on a hose and another on its fitting will allow you to assign your own label such as the letter "A", or a short name. As long as you remember your own code, you can reconnect

the lines by matching letters or names. Do remember that tape will dissolve when saturated in some fluids (especially cleaning solvents). If a component is to be washed or cleaned, use another method of identification. A permanent felt-tipped marker can be very handy for marking metal parts; but remember that some solvents will remove permanent marker. A scribe can be used to carefully etch a small mark in some metal parts, but be sure NOT to do that on a gasket-making surface.

SAFETY is the most important thing to remember when performing maintenance or repairs. Be sure to read the information on safety in this manual.

## Maintenance or Repair?

Proper maintenance is the key to long and trouble-free engine life, and the work can yield its own rewards. A properly maintained engine performs better than one that is neglected. As a conscientious boat owner, set aside a Saturday morning, at least once a month, to perform a thorough check of items that could cause problems. Keep your own personal log to jot down which services you performed, how much the parts cost you, the date, and the amount of hours on the engine at the time. Keep all receipts for parts purchased, so that they may be referred to in case of related problems or to determine operating expenses. As a do-it-yourselfer, these receipts are the only proof you have that the required maintenance was performed. In the event of a warranty problem (on new motors), these receipts can be invaluable.

It's necessary to mention the difference between maintenance and repair. Maintenance includes routine inspections, adjustments, and replacement of parts that show signs of normal wear. Maintenance compensates for wear or deterioration. Repair implies that something has broken or is not working. A need for repair is often caused by lack of maintenance.

For example: draining and refilling the gearcase oil is maintenance recommended by all manufacturers at specific intervals. Failure to do this can allow internal corrosion or damage and impair the operation of the motor, requiring expensive repairs. While no maintenance program can prevent items from breaking or wearing out, a general rule can be stated: MAINTENANCE IS CHEAPER THAN REPAIR.

## Directions and Locations

### ◆ See Figure 1

Two basic rules should be mentioned here. First, whenever the Port side of the engine (or boat) is referred to, it is meant to specify the left side of the engine when you are sitting at the helm. Conversely, the Starboard means your right side. The Bow is the front of the boat and the Stern or Aft is the rear.

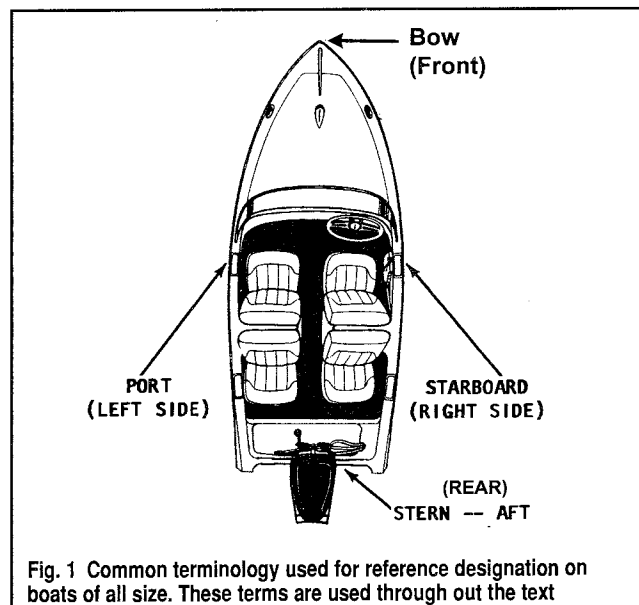


Fig. 1 Common terminology used for reference designation on boats of all size. These terms are used through out the text

Most screws and bolts are removed by turning counterclockwise, and tightened by turning clockwise. An easy way to remember this is: righty-tighty; lefty-loosey. Corny, but effective. And if you are really dense (and we have all been so at one time or another), buy a ratchet that is marked ON and OFF (like Snap-on® ratchets), or mark your own. This can be especially helpful when you are bent over backwards, upside down or otherwise turned around when working on a boat-mounted component.

## Professional Help

Occasionally, there are some things when working on an outboard that are beyond the capabilities or tools of the average Do-It-Yourselfer (DIYer). This shouldn't include most of the topics of this manual, but you will have to be the judge. Some engines require special tools or a selection of special parts, even for some basic maintenance tasks.

Talk to other boaters who use the same model of engine and speak with a trusted marina to find if there is a particular system or component on your engine that is difficult to maintain.

You will have to decide for yourself where basic maintenance ends and where professional service should begin. Take your time and do your research first (starting with the information contained within) and then make your own decision. If you really don't feel comfortable with attempting a procedure, DON'T DO IT. If you've gotten into something that may be over your head, don't panic. Tuck your tail between your legs and call a marine mechanic. Marinas and independent shops will be able to finish a job for you. Your ego may be damaged, but your boat will be properly restored to its full running order. So, as long as you approach jobs slowly and carefully, you really have nothing to lose and everything to gain by doing it yourself.

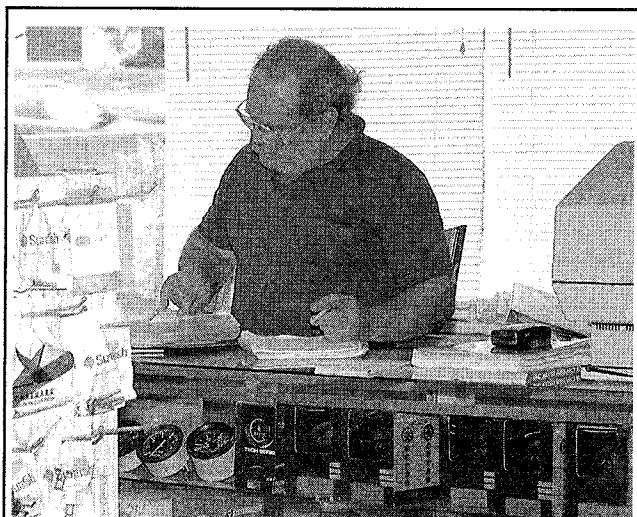
On the other hand, even the most complicated repair is within the ability of a person who takes their time and follows the steps of a procedure. A rock climber doesn't run up the side of a cliff, he/she takes it one step at a time and in the end, what looked difficult or impossible was conquerable. Worry about one step at a time.

## Purchasing Parts

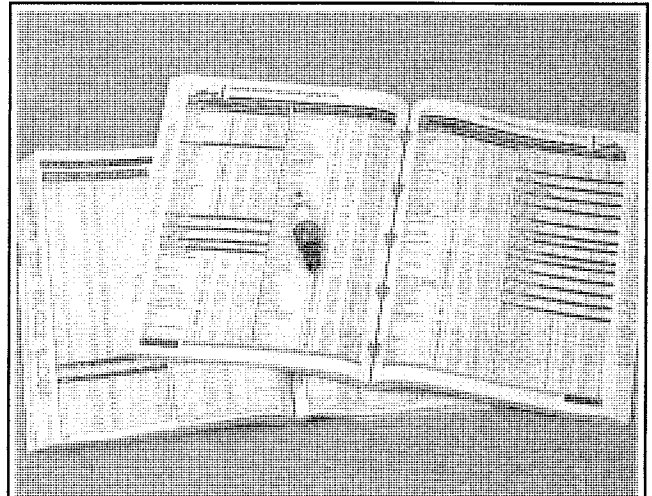
### ◆ See Figures 2 and 3

When purchasing parts there are two things to consider. The first is quality and the second is to be sure to get the correct part for your engine. To get quality parts, always deal directly with a reputable retailer. To get the proper parts always refer to the model number from the information tag on your engine prior to calling the parts counter. An incorrect part can adversely affect your engine performance and fuel economy, and will cost you more money and aggravation in the end.

Just remember a tow back to shore will cost plenty. That charge is per hour from the time the towboat leaves their home port, to the time they return to their home port. Get the picture...\$\$\$?



**Fig. 2** By far the most important asset in purchasing parts is a knowledgeable and enthusiastic parts person



**Fig. 3** Parts catalogs, giving application and part number information, are provided by manufacturers for most replacement parts

So whom should you call for parts? Well, there are many sources for the parts you will need. Where you shop for parts will be determined by what kind of parts you need, how much you want to pay, and the types of stores in your neighborhood.

Your marina can supply you with many of the common parts you require. Using a marina as your parts supplier may be handy because of location (just walk right down the dock) or because the marina specializes in your particular brand of engine. In addition, it is always a good idea to get to know the marina staff (especially the marine mechanic).

The marine parts jobber, who is usually listed in the yellow pages or whose name can be obtained from the marina, is another excellent source for parts. In addition to supplying local marinas, they also do a sizeable business in over-the-counter parts sales for the do-it-yourselfer.

Almost every boating community has one or more convenient marine chain stores. These stores often offer the best retail prices and the convenience of one-stop shopping for all your needs. Since they cater to the do-it-yourselfer, these stores are almost always open weeknights, Saturdays, and Sundays, when the jobbers are usually closed.

The lowest prices for parts are most often found in discount stores or the auto department of mass merchandisers. Parts sold here are name and private brand parts bought in huge quantities, so they can offer a competitive price. Private brand parts are made by major manufacturers and sold to large chains under a store label. And, of course, more and more large automotive parts retailers are stocking basic marine supplies.

## Avoiding the Most Common Mistakes

There are 3 common mistakes in mechanical work:

1. Following the incorrect order of assembly, disassembly or adjustment. When taking something apart or putting it together, performing steps in the wrong order usually just costs you extra time; however, it CAN break something. Read the entire procedure before beginning disassembly. Perform everything in the order in which the instructions say you should, even if you can't immediately see a reason for it. When you're taking apart something that is very intricate, you might want to draw a picture of how it looks when assembled at one point in order to make sure you get everything back in its proper position. When making adjustments, perform them in the proper order; often, one adjustment affects another, and you cannot expect satisfactory results unless each adjustment is made only when it cannot be changed by subsequent adjustments.

■ Digital cameras are handy. If you've got access to one, take pictures of intricate assemblies during the disassembly process and refer to them during assembly for tips on part orientation.

# 1-4 GENERAL INFORMATION, SAFETY AND TOOLS

2. Over-torquing (or under-torquing). While it is more common for over-torquing to cause damage, under-torquing may allow a fastener to vibrate loose causing serious damage. Especially when dealing with plastic and aluminum parts, pay attention to torque specifications and utilize a torque wrench in assembly. If a torque figure is not available, remember that if you are using the right tool to perform the job, you will probably not have to strain yourself to get a fastener tight enough. The pitch of most threads is so slight that the tension you put on the wrench will be multiplied many times in actual force on what you are tightening.

3. Cross-threading. This occurs when a part such as a bolt is screwed into a nut or casting at the wrong angle and forced. Cross-threading is more likely to occur if access is difficult. It helps to clean and lubricate fasteners, then to start threading with the part to be installed positioned straight inward. Always start a fastener, etc. with your fingers. If you encounter resistance, unscrew the part and start over again at a different angle until it can be inserted and turned several times without much effort. Keep in mind that some parts may have tapered threads, so that gentle turning will automatically bring the part you're threading to the proper angle, but only if you don't force it or resist a change in angle. Don't put a wrench on the part until it has been tightened a couple of turns by hand. If you suddenly encounter resistance, and the part has not seated fully, don't force it. Pull it back out to make sure it's clean and threading properly.

## BOATING SAFETY

In 1971 Congress ordered the U.S. Coast Guard to improve recreational boating safety. In response, the Coast Guard drew up a set of regulations.

Aside from these federal regulations, there are state and local laws you must follow. These sometimes exceed the Coast Guard requirements. This section discusses only the federal laws. State and local laws are available from your local Coast Guard. As with other laws, "Ignorance of the boating laws is no excuse." The rules fall into two groups: regulations for your boat and required safety equipment on your boat.

### Regulations For Your Boat

Most boats on waters within Federal jurisdiction must be registered or documented. These waters are those that provide a means of transportation between two or more states or to the sea. They also include the territorial waters of the United States.

### DOCUMENTING OF VESSELS

A vessel of five or more net tons may be documented as a yacht. In this process, papers are issued by the U.S. Coast Guard as they are for large ships. Documentation is a form of national registration. The boat must be used solely for pleasure. Its owner must be a citizen of the U.S., a partnership of U.S. citizens, or a corporation controlled by U.S. citizens. The captain and other officers must also be U.S. citizens. The crew need not be.

If you document your yacht, you have the legal authority to fly the yacht ensign. You also may record bills of sale, mortgages, and other papers of title with federal authorities. Doing so gives legal notice that such instruments exist. Documentation also permits preferred status for mortgages. This gives you additional security, and it aids in financing and transfer of title. You must carry the original documentation papers aboard your vessel. Copies will not suffice.

### REGISTRATION OF BOATS

If your boat is not documented, registration in the state of its principal use is probably required. If you use it mainly on an ocean, a gulf, or other similar water, register it in the state where you moor it.

If you use your boat solely for racing, it may be exempt from the requirement in your state. Some states may also exclude dinghies, while others require registration of documented vessels and non-power driven boats.

All states, except Alaska, register boats. In Alaska, the U.S. Coast Guard issues the registration numbers. If you move your vessel to a new state of principal use, a valid registration certificate is good for 60 days. You must have the registration certificate (certificate of number) aboard your vessel when it is in use. A copy will not suffice. You may be cited if you do not have the original on board.

### NUMBERING OF VESSELS

A registration number is on your registration certificate. You must paint or permanently attach this number to both sides of the forward half of your boat. Do not display any other number there.

The registration number must be clearly visible. It must not be placed on the obscured underside of a flared bow. If you can't place the number on the bow, place it on the forward half of the hull. If that doesn't work, put it on the superstructure. Put the number for an inflatable boat on a bracket or fixture. Then, firmly attach it to the forward half of the boat. The letters and numbers

must be plain block characters and must read from left to right. Use a space or a hyphen to separate the prefix and suffix letters from the numerals. The color of the characters must contrast with that of the background, and they must be at least three inches high.

In some states your registration is good for only one year. In others, it is good for as long as three years. Renew your registration before it expires. At that time you will receive a new decal or decals. Place them as required by state law. You should remove old decals before putting on the new ones. Some states require that you show only the current decal or decals. If your vessel is moored, it must have a current decal even if it is not in use.

If your vessel is lost, destroyed, abandoned, stolen, or transferred, you must inform the issuing authority. If you lose your certificate of number or your address changes, notify the issuing authority as soon as possible.

### SALES AND TRANSFERS

Your registration number is not transferable to another boat. The number stays with the boat unless its state of principal use is changed.

### HULL IDENTIFICATION NUMBER

A Hull Identification Number (HIN) is like the Vehicle Identification Number (VIN) on your car. Boats built between November 1, 1972 and July 31, 1984 have old format HINs. Since August 1, 1984 a new format has been used.

Your boat's HIN must appear in two places. If it has a transom, the primary number is on its starboard side within two inches of its top. If it does not have a transom or if it was not practical to use the transom, the number is on the starboard side. In this case, it must be within one foot of the stern and within two inches of the top of the hull side. On pontoon boats, it is on the aft crossbeam within one foot of the starboard hull attachment. Your boat also has a duplicate number in an unexposed location. This is on the boat's interior or under a fitting or item of hardware.

### LENGTH OF BOATS

For some purposes, boats are classed by length. Required equipment, for example, differs with boat size. Manufacturers may measure a boat's length in several ways. Officially, though, your boat is measured along a straight line from its bow to its stern. This line is parallel to its keel.

The length does not include bowsprits, boomkins, or pulpits. Nor does it include rudders, brackets, outboard motors, outdrives, diving platforms, or other attachments.

### CAPACITY INFORMATION

#### ◆ See Figure 4

Manufacturers must put capacity plates on most recreational boats less than 20 feet long. Sailboats, canoes, kayaks, and inflatable boats are usually exempt. Outboard boats must display the maximum permitted horsepower of their engines. The plates must also show the allowable maximum weights of the people on board. And they must show the allowable maximum combined weights of people, engine(s), and gear. Inboards and stern drives need not show the weight of their engines on their capacity plates. The capacity plate must appear where it is clearly visible to the operator when underway. This information serves to remind you of the capacity of your boat under normal circumstances. You should ask yourself, "Is my boat loaded above its recommended capacity?" and, "Is my boat overloaded for the present sea and wind conditions?" If you are stopped by a legal authority, you may be cited if you are overloaded.

## CERTIFICATE OF COMPLIANCE

### ◆ See Figure 4

Manufacturers are required to put compliance plates on motorboats greater than 20 feet in length. The plates must say, "This boat," or "This equipment complies with the U. S. Coast Guard Safety Standards in effect on the date of certification." Letters and numbers can be no less than one-eighth of an inch high. At the manufacturer's option, the capacity and compliance plates may be combined.

## VENTILATION

A cup of gasoline spilled in the bilge has the potential explosive power of 15 sticks of dynamite. This statement, commonly quoted over 20 years ago, may be an exaggeration; however, it illustrates a fact. Gasoline fumes in the bilge of a boat are highly explosive and a serious danger. They are heavier than air and will stay in the bilge until they are vented out.

Because of this danger, Coast Guard regulations require ventilation on many powerboats. There are several ways to supply fresh air to engine and gasoline tank compartments and to remove dangerous vapors. Whatever the choice, it must meet Coast Guard standards.

■ **The following is not intended to be a complete discussion of the regulations. It is limited to the majority of recreational vessels. Contact your local Coast Guard office for further information.**

### General Precautions

Ventilation systems will not remove raw gasoline that leaks from tanks or fuel lines. If you smell gasoline fumes, you need immediate repairs. The best device for sensing gasoline fumes is your nose. Use it! If you smell gasoline in a bilge, engine compartment, or elsewhere, don't start your engine. The smaller the compartment, the less gasoline it takes to make an explosive mixture.

### Ventilation for Open Boats

In open boats, gasoline vapors are dispersed by the air that moves through them. So they are exempt from ventilation requirements.

To be "open," a boat must meet certain conditions. Engine and fuel tank compartments and long narrow compartments that join them must be open to the atmosphere." This means they must have at least 15 square inches of open area for each cubic foot of net compartment volume. The open area must be in direct contact with the atmosphere. There must also be no long, unventilated spaces open to engine and fuel tank compartments into which flames could extend.

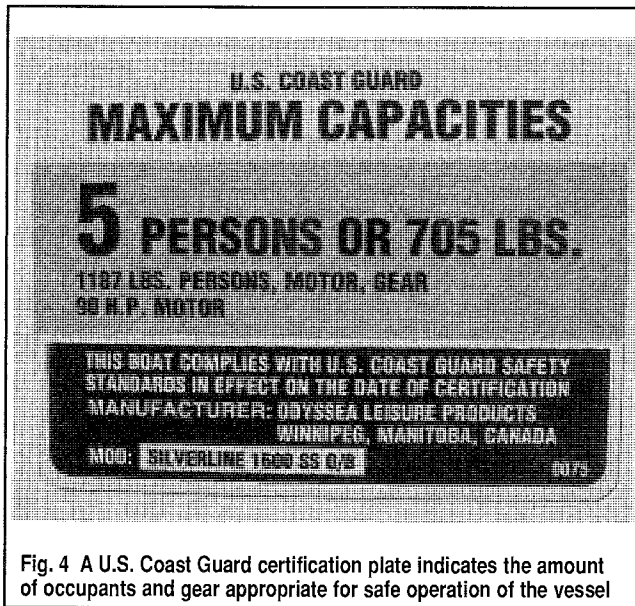


Fig. 4 A U.S. Coast Guard certification plate indicates the amount of occupants and gear appropriate for safe operation of the vessel

### Ventilation for All Other Boats

Powered and natural ventilation are required in an enclosed compartment with a permanently installed gasoline engine that has a cranking motor. A compartment is exempt if its engine is open to the atmosphere. Diesel powered boats are also exempt.

## VENTILATION SYSTEMS

There are two types of ventilation systems. One is "natural ventilation." In it, air circulates through closed spaces due to the boat's motion. The other type is "powered ventilation." In it, air is circulated by a motor-driven fan or fans.

### Natural Ventilation System Requirements

A natural ventilation system has an air supply from outside the boat. The air supply may also be from a ventilated compartment or a compartment open to the atmosphere. Intake openings are required. In addition, intake ducts may be required to direct the air to appropriate compartments.

The system must also have an exhaust duct that starts in the lower third of the compartment. The exhaust opening must be into another ventilated compartment or into the atmosphere. Each supply opening and supply duct, if there is one, must be above the usual level of water in the bilge. Exhaust openings and ducts must also be above the bilge water. Openings and ducts must be at least three square inches in area or two inches in diameter. Openings should be placed so exhaust gasses do not enter the fresh air intake. Exhaust fumes must not enter cabins or other enclosed, non-ventilated spaces. The carbon monoxide gas in them is deadly.

Intake and exhaust openings must be covered by cowls or similar devices. These registers keep out rain water and water from breaking seas. Most often, intake registers face forward and exhaust openings aft. This aids the flow of air when the boat is moving or at anchor since most boats face into the wind when properly anchored.

### Power Ventilation System Requirements

#### ◆ See Figure 5

Powered ventilation systems must meet the standards of a natural system, but in addition, they must also have one or more exhaust blowers. The blower duct can serve as the exhaust duct for natural ventilation if fan blades do not obstruct the air flow when not powered. Openings in engine compartment, for carburetion are in addition to ventilation system requirements.

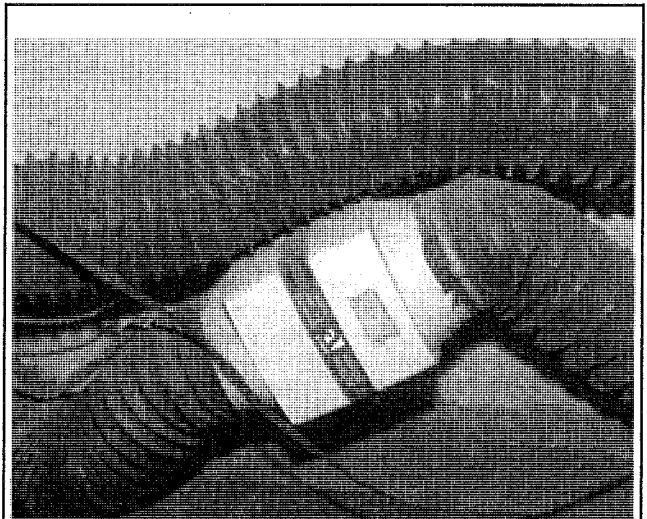


Fig. 5 Typical blower and duct system to vent fumes from the engine compartment

# 1-6 GENERAL INFORMATION, SAFETY AND TOOLS

## Required Safety Equipment

Coast Guard regulations require that your boat have certain equipment aboard. These requirements are minimums. Exceed them whenever you can.

### TYPES OF FIRES

There are four common classes of fires:

- Class A—fires are of ordinary combustible materials such as paper or wood.
- Class B—fires involve gasoline, oil and grease.
- Class C—fires are electrical.
- Class D—fires involve ferrous metals

One of the greatest risks to boaters is fire. This is why it is so important to carry the correct number and type of extinguishers onboard.

The best fire extinguisher for most boats is a Class B extinguisher. Never use water on Class B or Class C fires, as water spreads these types of fires. Additionally, you should never use water on a Class C fire as it may cause you to be electrocuted.

### FIRE EXTINGUISHERS

#### ◆ See Figure 6

If your boat meets one or more of the following conditions, you must have at least one fire extinguisher aboard. The conditions are:

- Inboard or stern drive engines
- Closed compartments under seats where portable fuel tanks can be stored
- Double bottoms not sealed together or not completely filled with flotation materials
- Closed living spaces
- Closed stowage compartments in which combustible or flammable materials are stored
- Permanently installed fuel tanks
- Boat is 26 feet or more in length.

#### Contents of Extinguishers

Fire extinguishers use a variety of materials. Those used on boats usually contain dry chemicals, Halon, or Carbon Dioxide (CO<sub>2</sub>). Dry chemical extinguishers contain chemical powders such as Sodium Bicarbonate—baking soda.

Carbon dioxide is a colorless and odorless gas when released from an extinguisher. It is not poisonous but caution must be used in entering compartments filled with it. It will not support life and keeps oxygen from reaching your lungs. A fire-killing concentration of Carbon Dioxide can be lethal. If you are in a compartment with a high concentration of CO<sub>2</sub>, you will have no difficulty breathing. But the air does not contain enough oxygen to support life. Unconsciousness or death can result.

#### HALON EXTINGUISHERS

Some fire extinguishers and "built-in" or "fixed" automatic fire extinguishing systems contain a gas called Halon. Like carbon dioxide it is colorless and odorless and will not support life. Some Halons may be toxic if inhaled.

To be accepted by the Coast Guard, a fixed Halon system must have an indicator light at the vessel's helm. A green light shows the system is ready. Red means it is being discharged or has been discharged. Warning horns are available to let you know the system has been activated. If your fixed Halon system discharges, ventilate the space thoroughly before you enter it. There are no residues from Halon but it will not support life.

Although Halon has excellent fire fighting properties; it is thought to deplete the earth's ozone layer and has not been manufactured since January 1, 1994. Halon extinguishers can be refilled from existing stocks of the gas until they are used up, but high federal excise taxes are being charged for the service. If you discontinue using your Halon extinguisher, take it to a recovery station rather than releasing the gas into the atmosphere. Compounds such as FE 241, designed to replace Halon, are now available.

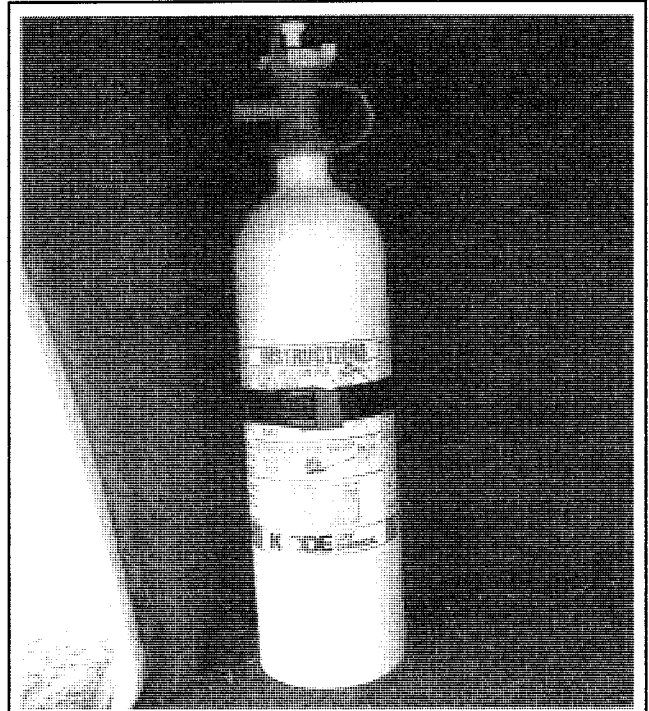


Fig. 6 An approved fire extinguisher should be mounted close to the operator for emergency use

#### Fire Extinguisher Approval

Fire extinguishers must be Coast Guard approved. Look for the approval number on the nameplate. Approved extinguishers have the following on their labels: "Marine Type USCG Approved, Size..., Type..., 162.208/," etc. In addition, to be acceptable by the Coast Guard, an extinguisher must be in serviceable condition and mounted in its bracket. An extinguisher not properly mounted in its bracket will not be considered serviceable during a Coast Guard inspection.

#### Care and Treatment

Make certain your extinguishers are in their stowage brackets and are not damaged. Replace cracked or broken hoses. Nozzles should be free of obstructions. Sometimes, wasps and other insects nest inside nozzles and make them inoperable. Check your extinguishers frequently. If they have pressure gauges, is the pressure within acceptable limits? Do the locking pins and sealing wires show they have not been used since recharging?

Don't try an extinguisher to test it. Its valves will not reseat properly and the remaining gas will leak out. When this happens, the extinguisher is useless.

Weigh and tag carbon dioxide and Halon extinguishers twice a year. If their weight loss exceeds 10 percent of the weight of the charge, recharge them. Check to see that they have not been used. They should have been inspected by a qualified person within the past six months, and they should have tags showing all inspection and service dates. The problem is that they can be partially discharged while appearing to be fully charged.

Some Halon extinguishers have pressure gauges the same as dry chemical extinguishers. Don't rely too heavily on the gauge. The extinguisher can be partially discharged and still show a good gauge reading. Weighing a Halon extinguisher is the only accurate way to assess its contents.

If your dry chemical extinguisher has a pressure indicator, check it frequently. Check the nozzle to see if there is powder in it. If there is, recharge it. Occasionally invert your dry chemical extinguisher and hit the base with the palm of your hand. The chemical in these extinguishers packs and cakes due to the boat's vibration and pounding. There is a difference of opinion about whether hitting the base helps, but it can't hurt. It is known that caking of the chemical powder is a major cause of failure of dry chemical extinguishers. Carry spares in excess of the minimum requirement. If you have guests aboard, make certain they know where the extinguishers are and how to use them.



## Using a Fire Extinguisher

A fire extinguisher usually has a device to keep it from being discharged accidentally. This is a metal or plastic pin or loop. If you need to use your extinguisher, take it from its bracket. Remove the pin or the loop and point the nozzle at the base of the flames. Now, squeeze the handle, and discharge the extinguisher's contents while sweeping from side to side. Recharge a used extinguisher as soon as possible.

If you are using a Halon or carbon dioxide extinguisher, keep your hands away from the discharge. The rapidly expanding gas will freeze them. If your fire extinguisher has a horn, hold it by its handle.

## Legal Requirements for Extinguishers

You must carry fire extinguishers as defined by Coast Guard regulations. They must be firmly mounted in their brackets and immediately accessible.

A motorboat less than 26 feet long must have at least one approved hand-portable, Type B-1 extinguisher. If the boat has an approved fixed fire extinguishing system, you are not required to have the Type B-1 extinguisher. Also, if your boat is less than 26 feet long, is propelled by an outboard motor, or motors, and does not have any of the first six conditions described at the beginning of this section, it is not required to have an extinguisher. Even so, it's a good idea to have one, especially if a nearby boat catches fire, or if a fire occurs at a fuel dock.

A motorboat 26 feet to less than 40 feet long, must have at least two Type B-1 approved hand-portable extinguishers. It can, instead, have at least one Coast Guard approved Type B-2. If you have an approved fire extinguishing system, only one Type B-1 is required.

A motorboat 40 to 65 feet long must have at least three Type B-1 approved portable extinguishers. It may have, instead, at least one Type B-1 plus a Type B-2. If there is an approved fixed fire extinguishing system, two Type B-1 or one Type B-2 is required.

## WARNING SYSTEM

Various devices are available to alert you to danger. These include fire, smoke, gasoline fumes, and carbon monoxide detectors. If your boat has a galley, it should have a smoke detector. Where possible, use wired detectors. Household batteries often corrode rapidly on a boat.

There are many ways in which carbon monoxide (a by-product of the combustion that occurs in an engine) can enter your boat. You can't see, smell, or taste carbon monoxide gas, but it is lethal. As little as one part in 10,000 parts of air can bring on a headache. The symptoms of carbon monoxide poisoning—headaches, dizziness, and nausea—are like seasickness. By the time you realize what is happening to you, it may be too late to take action. If you have enclosed living spaces on your boat, protect yourself with a detector.

## PERSONAL FLOTATION DEVICES

Personal Flotation Devices (PFDs) are commonly called life preservers or life jackets. You can get them in a variety of types and sizes. They vary with their intended uses. To be acceptable, PFDs must be Coast Guard approved.

### Type I PFDs

A Type I life jacket is also called an offshore life jacket. Type I life jackets will turn most unconscious people from facedown to a vertical or slightly backward position. The adult size gives a minimum of 22 pounds of buoyancy. The child size has at least 11 pounds. Type I jackets provide more protection to their wearers than any other type of life jacket. Type I life jackets are bulkier and less comfortable than other types. Furthermore, there are only two sizes, one for children and one for adults.

Type I life jackets will keep their wearers afloat for extended periods in rough water. They are recommended for offshore cruising where a delayed rescue is probable.

### Type II PFDs

#### ◆ See Figure 7

A Type II life jacket is also called a near-shore buoyant vest. It is an approved, wearable device. Type II life jackets will turn some unconscious people from facedown to vertical or slightly backward positions. The adult size gives at least 15.5 pounds of buoyancy. The medium child size has a minimum of 11 pounds. And the small child and infant sizes give seven pounds. A Type II life jacket is more comfortable than a Type I but it does not have as much buoyancy. It is not recommended for long hours in rough

water. Because of this, Type IIs are recommended for inshore and inland cruising on calm water. Use them only where there is a good chance of fast rescue.

### Type III PFDs

Type III life jackets or marine buoyant devices are also known as flotation aids. Like Type IIs, they are designed for calm inland or close offshore water where there is a good chance of fast rescue. Their minimum buoyancy is 15.5 pounds. They will **NOT** turn their wearers face up.

Type III devices are usually worn where freedom of movement is necessary. Thus, they are used for water skiing, small boat sailing, and fishing among other activities. They are available as vests and flotation coats. Flotation coats are useful in cold weather. Type IIIs come in many sizes from small child through large adult.

Life jackets come in a variety of colors and patterns—red, blue, green, camouflage, and cartoon characters. From purely a safety standpoint, the best color is bright orange. It is easier to see in the water, especially if the water is rough.

### Type IV PFDs

#### ◆ See Figures 8 and 9

Type IV ring life buoys, buoyant cushions and horseshoe buoys are Coast Guard approved devices called throwables. They are made to be thrown to people in the water, and should not be worn. Type IV cushions are often used as seat cushions. But, keep in mind that cushions are hard to hold onto in the water, thus, they do not afford as much protection as wearable life jackets.

The straps on buoyant cushions are for you to hold onto either in the water or when throwing them, they are **NOT** for your arms. A cushion should never be worn on your back, as it will turn you face down in the water.

Type IV throwables are not designed as personal flotation devices for unconscious people, non-swimmers, or children. Use them only in emergencies. They should not be used for, long periods in rough water.

Ring life buoys come in 18, 20, 24, and 30 in. diameter sizes. They usually have grab lines, but you will need to attach about 60 feet of polypropylene line to the grab rope to aid in retrieving someone in the water. If you throw a ring, be careful not to hit the person. Ring buoys can knock people unconscious

### Type V PFDs

Type V PFDs are of two kinds, special use devices and hybrids. Special use devices include boardsailing vests, deck suits, work vests, and others. They are approved only for the special uses or conditions indicated on their labels. Each is designed and intended for the particular application shown on its label. They do not meet legal requirements for general use aboard recreational boats.

Hybrid life jackets are inflatable devices with some built-in buoyancy provided by plastic foam or kapok. They can be inflated orally or by cylinders of compressed gas to give additional buoyancy. In some hybrids the gas is released manually. In others it is released automatically when the life jacket is immersed in water.

The inherent buoyancy of a hybrid may be insufficient to float a person unless it is inflated. The only way to find this out is for the user to try it in the water. Because of its limited buoyancy when deflated, a hybrid is recommended for use by a non-swimmer only if it is worn with enough inflation to float the wearer.

If they are to count against the legal requirement for the number of life jackets you must carry, hybrids manufactured before February 8, 1995 must be worn whenever a boat is underway and the wearer must not go below decks or in an enclosed space. To find out if your Type V hybrid must be worn to satisfy the legal requirement, read its label. If its use is restricted it will say, "REQUIRED TO BE WORN" in capital letters.

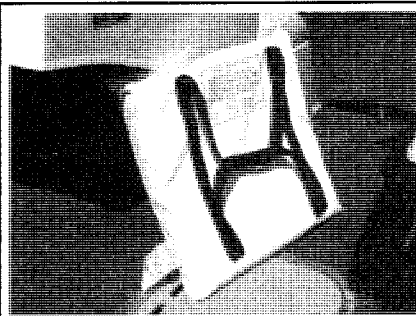
Hybrids cost more than other life jackets, but this factor must be weighed against the fact that they are more comfortable than Types I, II or III life jackets. Because of their greater comfort, their owners are more likely to wear them than are the owners of Type I, II or III life jackets.

The Coast Guard has determined that improved, less costly hybrids can save lives since they will be bought and used more frequently. For these reasons, a new federal regulation was adopted effective February 8, 1995. The regulation increases both the deflated and inflated buoyancies of hybrids, makes them available in a greater variety of sizes and types, and reduces their costs by reducing production costs.

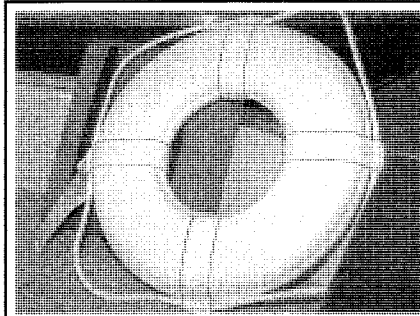
## 1-8 GENERAL INFORMATION, SAFETY AND TOOLS



**Fig. 7** Type II PFDs are recommended for inshore/inland use on calm water (where there is a good chance of fast rescue)



**Fig. 8** Type IV buoyant cushions are thrown to people in the water. If you can squeeze air out of the cushion, it should be replaced



**Fig. 9** Type IV throwables, such as this ring life buoy, are not designed for unconscious people, non-swimmers, or children

Even though it may not be required, the wearing of a hybrid or a life jacket is encouraged whenever a vessel is underway. Like life jackets, hybrids are now available in three types. To meet legal requirements, a Type I hybrid can be substituted for a Type I life jacket. Similarly Type II and III hybrids can be substituted for Type II and Type III life jackets. A Type I hybrid, when inflated, will turn most unconscious people from facedown to vertical or slightly backward positions just like a Type I life jacket. Type II and III hybrids function like Type II and III life jackets. If you purchase a new hybrid, it should have an owner's manual attached that describes its life jacket type and its deflated and inflated buoyancies. It warns you that it may have to be inflated to float you. The manual also tells you how to don the life jacket and how to inflate it. It also tells you how to change its inflation mechanism, recommended testing exercises, and inspection or maintenance procedures. The manual also tells you why you need a life jacket and why you should wear it. A new hybrid must be packaged with at least three gas cartridges. One of these may already be loaded into the inflation mechanism. Likewise, if it has an automatic inflation mechanism, it must be packaged with at least three of these water sensitive elements. One of these elements may be installed.

### Legal Requirements

A Coast Guard approved life jacket must show the manufacturer's name and approval number. Most are marked as Type I, II, III, IV or V. All of the newer hybrids are marked for type.

You are required to carry at least one wearable life jacket or hybrid for each person on board your recreational vessel. If your vessel is 16 feet or more in length and is not a canoe or a kayak, you must also have at least one Type IV on board. These requirements apply to all recreational vessels that are propelled or controlled by machinery, sails, oars, paddles, poles, or another vessel. Sailboards are not required to carry life jackets.

You can substitute an older Type V hybrid for any required Type I, II or III life jacket provided:

1. Its approval label shows it is approved for the activity the vessel is engaged in
2. It's approved as a substitute for a life jacket of the type required on the vessel
3. It's used as required on the labels and
4. It's used in accordance with any requirements in its owner's manual (if the approval label makes reference to such a manual.)

A water skier being towed is considered to be on board the vessel when judging compliance with legal requirements.

You are required to keep your Type I, II or III life jackets or equivalent hybrids readily accessible, which means you must be able to reach out and get them when needed. All life jackets must be in good, serviceable condition.

### General Considerations

The proper use of a life jacket requires the wearer to know how it will perform. You can gain this knowledge only through experience. Each person on your boat should be assigned a life jacket. Next, it should be fitted to the person who will wear it. Only then can you be sure that it will be ready for use in an emergency. This advice is good even if the water is calm, and you intend to boat near shore.

Boats can sink fast. There may be no time to look around for a life jacket. Fitting one on you in the water is almost impossible. Most drownings occur in inland waters within a few feet of safety. Most victims had life jackets, but they weren't wearing them.

Keeping life jackets in the plastic covers they came wrapped in, and in a cabin, assure that they will stay clean and unfaded. But this is no way to keep them when you are on the water. When you need a life jacket it must be readily accessible and adjusted to fit you. You can't spend time hunting for it or learning how to fit it.

There is no substitute for the experience of entering the water while wearing a life jacket. Children, especially, need practice. If possible, give your guests this experience. Tell them they should keep their arms to their sides when jumping in to keep the life jacket from riding up. Let them jump in and see how the life jacket responds. Is it adjusted so it does not ride up? Is it the proper size? Are all straps snug? Are children's life jackets the right sizes for them? Are they adjusted properly? If a child's life jacket fits correctly, you can lift the child by the jacket's shoulder straps and the child's chin and ears will not slip through. Non-swimmers, children, handicapped persons, elderly persons and even pets should always wear life jackets when they are aboard. Many states require that everyone aboard wear them in hazardous waters.

Inspect your lifesaving equipment from time to time. Leave any questionable or unsatisfactory equipment on shore. An emergency is no time for you to conduct an inspection.

Indelibly mark your life jackets with your vessel's name, number, and calling port. This can be important in a search and rescue effort. It could help concentrate effort where it will do the most good.

### Care of Life Jackets

Given reasonable care, life jackets last many years. Thoroughly dry them before putting them away. Stow them in dry, well-ventilated places. Avoid the bottoms of lockers and deck storage boxes where moisture may collect. Air and dry them frequently.

Life jackets should not be tossed about or used as fenders or cushions. Many contain kapok or fibrous glass material enclosed in plastic bags. The bags can rupture and are then unserviceable. Squeeze your life jacket gently. Does air leak out? If so, water can leak in and it will no longer be safe to use. Cut it up so no one will use it, and throw it away. The covers of some life jackets are made of nylon or polyester. These materials are plastics. Like many plastics, they break down after extended exposure to the ultraviolet light in sunlight. This process may be more rapid when the materials are dyed with bright dyes such as "neon" shades.

Ripped and badly faded fabrics are clues that the covering of your life jacket is deteriorating. A simple test is to pinch the fabric between your thumbs and forefingers. Now try to tear the fabric. If it can be torn, it should definitely be destroyed and discarded. Compare the colors in protected places to those exposed to the sun. If the colors have faded, the materials have been weakened. A life jacket covered in fabric should ordinarily last several boating seasons with normal use. A life jacket used every day in direct sunlight should probably be replaced more often.

## SOUND PRODUCING DEVICES

All boats are required to carry some means of making an efficient sound signal. Devices for making the whistle or horn noises required by the Navigation Rules must be capable of a four-second blast. The blast should be audible for at least one-half mile. Athletic whistles are not acceptable on boats 12 meters or longer. Use caution with athletic whistles. When wet, some of them come apart and lose their "pea." When this happens, they are useless.

If your vessel is 12 meters long and less than 20 meters, you must have a power whistle (or power horn) and a bell on board. The bell must be in operating condition and have a minimum diameter of at least 200mm (7.9 in.) at its mouth.

## VISUAL DISTRESS SIGNALS

◆ See Figure 10

Visual Distress Signals (VDS) attract attention to your vessel if you need help. They also help to guide searchers in search and rescue situations. Be sure you have the right types, and learn how to use them properly.

It is illegal to fire flares improperly. In addition, they cost the Coast Guard and its Auxiliary many wasted hours in fruitless searches. If you signal a distress with flares and then someone helps you, please let the Coast Guard or the appropriate Search And Rescue (SAR) Agency know so the distress report will be canceled.

Recreational boats less than 16 feet long must carry visual distress signals on coastal waters at night. Coastal waters are:

- The ocean (territorial sea)
- The Great Lakes
- Bays or sounds that empty into oceans
- Rivers over two miles across at their mouths upstream to where they narrow to two miles.

Recreational boats 16 feet or longer must carry VDS at all times on coastal waters. The same requirement applies to boats carrying six or fewer passengers for hire. Open sailboats less than 26 feet long without engines are exempt in the daytime as are manually propelled boats. Also exempt are boats in organized races, regattas, parades, etc. Boats owned in the United States and operating on the high seas must be equipped with VDS.

A wide variety of signaling devices meet Coast Guard regulations. For pyrotechnic devices, a minimum of three must be carried. Any combination can be carried as long as it adds up to at least three signals for day use and at least three signals for night use. Three day/night signals meet both requirements. If possible, carry more than the legal requirement.

■ **The American flag flying upside down is a commonly recognized distress signal. It is not recognized in the Coast Guard regulations, though. In an emergency, your efforts would probably be better used in more effective signaling methods.**

### Types of VDS

VDS are divided into two groups; daytime and nighttime use. Each of these groups is subdivided into pyrotechnic and non-pyrotechnic devices.

#### Daytime Non-Pyrotechnic Signals

A bright orange flag with a black square over a black circle is the simplest VDS. It is usable, of course, only in daylight. It has the advantage of being a continuous signal. A mirror can be used to good advantage on sunny days. It can attract the attention of other boaters and of aircraft from great distances. Mirrors are available with holes in their centers to aid in "aiming." In the absence of a mirror, any shiny object can be used. When another boat is in sight, an effective VDS is to extend your arms from your sides and move them up and down. Do it slowly. If you do it too fast the other people may think you are just being friendly. This simple gesture is seldom misunderstood, and requires no equipment.

#### Daytime Pyrotechnic Devices

Orange smoke is a useful daytime signal. Hand-held or floating smoke flares are very effective in attracting attention from aircraft. Smoke flares don't last long, and are not very effective in high wind or poor visibility. As with other pyrotechnic devices, use them only when you know there is a possibility that someone will see the display.

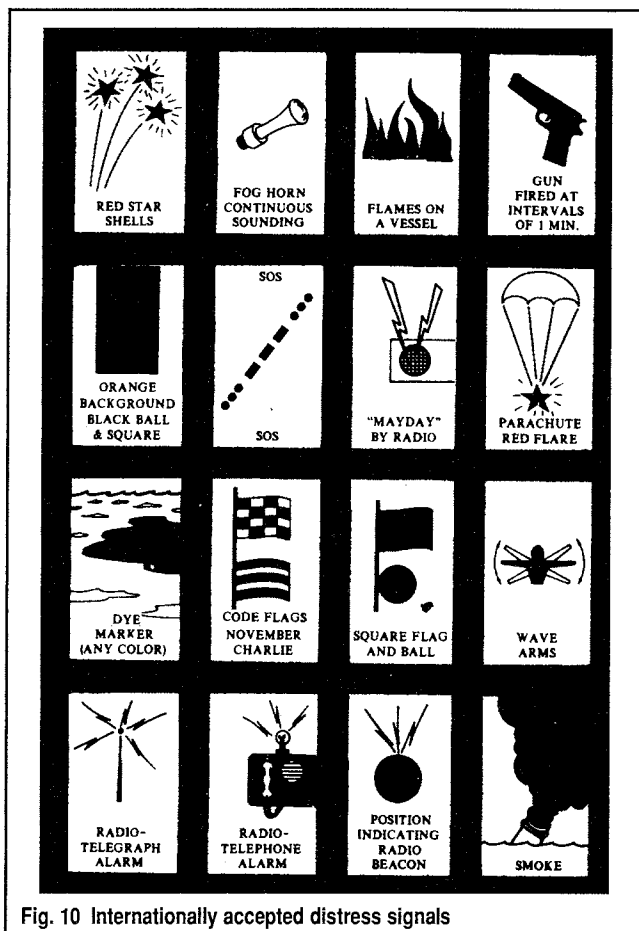


Fig. 10 Internationally accepted distress signals

To be usable, smoke flares must be kept dry. Keep them in airtight containers and store them in dry places. If the "striker" is damp, dry it out before trying to ignite the device. Some pyrotechnic devices require a forceful "strike" to ignite them.

All hand-held pyrotechnic devices may produce hot ashes or slag when burning. Hold them over the side of your boat in such a way that they do not burn your hand or drip into your boat.

### Nighttime Non-Pyrotechnic Signals

An electric distress light is available. This light automatically flashes the international morse code SOS distress signal (··· — ···). Flashed four to six times a minute, it is an unmistakable distress signal. It must show that it is approved by the Coast Guard. Be sure the batteries are fresh. Dated batteries give assurance that they are current.

Under the Inland Navigation Rules, a high intensity white light flashing 50-70 times per minute is a distress signal. Therefore, use strobe lights on inland waters only for distress signals.

### Nighttime Pyrotechnic Devices

◆ See Figure 11

Aerial and hand-held flares can be used at night or in the daytime. Obviously, they are more effective at night.

Currently, the serviceable life of a pyrotechnic device is rated at 42 months from its date of manufacture. Pyrotechnic devices are expensive. Look at their dates before you buy them. Buy them with as much time remaining as possible.

Like smoke flares, aerial and hand-held flares may fail to work if they have been damaged or abused. They will not function if they are or have been wet. Store them in dry, airtight containers in dry places. But store them where they are readily accessible.

Aerial VDSs, depending on their type and the conditions they are used in, may not go very high. Again, use them only when there is a good chance they will be seen.

## 1-10 GENERAL INFORMATION, SAFETY AND TOOLS

A serious disadvantage of aerial flares is that they burn for only a short time; most burn for less than 10 seconds. Most parachute flares burn for less than 45 seconds. If you use a VDS in an emergency, do so carefully. Hold hand-held flares over the side of the boat when in use. Never use a road hazard flare on a boat; it can easily start a fire. Marine type flares are specifically designed to lessen risk, but they still must be used carefully.

Aerial flares should be given the same respect as firearms since they are firearms! Never point them at another person. Don't allow children to play with them or around them. When you fire one, face away from the wind. Aim it downwind and upward at an angle of about 60 degrees to the horizon. If there is a strong wind, aim it somewhat more vertically. Never fire it straight up. Before you discharge a flare pistol, check for overhead obstructions that might be damaged by the flare. An obstruction might deflect the flare to where it will cause injury or damage.

### Disposal of VDS

Keep outdated flares when you get new ones. They do not meet legal requirements, but you might need them sometime, and they may work. It is illegal to fire a VDS on federal navigable waters unless an emergency exists. Many states have similar laws.

### Emergency Position Indicating Radio Beacon (EPIRB)

There is no requirement for recreational boats to have EPIRBs. Some commercial and fishing vessels, though, must have them if they operate beyond the three-mile limit. Vessels carrying six or fewer passengers for hire must have EPIRBs under some circumstances when operating beyond the three-mile limit. If you boat in a remote area or offshore, you should have an EPIRB. An EPIRB is a small (about 6 to 20 in. high), battery-powered, radio transmitting buoy-like device. It is a radio transmitter and requires a license or an endorsement on your radio station license by the Federal Communications Commission (FCC). EPIRBs are either automatically activated by being immersed in water or manually by a switch.

### Courtesy Marine Examinations

One of the roles of the Coast Guard Auxiliary is to promote recreational boating safety. This is why they conduct thousands of Courtesy Marine Examinations each year. The auxiliaries who do these examinations are well-trained and knowledgeable in the field.

## BOATING EQUIPMENT (NOT REQUIRED BUT RECOMMENDED)

Although not required by law, there are other pieces of equipment that are good to have onboard.

### Oar/Paddle (Second Means of Propulsion)

All boats less than 16 feet long should carry a second means of propulsion. A paddle or oar can come in handy at times. For most small boats, a spare trolling or outboard motor is an excellent idea. If you carry a spare motor, it should have its own fuel tank and starting power. If you use an electric trolling motor, it should have its own battery.

### Bailing Devices

All boats should carry at least one effective manual bailing device in addition to any installed electric bilge pump. This can be a bucket, can, scoop, hand-operated pump, etc. If your battery "goes dead" it will not operate your electric pump.

### First Aid Kit

◆ See Figure 12

All boats should carry a first aid kit. It should contain adhesive bandages, gauze, adhesive tape, antiseptic, aspirin, etc. Check your first aid kit from time to time. Replace anything that is outdated. It is to your advantage to know how to use your first aid kit. Another good idea would be to take a Red Cross first aid course.

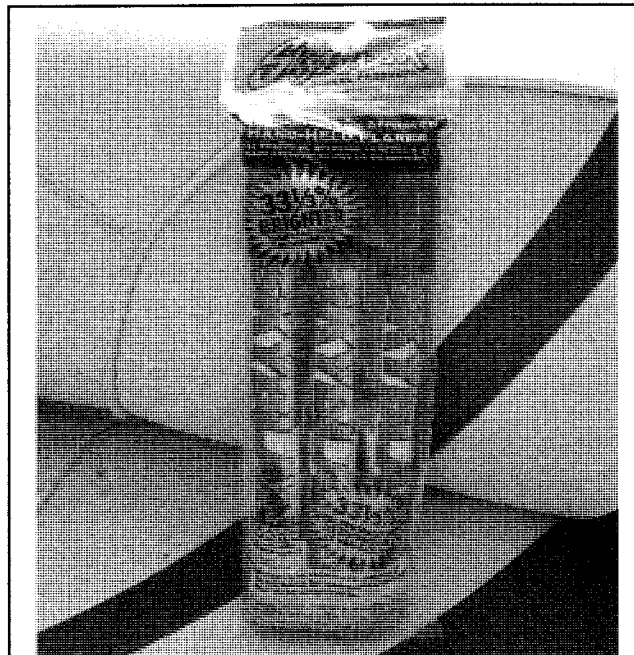


Fig. 11 Moisture-protected flares should be carried onboard any vessel for use as a distress signal

These examinations are free and done only at the consent of boat owners. To pass the examination, a vessel must satisfy federal equipment requirements and certain additional requirements of the coast guard auxiliary. If your vessel does not pass the Courtesy Marine Examination, no report of the failure is made. Instead, you will be told what you need to correct the deficiencies. The examiner will return at your convenience to redo the examination.

If your vessel qualifies, you will be awarded a safety decal. The decal does not carry any special privileges, it simply attests to your interest in safe boating.

### Anchors

◆ See Figure 13

All boats should have anchors. Choose one of suitable size for your boat. Better still, have two anchors of different sizes. Use the smaller one in calm water or when anchoring for a short time to fish or eat. Use the larger one when the water is rougher or for overnight anchoring.

Carry enough anchor line, of suitable size, for your boat and the waters in which you will operate. If your engine fails you, the first thing you usually should do is lower your anchor. This is good advice in shallow water where you may be driven aground by the wind or water. It is also good advice in windy weather or rough water, as the anchor, when properly affixed, will usually hold your bow into the waves.

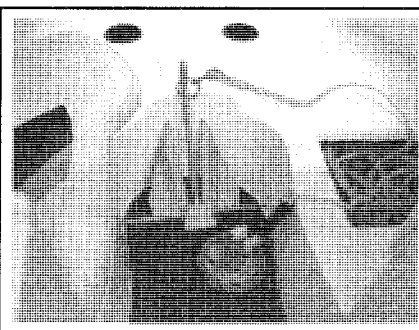
### VHF-FM Radio

Your best means of summoning help in an emergency or in case of a breakdown is a VHF-FM radio. This can be used to get advice or assistance from the Coast Guard. In the event of a serious illness or injury aboard your boat, the Coast Guard can have emergency medical equipment meet you ashore.

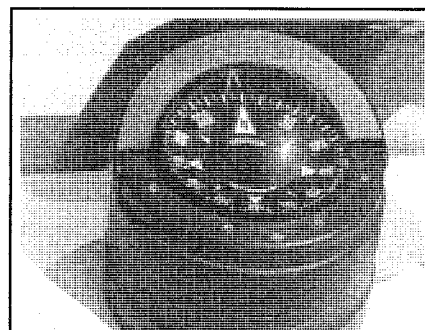
■ Although the VHF radio is the best way to get help, in this day and age, cell phones are a good backup source, especially for boaters on inland waters. You probably already know where you get a signal when boating, keep the phone charged, handy and off (so it doesn't bother you when boating right?). Keep phone numbers for a local dockmaster, coast guard, tow service or maritime police unit handy on board or stored in your phone directory.



**Fig. 12** Always carry an adequately stocked first aid kit on board for the safety of the crew and guests



**Fig. 13** Choose an anchor of sufficient weight to secure the boat without dragging



**Fig. 14** Don't hesitate to spend a few extra dollars for a reliable compass

## Compass

### SELECTION

◆ See Figure 14

The safety of the boat and her crew may depend on her compass. In many areas, weather conditions can change so rapidly that, within minutes, a skipper may find himself socked in by a fog bank, rain squall or just poor visibility. Under these conditions, he may have no other means of keeping to his desired course except with the compass. When crossing an open body of water, his compass may be the only means of making an accurate landfall.

During thick weather when you can neither see nor hear the expected aids to navigation, attempting to run out the time on a given course can disrupt the pleasure of the cruise. The skipper gains little comfort in a chain of soundings that does not match those given on the chart for the expected area. Any stranding, even for a short time, can be an unnerving experience.

A pilot will not knowingly accept a cheap parachute. By the same token, a good boater should not accept a bargain in lifejackets, fire extinguishers, or compass. Take the time and spend the few extra dollars to purchase a compass to fit your expected needs. Regardless of what the salesman may tell you, postpone buying until you have had the chance to check more than one make and model.

Lift each compass, tilt and turn it, simulating expected motions of the boat. The compass card should have a smooth and stable reaction.

The card of a good quality compass will come to rest without oscillations about the lubber's line. Reasonable movement in your hand, comparable to the rolling and pitching of the boat, should not materially affect the reading.

### INSTALLATION

◆ See Figure 15

Proper installation of the compass does not happen by accident. Make a critical check of the proposed location to be sure compass placement will permit the helmsman to use it with comfort and accuracy. First, the compass should be placed directly in front of the helmsman, and in such a position that it can be viewed without body stress as he sits or stands in a posture of relaxed alertness. The compass should be in the helmsman's zone of comfort. If the compass is too far away, he may have to bend forward to watch it; too close and he must rear backward for relief.

Second, give some thought to comfort in heavy weather and poor visibility conditions during the day and night. In some cases, the compass position may be partially determined by the location of the wheel, shift lever and throttle handle.

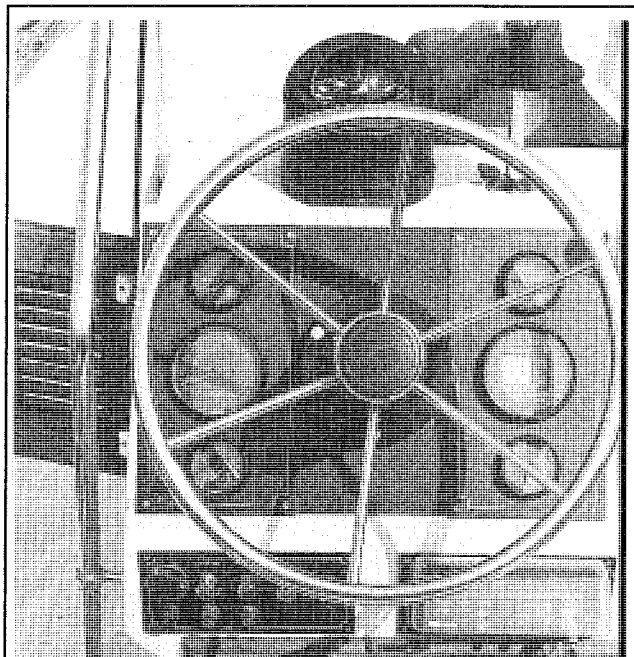
Third, inspect the compass site to be sure the instrument will be at least two feet from any engine indicators, bilge vapor detectors, magnetic instruments, or any steel or iron objects. If the compass cannot be placed at least two feet (six feet would be better but on a small craft, let's get real two feet is usually pushing it) from one of these influences, then either the compass or the other object must be moved, if first order accuracy is to be expected.

Once the compass location appears to be satisfactory, give the compass a test before installation. Hidden influences may be concealed under the cabin top, forward of the cabin aft bulkhead, within the cockpit ceiling, or in a wood-covered stanchion.

Move the compass around in the area of the proposed location. Keep an eye on the card. A magnetic influence is the only thing that will make the card turn. You can quickly find any such influence with the compass. If the influence cannot be moved away or replaced by one of non-magnetic material, test to determine whether it is merely magnetic, a small piece of iron or steel, or some magnetized steel. Bring the north pole of the compass near the object, then shift and bring the south pole near it. Both the north and south poles will be attracted if the compass is demagnetized. If the object attracts one pole and repels the other, then the compass is magnetized. If your compass needs to be demagnetized, take it to a shop equipped to do the job PROPERLY.

After you have moved the compass around in the proposed mounting area, hold it down or tape it in position. Test everything you feel might affect the compass and cause a deviation from a true reading. Rotate the wheel from hard over-to-hard over. Switch on and off all the lights, radios, radio direction finder, radio telephone, depth finder and, if installed, the shipboard intercom. Sound the electric whistle, turn on the windshield wipers, start the engine (with water circulating through the engine), work the throttle, and move the gear shift lever. If the boat has an auxiliary generator, start it.

If the card moves during any one of these tests, the compass should be relocated. Naturally, if something like the windshield wipers causes a slight deviation, it may be necessary for you to make a different deviation table to use only when certain pieces of equipment are operating. Bear in mind, following a course that is off only a degree or two for several hours can



**Fig. 15** The compass is a delicate instrument which should be mounted securely in a position where it can be easily observed by the helmsman

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make considerable difference at the end, putting you on a reef, rock or shoal. Check to be sure the intended compass site is solid. Vibration will increase pivot wear.

Now, you are ready to mount the compass. To prevent an error on all courses, the line through the lubber line and the compass card pivot must be exactly parallel to the keel of the boat. You can establish the fore-and-aft line of the boat with a stout cord or string. Use care to transfer this line to the compass site. If necessary, shim the base of the compass until the stile-type lubber line (the one affixed to the case and not gimbaled) is vertical when the boat is on an even keel. Drill the holes and mount the compass.

## COMPASS PRECAUTIONS

◆ See Figures 16, 17 and 18

Many times an owner will install an expensive stereo system in the cabin of his boat. It is not uncommon for the speakers to be mounted on the aft bulkhead up against the overhead (ceiling). In almost every case, this position places one of the speakers in very close proximity to the compass, mounted above the ceiling.

You probably already know that a magnet is used in the operation of the speaker. Therefore, it is very likely that the speaker, mounted almost under the compass in the cabin will have a very pronounced effect on the compass accuracy.

Consider the following test and the accompanying photographs as proof:

First, the compass was read as 190 degrees while the boat was secure in her slip.

Next, a full can of soda in an aluminum can was placed on one side and the compass read as 204 degrees, a good 14 degrees off.

Next, the full can was moved to the opposite side of the compass and again a reading was observed, this time as 189 degrees, 11 degrees off from the original reading.

Finally, the contents of the can were consumed, the can placed on both sides of the compass with NO effect on the compass reading.

Two very important conclusions can be drawn from these tests.

- Something must have been in the contents of the can to affect the compass so drastically.
- Keep even innocent things clear of the compass to avoid any possible error in the boat's heading.

■ Remember, a boat moving through the water at 10 knots on a compass error of just 5 degrees will be almost 1.5 miles off course in only ONE hour. At night, or in thick weather, this could very possibly put the boat on a reef, rock or shoal with disastrous results.

## Tools and Spare Parts

◆ See Figures 19 and 20

Carry a few tools and some spare parts, and learn how to make minor repairs. Many search and rescue cases are caused by minor breakdowns that boat operators could have repaired. Carry spare parts such as propellers, fuses or basic ignition components (like spark plugs, wires or even ignition coils) and the tools necessary to install them.

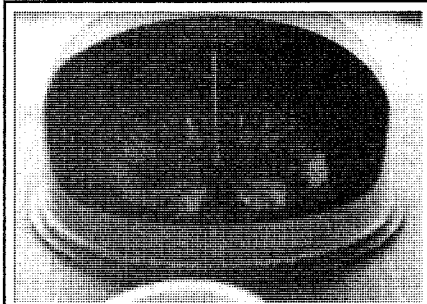


Fig. 16 This compass is giving an accurate reading, right?

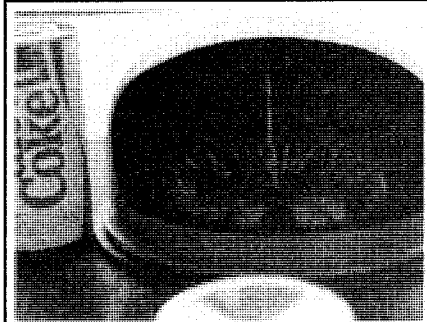


Fig. 17 ... well think again, as seemingly innocent objects may cause serious problems ...

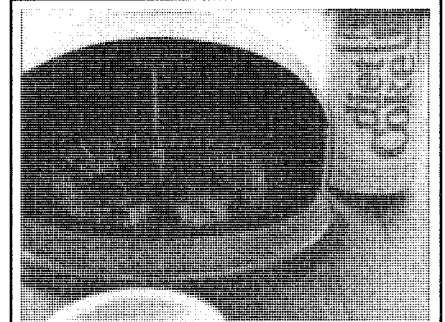


Fig. 18 ... a compass reading off by just a few degrees could lead to disaster

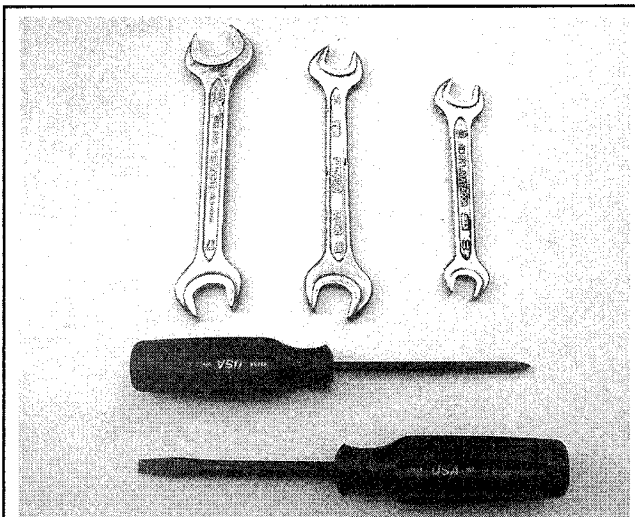


Fig. 19 A few wrenches, a screwdriver and maybe a pair of pliers can be very helpful to make emergency repairs

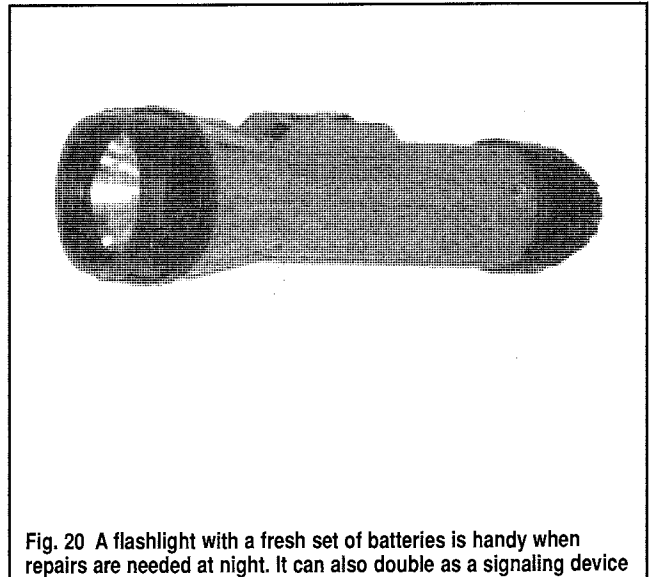


Fig. 20 A flashlight with a fresh set of batteries is handy when repairs are needed at night. It can also double as a signaling device

## SAFETY IN SERVICE

It is virtually impossible to anticipate all of the hazards involved with maintenance and service, but care and common sense will prevent most accidents.

The rules of safety for mechanics range from "don't smoke around gasoline," to "use the proper tool(s) for the job." The trick to avoiding injuries is to develop safe work habits and to take every possible precaution. Whenever you are working on your boat, pay attention to what you are doing. The more you pay attention to details and what is going on around you, the less likely you will be to hurt yourself or damage your boat.

### Do's

- Do keep a fire extinguisher and first aid kit handy.
- Do wear safety glasses or goggles when cutting, drilling, grinding or prying, even if you have 20-20 vision. If you wear glasses for the sake of vision, wear safety goggles over your regular glasses.
  - Do shield your eyes whenever you work around the battery. Batteries contain sulfuric acid. In case of contact with the eyes or skin, flush the area with water or a mixture of water and baking soda; then seek immediate medical attention.
- Do use adequate ventilation when working with any chemicals or hazardous materials.
  - Do disconnect the negative battery cable when working on the electrical system. The secondary ignition system contains EXTREMELY HIGH VOLTAGE. In some cases it can even exceed 50,000 volts. Furthermore, an accidental attempt to start the engine could cause the propeller or other components to rotate suddenly causing a potentially dangerous situation.
- Do follow manufacturer's directions whenever working with potentially hazardous materials. Most chemicals and fluids are poisonous if taken internally.
  - Do properly maintain your tools. Loose hammerheads, mushroomed punches and chisels, frayed or poorly grounded electrical cords, excessively worn screwdrivers, spread wrenches (open end), cracked sockets, or slipping ratchets can cause accidents.
  - Likewise, keep your tools clean; a greasy wrench can slip off a bolt head, ruining the bolt and often harming your knuckles in the process.
  - Do use the proper size and type of tool for the job at hand. Do select a wrench or socket that fits the nut or bolt. The wrench or socket should sit straight, not cocked.

## TROUBLESHOOTING

Troubleshooting can be defined as a methodical process during which one discovers what is causing a problem with engine operation. Although it is often a feared process to the uninitiated, there is no reason to believe that you cannot figure out what is wrong with a motor, as long as you follow a few basic rules.

To begin with, troubleshooting must be systematic. Haphazardly testing one component, then another, **might** uncover the problem, but it will more likely waste a lot of time. True troubleshooting starts by defining the problem and performing systematic tests to eliminate the largest and most likely causes first.

Start all troubleshooting by eliminating the most basic possible causes. Begin with a visual inspection of the boat and motor. If the engine won't crank, make sure that the kill switch or safety lanyard is in the proper position. Make sure there is fuel in the tank and the fuel system is primed before condemning the carburetor or fuel injection system. On electric start motors, make sure there are no blown fuses, the battery is fully charged, and the cable connections (at both ends) are clean and tight before suspecting a bad starter, solenoid or switch.

The majority of problems that occur suddenly can be fixed by simply identifying the one small item that brought them on. A loose wire, a clogged passage or a broken component can cause a lot of trouble and are often the cause of a sudden performance problem.

The next most basic step in troubleshooting is to test systems before components. For example, if the engine doesn't crank on an electric start motor, determine if the battery is in good condition (fully charged and properly connected) before testing the starting system. If the engine cranks, but doesn't start, you know already know the starting system and battery (if it cranks fast enough) are in good condition, now it is time to look at the

- Do, when possible, pull on a wrench handle rather than push on it, and adjust your stance to prevent a fall.
  - Do be sure that adjustable wrenches are tightly closed on the nut or bolt and pulled so that the force is on the side of the fixed jaw. Better yet, avoid the use of an adjustable if you have a fixed wrench that will fit.
  - Do strike squarely with a hammer; avoid glancing blows.
  - Do use common sense whenever you work on your boat or motor. If a situation arises that doesn't seem right, sit back and have a second look. It may save an embarrassing moment or potential damage to your beloved boat.

### Don'ts

- Don't run the engine in an enclosed area or anywhere else without proper ventilation—EVER! Carbon monoxide is poisonous; it takes a long time to leave the human body and you can build up a deadly supply of it in your system by simply breathing in a little every day. You may not realize you are slowly poisoning yourself.
  - Don't work around moving parts while wearing loose clothing. Short sleeves are much safer than long, loose sleeves. Hard-toed shoes with neoprene soles protect your toes and give a better grip on slippery surfaces. Jewelry, watches, large belt buckles, or body adornment of any kind is not safe working around any craft or vehicle. Long hair should be tied back under a hat.
  - Don't use pockets for toolboxes. A fall or bump can drive a screwdriver deep into your body. Even a rag hanging from your back pocket can wrap around a spinning shaft.
  - Don't smoke when working around gasoline, cleaning solvent or other flammable material.
  - Don't smoke when working around the battery. When the battery is being charged, it gives off explosive hydrogen gas. Actually, you shouldn't smoke anyway, it's bad for you. Instead, save the cigarette money and put it into your boat!
    - Don't use gasoline to wash your hands; there are excellent soaps available. Gasoline contains dangerous additives that can enter the body through a cut or through your pores. Gasoline also removes all the natural oils from the skin so that bone dry hands will suck up oil and grease.
    - Don't use screwdrivers for anything other than driving screws! A screwdriver used as a prying tool can snap when you least expect it, causing injuries. At the very least, you'll ruin a good screwdriver.

ignition or fuel systems. Once you've isolated the problem to a particular system, follow the troubleshooting/testing procedures in the section for that system to test either subsystems (if applicable, for example: the starter circuit) or components (starter solenoid).

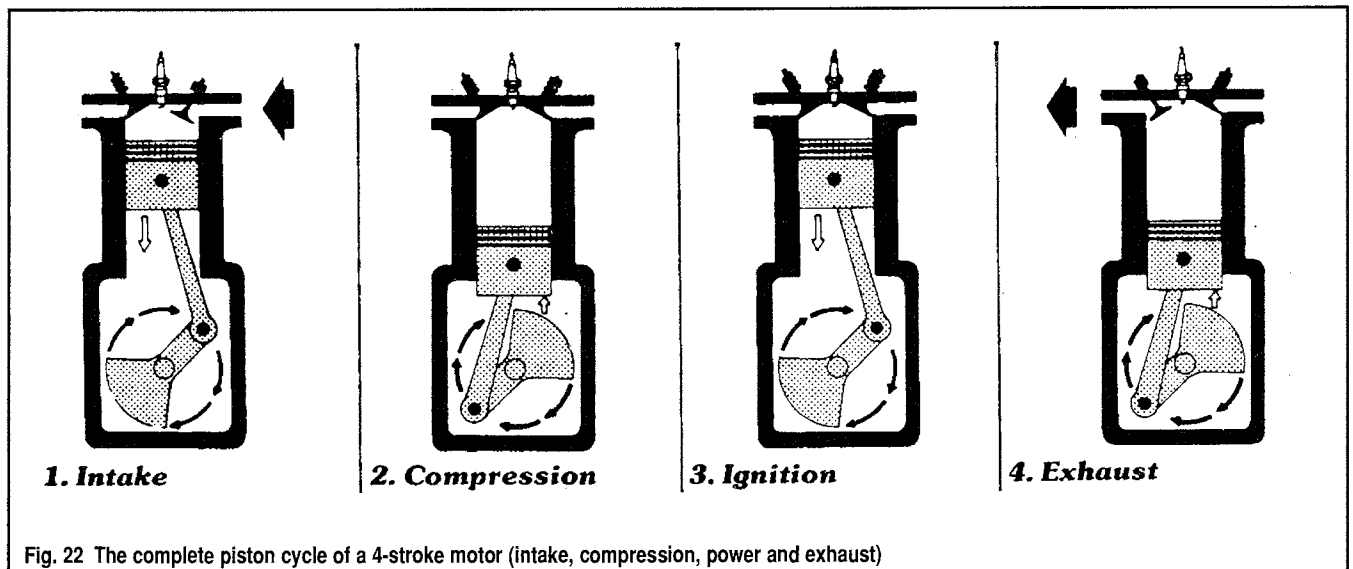
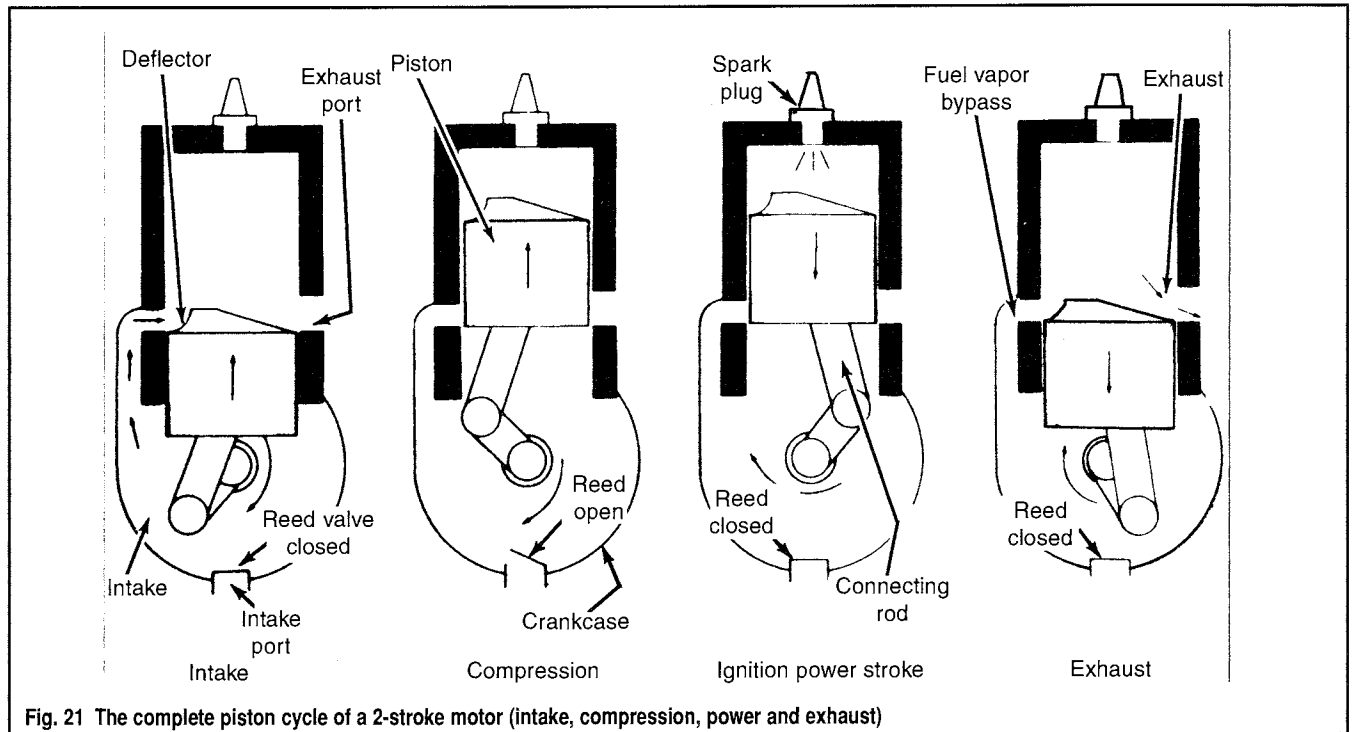
## Basic Operating Principles

### ◆ See Figures 21 and 22

Before attempting to troubleshoot a problem with your motor, it is important that you understand how it operates. Once normal engine or system operation is understood, it will be easier to determine what might be causing the trouble or irregular operation in the first place. System descriptions are found throughout this manual, but the basic mechanical operating principles for both 2-stroke engines (like most of the outboards covered here) and 4-stroke engines (like some outboards and like your car) are given here. A basic understanding of both types of engines is useful not only in understanding and troubleshooting your outboard, but also for dealing with other motors in your life.

All motors covered by this manual (and probably MOST of the motors you own) operate according to the Otto cycle principle of engine operation. This means that all motors follow the stages of intake, compression, power and exhaust. But, the difference between a 2- and 4-stroke motor is in how many times the piston moves up and down within the cylinder to accomplish this. On 2-stroke motors (as the name suggests) the four cycles take place in 2 movements (one up and one down) of the piston. Again, as the name suggests, the cycles take place in 4 movements of the piston for 4-stroke motors.

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## 2-STROKE MOTORS

The 2-stroke engine differs in several ways from a conventional four-stroke (automobile or marine) engine.

1. The intake/exhaust method by which the fuel-air mixture is delivered to the combustion chamber.
2. The complete lubrication system.
3. The frequency of the power stroke.

Let's discuss these differences briefly (and compare 2-stroke engine operation with 4-stroke engine operation.)

### Intake/Exhaust

◆ See Figures 23, 24, 25 and 25a

Two-stroke engines utilize an arrangement of port openings to admit fuel to the combustion chamber and to purge the exhaust gases after burning has been completed. The ports are located in a precise pattern in order for them to be open and closed off at an exact moment by the piston as it

moves up and down in the cylinder. The exhaust port is located slightly higher than the fuel intake port. This arrangement opens the exhaust port first as the piston starts downward and therefore, the exhaust phase begins a fraction of a second before the intake phase.

Actually, the intake and exhaust ports are spaced so closely together that both open almost simultaneously. For this reason, some 2-stroke engines utilize deflector-type pistons. This design of the piston top serves two purposes very effectively.

First, it creates turbulence when the incoming charge of fuel enters the combustion chamber. This turbulence results in a more complete burning of the fuel than if the piston top were flat. The second effect of the deflector-type piston crown is to force the exhaust gases from the cylinder more rapidly. Although this configuration is used in many older outboards, it is generally found only on some of the smaller Yamaha motors. The majority of Yamaha motors are of the Loop (L) charged.

Loop charged motors, or as they are commonly called "loopers", differ in how the air/fuel charge is introduced to the combustion chamber. Instead of the charge flowing across the top of the piston from one side of the cylinder



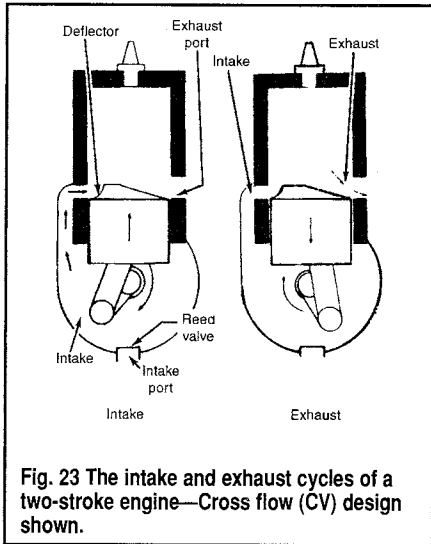


Fig. 23 The intake and exhaust cycles of a two-stroke engine—Cross flow (CV) design shown.

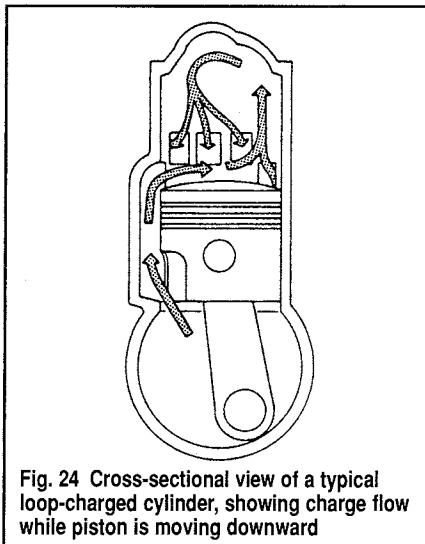


Fig. 24 Cross-sectional view of a typical loop-charged cylinder, showing charge flow while piston is moving downward

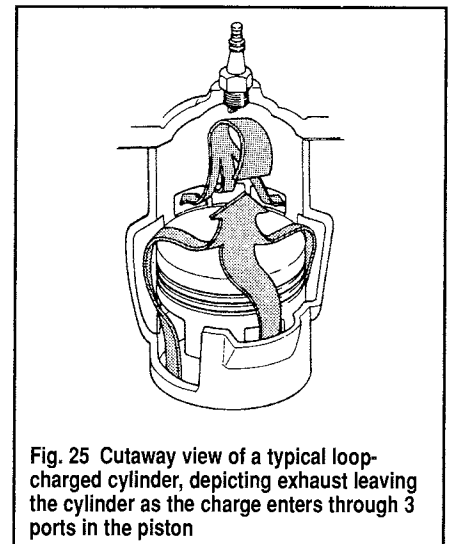


Fig. 25 Cutaway view of a typical loop-charged cylinder, depicting exhaust leaving the cylinder as the charge enters through 3 ports in the piston

to the other (CV) the use a looping action on top of the piston as the charge is forced through irregular shaped openings cut in the piston's skirt. In a LV motor, the charge is forced out from the crankcase by the downward motion of the piston, through the irregular shaped openings and transferred upward by long, deep grooves in the cylinder wall. The charge completes its looping action by entering the combustion chamber, just above the piston, where the upward motion of the piston traps it in the chamber and compresses it for optimum ignition power.

Unlike the knife-edged deflector top pistons used in CV motors, the piston domes on Loop motors are relatively flat.

These systems of intake and exhaust are in marked contrast to individual intake and exhaust valve arrangement employed on four-stroke engines (and the mechanical methods of opening and closing these valves).

■ It should be noted here that there are some 2-stroke engines that utilize a mechanical valve train, though it is very different from the valve train employed by most 4-stroke motors. Rotary 2-stroke engines use a circular valve or rotating disc that contains a port opening around part of one edge of the disc. As the engine (and disc) turns, the opening aligns with the intake port and for a predetermined amount of time, closing off the port again as the opening passes by and the solid portion of the disc covers the port.

#### Lubrication

A 2-stroke engine is lubricated by mixing oil with the fuel. Therefore, various parts are lubricated as the fuel mixture passes through the crankcase and the cylinder. In contrast, four-stroke engines have a crankcase containing oil. This oil is pumped through a circulating system and returned to the crankcase to begin the routing again.

#### Power Stroke

The combustion cycle of a 2-stroke engine has four distinct phases.

1. Intake
2. Compression
3. Power
4. Exhaust

The four phases of the cycle are accomplished with each up and down stroke of the piston, and the power stroke occurs with each complete revolution of the crankshaft. Compare this system with a four-stroke engine. A separate stroke of the piston is required to accomplish each phase of the cycle and the power stroke occurs only every other revolution of the crankshaft. Stated another way, two revolutions of the four-stroke engine crankshaft are required to complete one full cycle, the four phases.

#### Physical Laws

◆ See Figure 26

The 2-stroke engine is able to function because of two very simple physical laws.

One: Gases will flow from an area of high pressure to an area of lower pressure. A tire blowout is an example of this principle. The high-pressure air escapes rapidly if the tube is punctured.

Two: If a gas is compressed into a smaller area, the pressure increases, and if a gas expands into a larger area, the pressure is decreased.

If these two laws are kept in mind, the operation of the 2-stroke engine will be easier understood.

#### Actual Operation

◆ See Figure 21

■ The engine described here is of a carbureted type. EFI and HPDI motors operate similarly for intake of the air charge and for exhaust of the unburned gasses. Obviously though, the very nature of fuel injection changes the actual delivery of the fuel/oil charge.

Beginning with the piston approaching top dead center on the compression stroke: the intake and exhaust ports are physically closed (blocked) by the piston. During this stroke, the reed valve is open (because as the piston moves upward, the crankcase volume increases, which reduces the crankcase pressure to less than the outside atmosphere (creates a vacuum under the piston). The spark plug fires; the compressed fuel-air mixture is ignited; and the power stroke begins.

As the piston moves downward on the power stroke, the combustion chamber is filled with burning gases. As the exhaust port is uncovered, the gases, which are under great pressure, escape rapidly through the exhaust ports. The piston continues its downward movement. Pressure within the

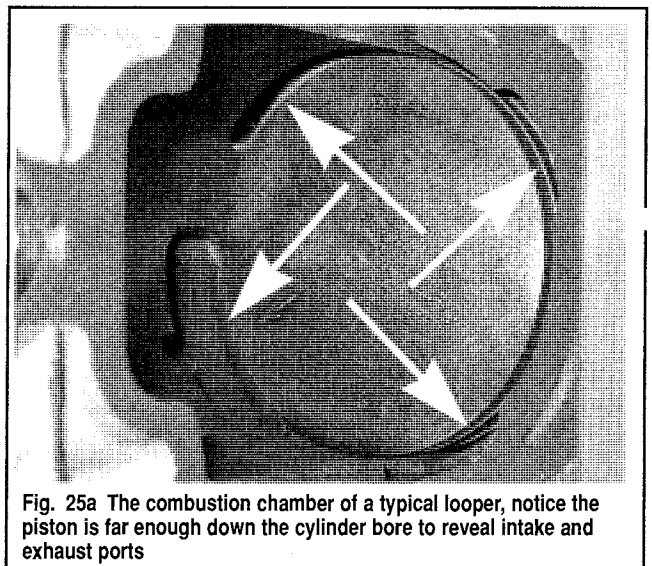
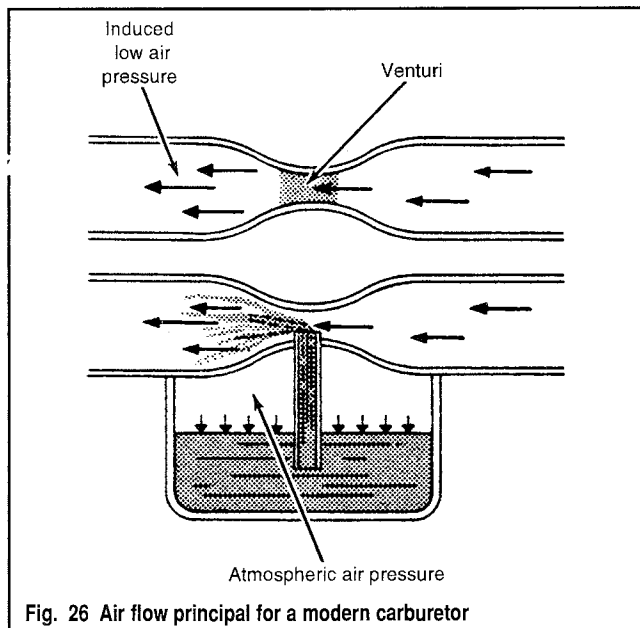


Fig. 25a The combustion chamber of a typical looper, notice the piston is far enough down the cylinder bore to reveal intake and exhaust ports

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crankcase (again, under the piston) increases, closing the reed valves against their seats. The crankcase then becomes a sealed chamber so the air-fuel mixture becomes compressed (pressurized) and ready for delivery to the combustion chamber. As the piston continues to move downward, the intake port is uncovered. The fresh fuel mixture rushes through the intake port into the combustion chamber striking the top of the piston where it is deflected along the cylinder wall. The reed valve remains closed until the piston moves upward again.

When the piston begins to move upward on the compression stroke, the reed valve opens because the crankcase volume has been increased, reducing crankcase pressure to less than the outside atmosphere. The intake and exhaust ports are closed and the fresh fuel charge is compressed inside the combustion chamber.

Pressure in the crankcase (beneath the piston) decreases as the piston moves upward and a fresh charge of air flows through the carburetor picking up fuel. As the piston approaches top dead center, the spark plug ignites the air-fuel mixture, the power stroke begins and one complete Otto cycle has been completed.

## 4-STROKE MOTORS

### ◆ See Figure 22

The 4-stroke motor may be easier to understand for some people either because of its prevalence in automobile and street motorcycle motors today or perhaps because each of the four strokes corresponds to one distinct phase of the Otto cycle. Essentially, a 4-stroke engine completes one Otto cycle of intake, compression, ignition/power and exhaust using two full revolutions of the crankshaft and four distinct movements of the piston (down, up, down and up).

### Intake

The intake stroke begins with the piston near the top of its travel. As crankshaft rotation begins to pull the piston downward, the exhaust valve closes and the intake opens. As volume of the combustion chamber increases, a vacuum is created that draws in the air/fuel mixture from the intake manifold.

### Compression

Once the piston reaches the bottom of its travel, crankshaft rotation will begin to force it upward. At this point the intake valve closes. As the piston rises in the bore, the volume of the sealed combustion chamber (both intake and exhaust valves are closed) decreases and the air/fuel mixture is compressed. This raises the temperature and pressure of the mixture and increases the amount of force generated by the expanding gases during the Ignition/Power stroke.

### Ignition/Power

As the piston approaches top dead center (the highest point of travel in the bore), the spark plug will fire, igniting the air/fuel mixture. The resulting combustion of the air/fuel mixture forces the piston downward, rotating the crankshaft (causing other pistons to move in other phases/strokes of the Otto cycle on multi-cylinder motors).

### Exhaust

As the piston approaches the bottom of the Ignition/Power stroke, the exhaust valve opens. When the piston begins its upward path of travel once again, any remaining unburned gasses are forced out through the exhaust valve. This completes one Otto cycle, which begins again as the piston passes top dead center, the intake valve opens and the Intake stroke starts.

## COMBUSTION

Whether we are talking about a 2- or 4-stroke engine, all Otto cycle, internal combustion engines require three basic conditions to operate properly,

1. Compression
2. Ignition (Spark)
3. Fuel

A lack of any one of these conditions will prevent the engine from operating. A problem with any one of these will manifest itself in hard-starting or poor performance.

### Compression

An engine that has insufficient compression will not draw an adequate supply of air/fuel mixture into the combustion chamber and, subsequently, will not make sufficient power on the power stroke. A lack of compression in just one cylinder of a multi-cylinder motor will cause the motor to stumble or run irregularly.

But, keep in mind that a sudden change in compression is unlikely in 2-stroke motors (unless something major breaks inside the crankcase, but that would usually be accompanied by other symptoms such as a loud noise when it occurred or noises during operation). On 4-stroke motors, a sudden change in compression is also unlikely, but could occur if the timing belt or chain was to suddenly break. Remember that the timing belt/chain is used to synchronize the valve train with the crankshaft. If the valve train suddenly ceases to turn, some intake and some exhaust valves will remain open, relieving compression in that cylinder.

### Ignition (Spark)

Traditionally, the ignition system is the weakest link in the chain of conditions necessary for engine operation. Spark plugs may become worn or fouled, wires will deteriorate allowing arcing or misfiring, and poor connections can place an undue load on coils leading to weak spark or even a failed coil. The most common question asked by a technician under a no-start condition is: "do I have spark and fuel" (as they've already determined that they have compression).

A quick visual inspection of the spark plug(s) will answer the question as to whether or not the plug(s) is/are worn or fouled. While the engine is shut OFF a physical check of the connections could show a loose primary or secondary ignition circuit wire. An obviously physically damaged wire may also be an indication of system problems and certainly encourages one to inspect the related system more closely.

If nothing is turned up by the visual inspection, perform the Spark Test provided in the Ignition System section to determine if the problem is a lack of or a weak spark. If the problem is not compression or spark, it's time to look at the fuel system.

### Fuel

If compression and spark is present (and within spec), but the engine won't start or won't run properly, the only remaining condition to fulfill is fuel. As usual, start with the basics. Is the fuel tank full? Is the fuel stale? If the engine has not been run in some time (a matter of months, not weeks) there is a good chance that the fuel is stale and should be properly disposed of and replaced.

■ Depending on how stale or contaminated (with moisture) the fuel is, it may be burned in an automobile or in yard equipment, though it would be wise to mix it well with a much larger supply of fresh gasoline to prevent moving your driveability problems to that motor. But it is better to get the lawn tractor stuck on stale gasoline than it would be to have your boat motor quit in the middle of the bay or lake.

For hard starting motors, is the choke or primer system operating properly. Remember that the choke/prime should only be used for **cold** starts. A true cold start is really only the first start of the day, but it may be applicable to subsequent starts on cooler days, if the engine sat for more than a few hours and completely cooled off since the last use. Applying the primer to the motor for a hot start may flood the engine, preventing it from starting properly. One method to clear a flood is to crank the motor while the engine is at wide-open throttle (allowing the maximum amount of air into the motor to compensate for the excess fuel). But, keep in mind that the throttle should be returned to idle immediately upon engine start-up to prevent damage from over-revving.

## SHOP EQUIPMENT

### Safety Tools

#### WORK GLOVES

◆ See Figure 27

Unless you think scars on your hands are cool, enjoy pain and like wearing bandages, get a good pair of work gloves. Canvas or leather gloves are the best. And yes, we realize that there are some jobs involving small parts that can't be done while wearing work gloves. These jobs are not the ones usually associated with hand injuries.

A good pair of rubber gloves (such as those usually associated with dish washing) or vinyl gloves is also a great idea. There are some liquids such as solvents and penetrants that don't belong on your skin. Avoid burns and rashes. Wear these gloves.

And lastly, an option. If you're tired of being greasy and dirty all the time, go to the drug store and buy a box of disposable latex gloves like medical professionals wear. You can handle greasy parts, perform small tasks, wash parts, etc. all without getting dirty! These gloves take a surprising amount of abuse without tearing and aren't expensive. Note however, that some people are allergic to the latex or the powder used inside some gloves, so pay attention to what you buy.

#### EYE AND EAR PROTECTION

◆ See Figures 28 and 29

Don't begin any job without a good pair of work goggles or impact resistant glasses! When doing any kind of work, it's all too easy to avoid eye injury through this simple precaution. And don't just buy eye protection and leave it on the shelf. Wear it all the time! Things have a habit of breaking, chipping, splashing, spraying, splintering and flying around. And, for some reason, your eye is always in the way!

If you wear vision-correcting glasses as a matter of routine, get a pair made with polycarbonate lenses. These lenses are impact resistant and are available at any optometrist.

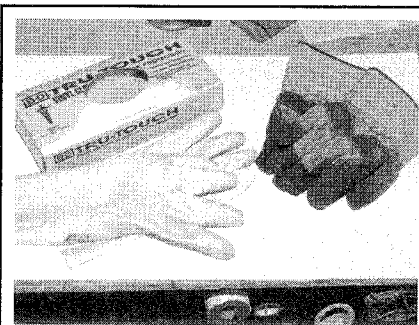


Fig. 27 Three different types of work gloves. The box contains latex gloves

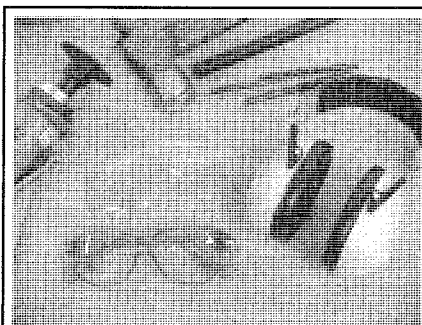


Fig. 28 Don't begin major repairs without a pair of goggles for your eyes and earmuffs to protect your hearing

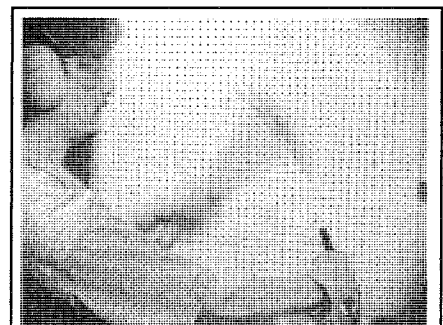


Fig. 29 Things have a habit of, splashing, spraying, splintering and flying around during repairs

Fuel delivery and pressure should be checked before delving into the carburetor(s) or fuel injection system. Make sure there are no clogs in the fuel line or vacuum leaks that would starve the motor of fuel.

Make sure that all other possible problems have been eliminated before touching the carburetor. It is rare that a carburetor will suddenly require an adjustment in order for the motor to run properly. It is much more likely that an improperly stored motor (one stored with untreated fuel in the carburetor) would suffer from one or more clogged carburetor passages sometime after shortly returning to service. Fuel will evaporate over time, leaving behind gummy deposits. If untreated fuel is left in the carburetor for some time (again typically months more than weeks), the varnish left behind by evaporating fuel will likely clog the small passages of the carburetor and cause problems with engine performance. If you suspect this, remove and disassemble the carburetor following procedures under Fuel System.

Often overlooked is hearing protection. Engines and power tools are noisy! Loud noises damage your ears. It's as simple as that! The simplest and cheapest form of ear protection is a pair of noise-reducing ear plugs. Cheap insurance for your ears! And, they may even come with their own, cute little carrying case.

More substantial, more protection and more money is a good pair of noise reducing earmuffs. They protect from all but the loudest sounds. Hopefully those are sounds that you'll never encounter since they're usually associated with disasters.

#### WORK CLOTHES

Everyone has "work clothes." Usually these consist of old jeans and a shirt that has seen better days. That's fine. In addition, a denim work apron is a nice accessory. It's rugged, can hold some spare bolts, and you don't feel bad wiping your hands or tools on it. That's what it's for.

When working in cold weather, a one-piece, thermal work outfit is invaluable. Most are rated to below freezing temperatures and are ruggedly constructed. Just look at what local marine mechanics are wearing and that should give you a clue as to what type of clothing is good.

### Chemicals

There is a whole range of chemicals that you'll find handy for maintenance and repair work. The most common types are: lubricants, penetrants and sealers. Keep these handy. There are also many chemicals that are used for detailing or cleaning.

When a particular chemical is not being used, keep it capped, upright and in a safe place. These substances may be flammable, may be irritants or might even be caustic and should always be stored properly, used properly and handled with care. Always read and follow all label directions and be sure to wear hand and eye protection!

# 1-18 GENERAL INFORMATION, SAFETY AND TOOLS

## LUBRICANTS & PENETRANTS

### ◆ See Figure 30

Anti-seize is used to coat certain fasteners prior to installation. This can be especially helpful when two dissimilar metals are in contact (to help prevent corrosion that might lock the fastener in place). This is a good practice on a lot of different fasteners, BUT, NOT on any fastener that might vibrate loose causing a problem. If anti-seize is used on a fastener, it should be checked periodically for proper tightness.

Lithium grease, chassis lube, silicone grease or a synthetic brake caliper grease can all be used pretty much interchangeably. All can be used for coating rust-prone fasteners and for facilitating the assembly of parts that are a tight fit. Silicone and synthetic greases are the most versatile.

■ **Silicone dielectric grease is a non-conductor that is often used to coat the terminals of wiring connectors before fastening them. It may sound odd to coat metal portions of a terminal with something that won't conduct electricity, but here is how it works. When the connector is fastened the metal-to-metal contact between the terminals will displace the grease (allowing the circuit to be completed). The grease that is displaced will then coat the non-contacted surface and the cavity around the terminals, SEALING them from atmospheric moisture that could cause corrosion.**

Silicone spray is a good lubricant for hard-to-reach places and parts that shouldn't be gooped up with grease.

Penetrating oil may turn out to be one of your best friends when taking something apart that has corroded fasteners. Not only can they make a job easier, they can really help to avoid broken and stripped fasteners. The most familiar penetrating oils are Liquid Wrench® and WD-40®. A newer penetrant, PB Blaster® works very well (and has become a mainstay in our shops). These products have hundreds of uses. For your purposes, they are vital!

Before disassembling any part, check the fasteners. If any appear rusted, soak them thoroughly with the penetrant and let them stand while you do something else (for particularly rusted or frozen parts you may need to soak them a few days in advance). This simple act can save you hours of tedious work trying to extract a broken bolt or stud.

## SEALANTS

### ◆ See Figures 31 and 32

Sealants are an indispensable part for certain tasks, especially if you are trying to avoid leaks. The purpose of sealants is to establish a leak-proof bond between or around assembled parts. Most sealers are used in conjunction with gaskets, but some are used instead of conventional gasket material.

The most common sealers are the non-hardening types such as Permatex® No.2 or its equivalents. These sealers are applied to the mating surfaces of each part to be joined, then a gasket is put in place and the parts are assembled.

■ **A sometimes overlooked use for sealants like RTV is on the threads of vibration prone fasteners.**

One very helpful type of non-hardening sealer is the "high tack" type. This type is a very sticky material that holds the gasket in place while the parts are being assembled. This stuff is really a good idea when you don't have enough hands or fingers to keep everything where it should be.

The stand-alone sealers are the Room Temperature Vulcanizing (RTV) silicone gasket makers. On some engines, this material is used instead of a gasket. In those instances, a gasket may not be available or, because of the shape of the mating surfaces, a gasket shouldn't be used. This stuff, when used in conjunction with a conventional gasket, produces the surest bonds.

RTV does have its limitations though. When using this material, you will have a time limit. It starts to set-up within 15 minutes or so, so you have to assemble the parts without delay. In addition, when squeezing the material out of the tube, don't drop any glops into the engine. The stuff will form and set and travel around a cooling passage, possibly blocking it. Also, most types are not fuel-proof. Check the tube for all cautions.

## CLEANERS

### ◆ See Figures 33 and 34

There are two basic types of cleaners on the market today: parts cleaners and hand cleaners. The parts cleaners are for the parts; the hand cleaners are for you. They are **NOT** interchangeable.

There are many good, non-flammable, biodegradable parts cleaners on the market. These cleaning agents are safe for you, the parts and the environment. Therefore, there is no reason to use flammable, caustic or toxic substances to clean your parts or tools.

As far as hand cleaners go; the waterless types are the best. They have always been efficient at cleaning, but they used to all leave a pretty smelly odor. Recently though, most of them have eliminated the odor and added stuff that actually smells good. Make sure that you pick one that contains lanolin or some other moisture-replenishing additive. Cleaners not only remove grease and oil but also skin oil.

■ **Most women already know to use a hand lotion when you're all cleaned up. It's okay. Real men DO use hand lotion too! Believe it or not, using hand lotion before your hands are dirty will actually make them easier to clean when you're finished with a dirty job. Lotion seals your hands, and keeps dirt and grease from sticking to your skin.**



Fig. 30 Keep a supply of anti-seize, penetrating oil, lithium grease, electronic cleaner and silicone spray



Fig. 31 Sealants are essential for preventing leaks

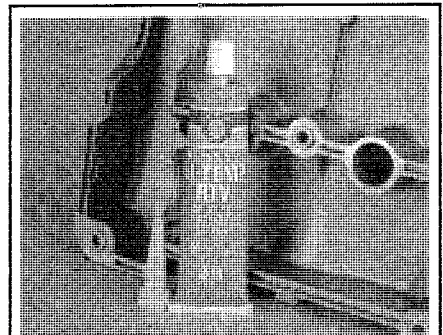


Fig. 32 On some engines, RTV is used instead of gasket material to seal components



Fig. 33 Citrus hand cleaners not only work well, but they smell pretty good too. Choose one with pumice for added cleaning power



Fig. 34 The use of hand lotion seals your hands and keeps dirt and grease from sticking to your skin

**TOOLS**

◆ See Figure 35

Tools; this subject could fill a completely separate manual. The first thing you will need to ask yourself, is just how involved do you plan to get. If you are serious about maintenance and repair you will want to gather a quality set of tools to make the job easier, and more enjoyable. BESIDES, TOOLS ARE FUN!!!

Almost every do-it-yourselfer loves to accumulate tools. Though most find a way to perform jobs with only a few common tools, they tend to buy more over time, as money allows. So gathering the tools necessary for maintenance or repair does not have to be an expensive, overnight proposition.

When buying tools, the saying "You get what you pay for..." is absolutely true! Don't go cheap! Any hand tool that you buy should be drop forged and/or chrome vanadium. These two qualities tell you that the tool is strong enough for the job. With any tool, go with a name that you've heard of before, or, that is recommended by your local professional retailer. Let's go over a list of tools that you'll need.

Most of the world uses the metric system. However, some American-built engines and aftermarket accessories use standard fasteners. So, accumulate your tools accordingly. Any good DIYer should have a decent set of both U.S. and metric measure tools.

■ Don't be confused by terminology. Most advertising refers to "SAE and metric", or "standard and metric." Both are misnomers. The Society of Automotive Engineers (SAE) did not invent the English system of measurement; the English did. The SAE likes metrics just fine. Both English (U.S.) and metric measurements are SAE approved. Also, the current "standard" measurement IS metric. So, if it's not metric, it's U.S. measurement.

**Hand Tools**

**SOCKET SETS**

◆ See Figures 36, 37, 38, 39, 40, 41 and 42

Socket sets are the most basic hand tools necessary for repair and maintenance work. For our purposes, socket sets come in three drive sizes: 1/4 inch, 3/8 inch and 1/2 inch. Drive size refers to the size of the drive lug on the ratchet, breaker bar or speed handle.

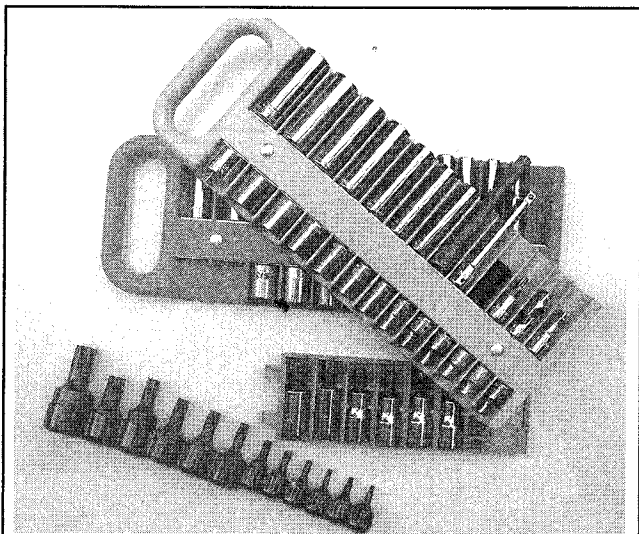


Fig. 35 Socket holders, especially the magnetic type, are handy items to keep tools in order

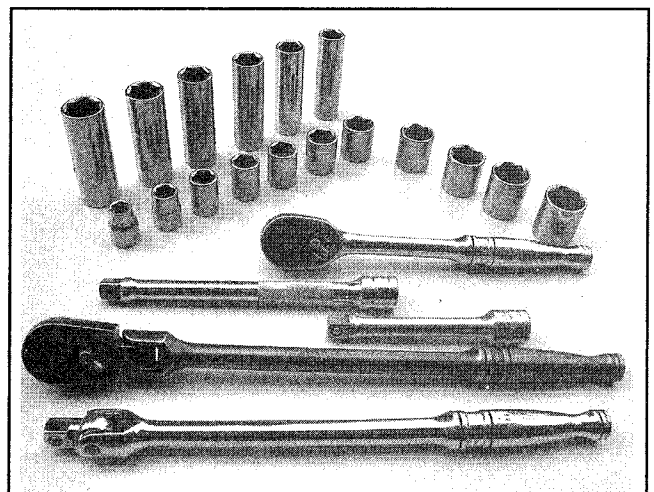


Fig. 36 A 3/8 in. socket set is probably the most versatile tool in any mechanic's tool box

# 1-20 GENERAL INFORMATION, SAFETY AND TOOLS

A 3/8 inch set is probably the most versatile set in any mechanic's toolbox. It allows you to get into tight places that the larger drive ratchets can't and gives you a range of larger sockets that are still strong enough for heavy-duty work. The socket set that you'll need should range in sizes from 1/4 inch through 1 inch for standard fasteners, and a 6mm through 19mm for metric fasteners.

You'll need a good 1/2 inch set since this size drive lug assures that you won't break a ratchet or socket on large or heavy fasteners. Also, torque wrenches with a torque scale high enough for larger fasteners are usually 1/2 inch drive.

Plus, 1/4 inch drive sets can be very handy in tight places. Though they usually duplicate functions of the 3/8 in. set, 1/4 in. drive sets are easier to use for smaller bolts and nuts.

As for the sockets themselves, they come in shallow (standard) and deep lengths as well as 6 or 12 point. The 6 and 12 points designation refers to how many sides are in the socket itself. Each has advantages. The 6 point socket is stronger and less prone to slipping which would strip a bolt head or nut. 12 point sockets are more common, usually less expensive and can operate better in tight places where the ratchet handle can't swing far.

Standard length sockets are good for just about all jobs, however, some stud-head bolts, hard-to-reach bolts, nuts on long studs, etc., require the deep sockets.

Most marine manufacturers use recessed hex-head fasteners to retain many of the engine parts. These fasteners require a socket with a hex shaped driver or a large sturdy hex key. To help prevent torn knuckles, we would recommend that you stick to the sockets on any tight fastener and leave the hex keys for lighter applications. Hex driver sockets are available individually or in sets just like conventional sockets.

More and more, manufacturers are using Torx® head fasteners, which were once known as tamper resistant fasteners (because many people did not have tools with the necessary odd driver shape). Since Torx® fasteners have become commonplace in many DIYer tool boxes, manufacturers designed newer tamper resistant fasteners that are essentially Torx® head bolts that contain a small protrusion in the center (requiring the driver to contain a small hole to slide over the protrusion). Tamper resistant fasteners are often used where the manufacturer would prefer only knowledgeable mechanics or advanced Do-It-Yourselfers (DIYers) work.

## Torque Wrenches

◆ See Figure 43

In most applications, a torque wrench can be used to ensure proper installation of a fastener. Torque wrenches come in various designs and most stores will carry a variety to suit your needs. A torque wrench should be used any time you have a specific torque value for a fastener. Keep in mind that because there is no worldwide standardization of fasteners, so charts or figure found in each repair section refer to the manufacturer's fasteners. Any general guideline charts that you might come across based on fastener size (they are sometimes included in a repair manual or with torque wrench packaging) should be used with caution. Just keep in mind that if you are using the right tool for the job, you should not have to strain to tighten a fastener.

## BEAM TYPE

◆ See Figures 44 and 45

The beam type torque wrench is one of the most popular styles in use. If used properly, it can be the most accurate also. It consists of a pointer attached to the head that runs the length of the flexible beam (shaft) to a scale located near the handle. As the wrench is pulled, the beam bends and the pointer indicates the torque using the scale.

## CLICK (BREAKAWAY) TYPE

◆ See Figures 46 and 47

Another popular torque wrench design is the click type. The clicking mechanism makes achieving the proper torque easy and most use a ratcheting head for ease of bolt installation. To use the click type wrench you pre-adjust it to a torque setting. Once the torque is reached, the wrench has a reflex signaling feature that causes a momentary breakaway of the torque wrench body, sending an impulse to the operator's hand. But be careful, as continuing the turn the wrench after the momentary release will increase torque on the fastener beyond the specified setting.

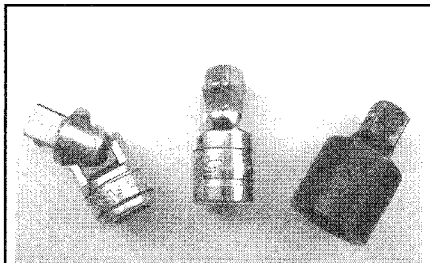


Fig. 37 A swivel (U-joint) adapter (left), a 1/4 in.-to-3/8 in. adapter (center) and a 3/8 in.-to-1/4 in. adapter (right)

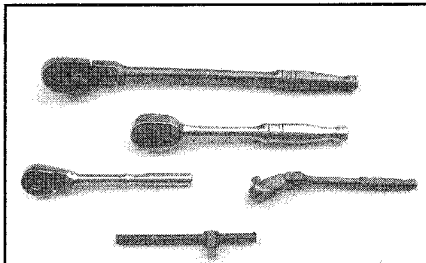


Fig. 38 Ratchets come in all sizes and configurations from rigid to swivel-headed

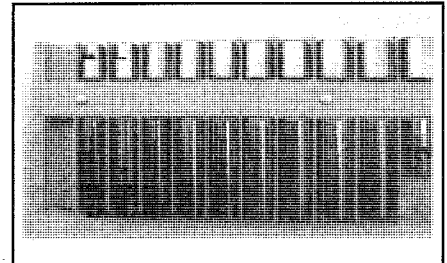


Fig. 39 Shallow sockets (top) are good for most jobs. But, some bolts require deep sockets (bottom)

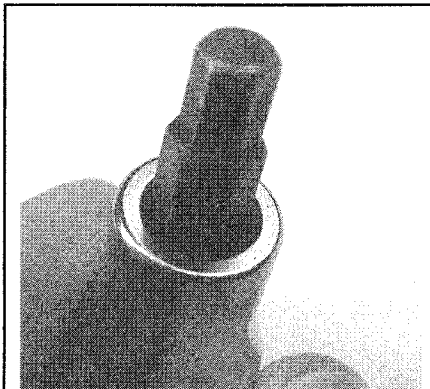


Fig. 40 Hex-head fasteners require a socket with a hex shaped driver

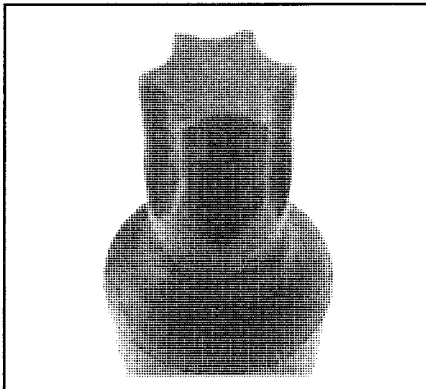


Fig. 41 Torx® drivers . . .

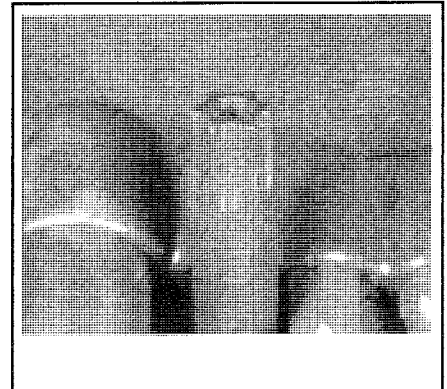


Fig. 42 . . . and tamper resistant drivers are required to remove special fasteners

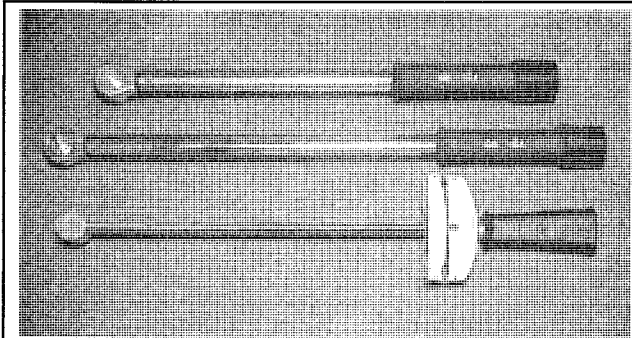


Fig. 43 Three types of torque wrenches. Top to bottom: a 3/8 in. drive beam type that reads in inch lbs., a 1/2 in. drive clicker type and a 1/2 in. drive beam type

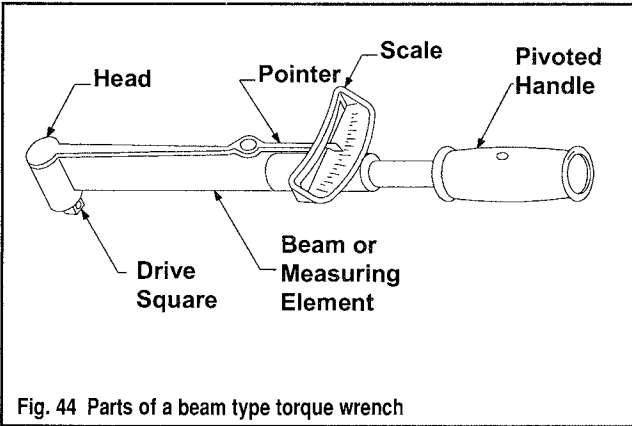


Fig. 44 Parts of a beam type torque wrench

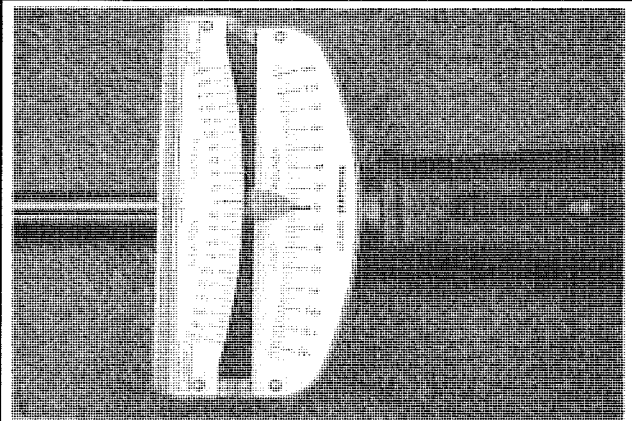


Fig. 45 A beam type torque wrench consists of a pointer attached to the head that runs the length of the flexible beam (shaft) to a scale located near the handle

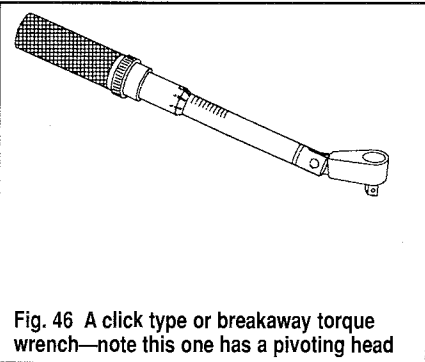


Fig. 46 A click type or breakaway torque wrench—note this one has a pivoting head

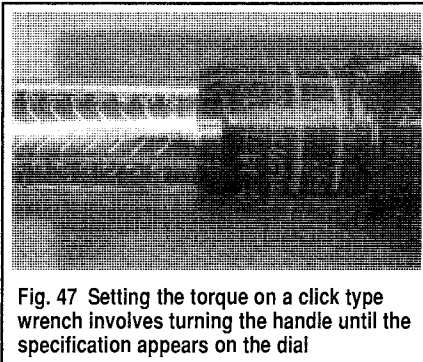


Fig. 47 Setting the torque on a click type wrench involves turning the handle until the specification appears on the dial

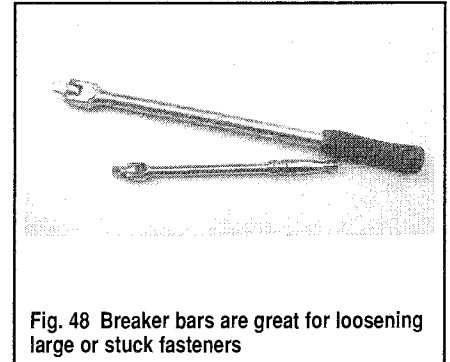


Fig. 48 Breaker bars are great for loosening large or stuck fasteners

**Breaker Bars**

◆ See Figure 48

Breaker bars are long handles with a drive lug. Their main purpose is to provide extra turning force when breaking loose tight bolts or nuts. They come in all drive sizes and lengths. Always take extra precautions and use the proper technique when using a breaker bar (pull on the bar, don't push, to prevent skinned knuckles).

**WRENCHES**

◆ See Figures 49, 50, 51, 52 and 53

Basically, there are 3 kinds of fixed wrenches: open end, box end, and combination.

Open-end wrenches have 2-jawed openings at each end of the wrench. These wrenches are able to fit onto just about any nut or bolt. They are extremely versatile but have one major drawback. They can slip on a worn or rounded bolt head or nut, causing bleeding knuckles and a useless fastener.

■ Line wrenches are a special type of open-end wrench designed to fit onto more of the fastener than standard open-end wrenches, thus reducing the chance of rounding the corners of the fastener.

Box-end wrenches have a 360° circular jaw at each end of the wrench. They come in both 6 and 12 point versions just like sockets and each type has some of the same advantages and disadvantages as sockets.

Combination wrenches have the best of both. They have a 2-jawed open end and a box end. These wrenches are probably the most versatile.

As for sizes, you'll probably need a range similar to that of the sockets, about 1/4 in. through 1 in. for standard fasteners, or 6mm through 19mm for metric fasteners. As for numbers, you'll need 2 of each size, since, in many instances, one wrench holds the nut while the other turns the bolt. On most fasteners, the nut and bolt are the same size so having two wrenches of the same size comes in handy.

■ Although you will typically just need the sizes we specified, there are some exceptions. Occasionally you will find a nut that is larger. For these, you will need to buy ONE expensive wrench or a very large adjustable. Or you can always just convince the spouse that we are talking about SAFETY here and buy a whole (read expensive) large wrench set.

One extremely valuable type of wrench is the adjustable wrench. An adjustable wrench has a fixed upper jaw and a moveable lower jaw. The lower jaw is moved by turning a threaded drum. The advantage of an adjustable wrench is its ability to be adjusted to just about any size fastener.

The main drawback of an adjustable wrench is the lower jaw's tendency to move slightly under heavy pressure. This can cause the wrench to slip if it is not facing the right way. Pulling on an adjustable wrench in the proper direction will cause the jaws to lock in place. Adjustable wrenches come in a large range of sizes, measured by the wrench length.

**PLIERS**

◆ See Figure 54

Pliers are simply mechanical fingers. They are, more than anything, an extension of your hand. At least 3 pairs of pliers are an absolute necessity—standard, needle nose and slip joint.

# 1-22 GENERAL INFORMATION, SAFETY AND TOOLS

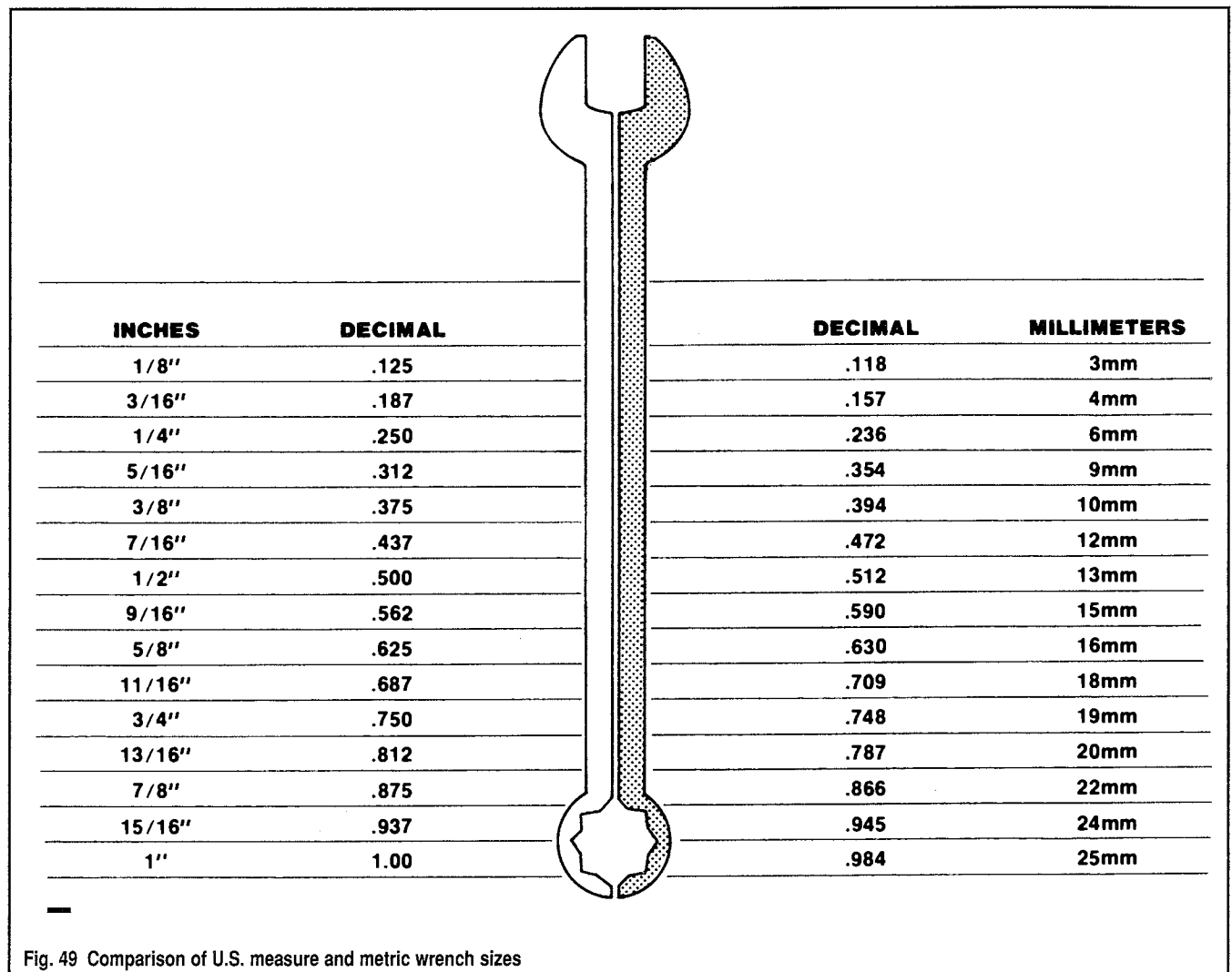


Fig. 49 Comparison of U.S. measure and metric wrench sizes

In addition to standard pliers there are the slip-joint, multi-position pliers such as ChannelLock® pliers and locking pliers, such as Vise Grips®.

Slip joint pliers are extremely valuable in grasping oddly sized parts and fasteners. Just make sure that you don't use them instead of a wrench too often since they can easily round off a bolt head or nut.

Locking pliers are usually used for gripping bolts or studs that can't be removed conventionally. You can get locking pliers in square jawed, needle-nosed and pipe-jawed. Locking pliers can rank right up behind duct tape as the handy-man's best friend.

## SCREWDRIVERS

You can't have too many screwdrivers. They come in 2 basic flavors, either standard or Phillips. Standard blades come in various sizes and thickness for all types of slotted fasteners. Phillips screwdrivers come in sizes with number designations from 1 on up, with the lower number designating the smaller size. Screwdrivers can be purchased separately or in sets.

## HAMMERS

◆ See Figure 55

You need a hammer for just about any kind of work. You need a ball-peen hammer for most metal work when using drivers and other like tools. A plastic hammer comes in handy for hitting things safely. A soft-faced dead-blow hammer is used for hitting things safely and hard. Hammers are also VERY useful with non air-powered impact drivers.

## Other Common Tools

There are a lot of other tools that every D'IYer will eventually need (though not all for basic maintenance). They include:

- Funnels
- Chisels
- Punches
- Files
- Hacksaw
- Portable Bench Vise
- Tap and Die Set
- Flashlight
- Magnetic Bolt Retriever
- Gasket scraper
- Putty Knife
- Screw/Bolt Extractors
- Prybars

Hacksaws have just one use—cutting things off. You may wonder why you'd need one for something as simple as maintenance or repair, but you never know. Among other things, guide studs to ease parts installation can be made from old bolts with their heads cut off.

A tap and die set might be something you've never needed, but you will eventually. It's a good rule, when everything is apart, to clean-up all threads, on bolts, screws or threaded holes. Also, you'll likely run across a situation in which you will encounter stripped threads. The tap and die set will handle that for you.



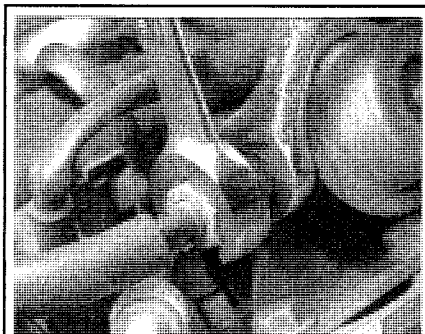


Fig. 50 Always use a backup wrench to prevent rounding flare nut fittings

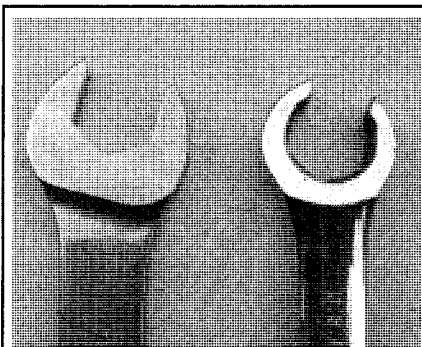


Fig. 51 Note how the flare wrench sides are extended to grip the fitting tighter and prevent rounding

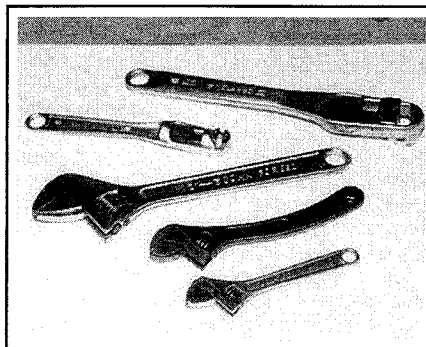


Fig. 52 Several types and sizes of adjustable wrenches

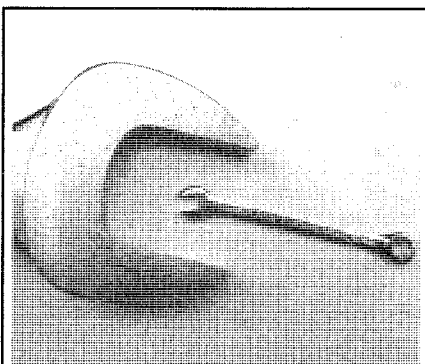


Fig. 53 You may find a nut that requires a particularly large or small wrench (it is usually available at your local tool store)

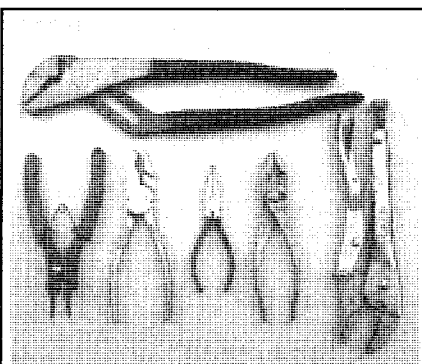


Fig. 54 Pliers and cutters come in many shapes and sizes. You should have an assortment on hand

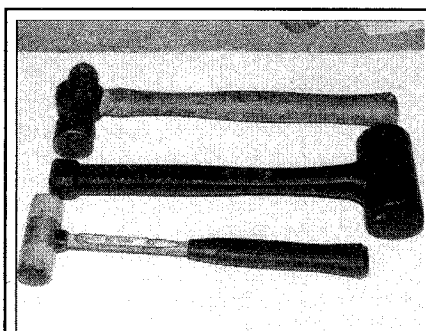


Fig. 55 Three types of hammers. Top to bottom: ball peen, rubber dead-blow, and plastic

Gasket scrapers are just what you'd think, tools made for scraping old gasket material off of parts. You don't absolutely need one. Old gasket material can be removed with a putty knife or single edge razor blade. However, putty knives may not be sharp enough for some really stubborn gaskets and razor blades have a knack of breaking just when you don't want them to, inevitably slicing the nearest body part! As the old saying goes, "always use the proper tool for the job". If you're going to use a razor to scrape a gasket, be sure to always use a blade holder.

Putty knives really do have a use in a repair shop. Just because you remove all the bolts from a component sealed with a gasket doesn't mean it's going to come off. Most of the time, the gasket and sealer will hold it tightly. Lightly inserting a putty knife at various points between the two parts will break the seal without damage to the parts.

A small — 8-10 in. (20-25cm) long — prybar is extremely useful for removing stuck parts.

■ **Never use a screwdriver as a prybar! Screwdrivers are not meant for prying. Screwdrivers, used for prying, can break, sending the broken shaft flying!**

Screw/bolt extractors are used for removing broken bolts or studs that have broken off flush with the surface of the part.

### Special Tools

◆ See Figure 56

Almost every marine engine around today requires at least one special tool to perform a certain task. In most cases, these tools are specially designed to overcome some unique problem or to fit on some oddly sized component.

When manufacturers go through the trouble of making a special tool, it is usually necessary to use it to ensure that the job will be done right. A special

tool might be designed to make a job easier, or it might be used to keep you from damaging or breaking a part.

Don't worry, MOST maintenance procedures can either be performed without any special tools OR, because the tools must be used for such basic things, they are commonly available for a reasonable price. It is usually just the low production, highly specialized tools (like a super thin 7-point star-shaped socket capable of 150 ft. lbs. (203 Nm) of torque that is used only on the crankshaft nut of the limited production what-dya-call-it engine) that tend to be outrageously expensive and hard to find. Hopefully, you will probably never need such a tool.

Special tools can be as inexpensive and simple as an adjustable strap wrench or as complicated as an ignition tester. A few common specialty tools are listed here, but check with your dealer or with other boaters for help in determining if there are any special tools for YOUR particular engine. There is an added advantage in seeking advice from others, chances are they may have already found the special tool you will need, and know how to get it cheaper (or even let you borrow it).

### Electronic Tools

#### BATTERY TESTERS

The best way to test a non-sealed battery is using a hydrometer to check the specific gravity of the acid. Luckily, these are usually inexpensive and are available at most parts stores. Just be careful because the larger testers are usually designed for larger batteries and may require more acid than you will be able to draw from the battery cell. Smaller testers (usually a short, squeeze bulb type) will require less acid and should work on most batteries.

Electronic testers are available and are often necessary to tell if a sealed battery is usable. Luckily, many parts stores have them on hand and are willing to test your battery for you.

# 1-24 GENERAL INFORMATION, SAFETY AND TOOLS

## BATTERY CHARGERS

### ◆ See Figure 57

If you are a weekend boater and take your boat out every week, then you will most likely want to buy a battery charger to keep your battery fresh. There are many types available, from low amperage trickle chargers to electronically controlled battery maintenance tools that monitor the battery voltage to prevent over or undercharging. This last type is especially useful if you store your boat for any length of time (such as during the severe winter months found in many Northern climates).

Even if you use your boat on a regular basis, you will eventually need a battery charger. The charger should be used anytime the boat is going to be in storage for more than a few weeks or so. Never leave the dock or loading ramp without a battery that is fully charged.

Also, some smaller batteries are shipped dry and in a partial charged state. Before placing a new battery of this type into service it must be filled and properly charged. Failure to properly charge a battery (which was shipped dry) before it is put into service will prevent it from ever reaching a fully charged state.

## MULTI-METERS (DVOMS)

### ◆ See Figure 58

Multi-meters or Digital Volt Ohmmeter (DVOMs) are an extremely useful tool for troubleshooting electrical problems. They can be purchased in either analog or digital form and have a price range to suit any budget. A multi-meter is a voltmeter, ammeter and ohmmeter (along with other features) combined into one instrument. It is often used when testing solid-state circuits because of its high input impedance (usually 10 mega-ohms or more). A brief description of the multi-meter main test functions follows:

- Voltmeter—the voltmeter is used to measure voltage at any point in a circuit or to measure the voltage drop across any part of a circuit. Voltmeters usually have various scales and a selector switch to allow the reading of different voltage ranges. The voltmeter has a positive and a negative lead. To avoid the possibility of damage to the meter, whenever possible, connect the negative lead to the negative (-) side of the circuit (to ground or nearest the ground side of the circuit) and connect the positive lead to the positive (+) side of the circuit (to the power source or the nearest power source). Luckily, most quality DVOMs can adjust their own polarity internally and will indicate (without damage) if the leads are reversed. Note that the negative voltmeter lead will always be black and that the positive voltmeter will always be some color other than black (usually red).

- Ohmmeter—the ohmmeter is designed to read resistance (measured in ohms) in a circuit or component. Most ohmmeters will have a selector switch which permits the measurement of different ranges of resistance (usually the selector switch allows the multiplication of the meter reading by 10, 100, 1,000 and 10,000). Some ohmmeters are “auto-ranging” which means the meter itself will determine which scale to use. Since the meters are powered by an internal battery, the ohmmeter can be used like a self-powered test light. When the ohmmeter is connected, current from the ohmmeter flows through the circuit or component being tested. Since the ohmmeter's internal resistance and voltage are known values, the amount of current flow through the meter depends on the resistance of the circuit or component being

tested. The ohmmeter can also be used to perform a continuity test for suspected open circuits. In using the meter for making continuity checks, do not be concerned with the actual resistance readings. Zero resistance, or any ohm reading, indicates continuity in the circuit. Infinite resistance indicates an opening in the circuit. A high resistance reading where there should be little or none indicates a problem in the circuit. Checks for short circuits are made in the same manner as checks for open circuits, except that the circuit must be isolated from both power and normal ground. Infinite resistance indicates no continuity, while zero resistance indicates a dead short.

### \*\* WARNING

**Never use an ohmmeter to check the resistance of a component or wire while there is voltage applied to the circuit.**

- Ammeter—an ammeter measures the amount of current flowing through a circuit in units called amperes or amps. At normal operating voltage, most circuits have a characteristic amount of amperes, called “current draw” which can be measured using an ammeter. By referring to a specified current draw rating, then measuring the amperes and comparing the two values; one can determine what is happening within the circuit to aid in diagnosis. An open circuit, for example, will not allow any current to flow, so the ammeter reading will be zero. A damaged component or circuit will have an increased current draw, so the reading will be high. The ammeter is always connected in series with the circuit being tested. All of the current that normally flows through the circuit must also flow through the ammeter; if there is any other path for the current to follow, the ammeter reading will not be accurate. The ammeter itself has very little resistance to current flow and, therefore, will not affect the circuit, but, it will measure current draw only when the circuit is closed and electricity is flowing. Excessive current draw can blow fuses and drain the battery, while a reduced current draw can cause motors to run slowly, lights to dim and other components to not operate properly.

## GAUGES

### Compression Gauge

#### ◆ See Figure 59

An important element in checking the overall condition of your engine is to check compression. This becomes increasingly more important on outboards with high hours. Compression gauges are available as screw-in types and hold-in types. The screw-in type is slower to use, but eliminates the possibility of a faulty reading due to pressure escaping by the seal. A compression reading will uncover many problems that can cause rough running. Normally, these are not the sort of problems that can be cured by a tune-up.

### Vacuum Gauge

#### ◆ See Figures 60 and 61

Vacuum gauges are handy for discovering air leaks, late ignition or valve timing, and a number of other problems.

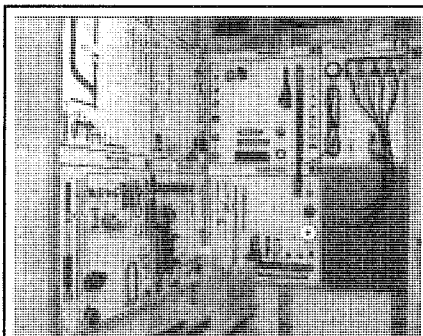


Fig. 56 Almost every marine engine around today requires at least one special tool to perform a certain task



Fig. 57 The Battery Tender® is more than just a battery charger, when left connected, it keeps your battery fully charged

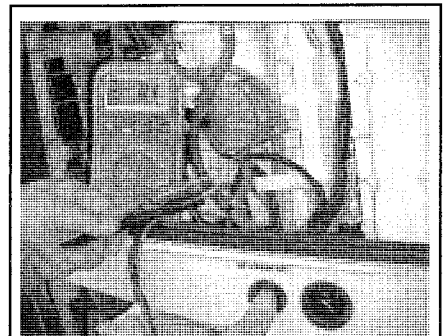
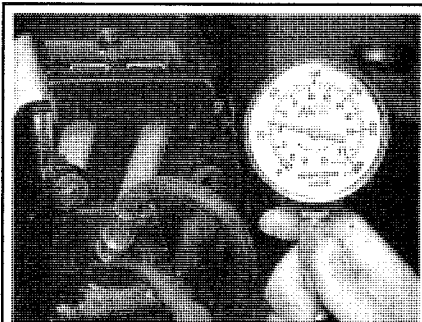
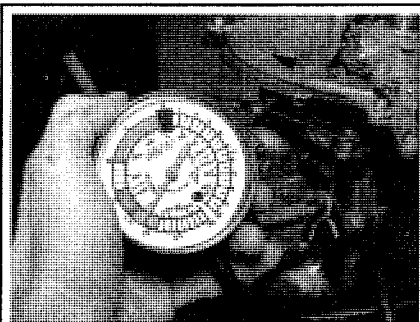


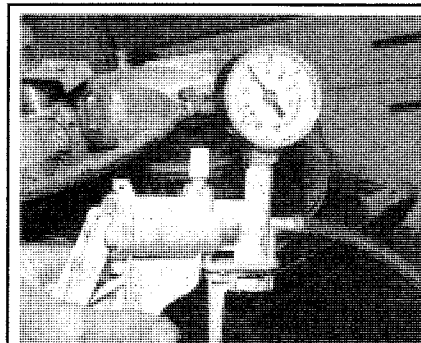
Fig. 58 Multi-meters, such as this one from UEI, are an extremely useful tool for troubleshooting electrical problems



**Fig. 59** Cylinder compression test results are extremely valuable indicators of internal engine condition



**Fig. 60** Vacuum gauges are useful for troubleshooting including testing some fuel pumps



**Fig. 61** You can also use the vacuum gauge on a hand-operated vacuum pump for tests

## Measuring Tools

Eventually, you are going to have to measure something. To do this, you will need at least a few precision tools.

### MICROMETERS & CALIPERS

Micrometers and calipers are devices used to make extremely precise measurements. The simple truth is that you really won't have the need for many of these items just for routine maintenance. But, measuring tools, such as an outside caliper can be handy during repairs. And, if you decide to tackle a major overhaul, a micrometer will absolutely be necessary.

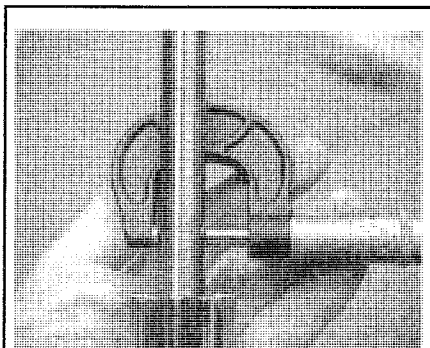
Should you decide on becoming more involved in boat engine mechanics, such as repair or rebuilding, then these tools will become very important. The success of any rebuild is dependent, to a great extent on the ability to check the size and fit of components as specified by the manufacturer. These measurements are often made in thousandths and ten-thousandths of an inch.

#### Micrometers

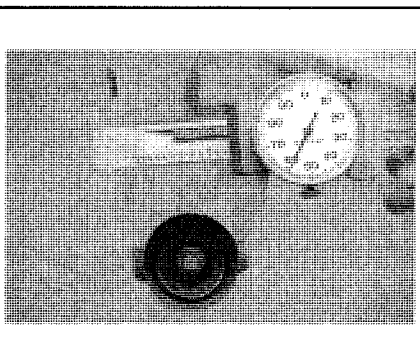
- ◆ See Figure 62

A micrometer is an instrument made up of a precisely machined spindle that is rotated in a fixed nut, opening and closing the distance between the end of the spindle and a fixed anvil. When measuring using a micrometer, don't overtighten the tool on the part as either the component or tool may be damaged, and either way, an incorrect reading will result. Most micrometers are equipped with some form of thumbwheel on the spindle that is designed to freewheel over a certain light touch (automatically adjusting the spindle and preventing it from overtightening).

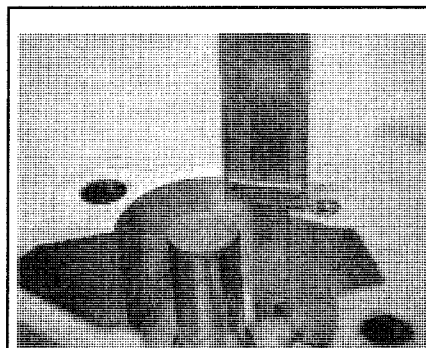
Outside micrometers can be used to check the thickness of parts such shims or the outside diameter of components like the crankshaft journals. They are also used during many rebuild and repair procedures to measure the diameter of components such as the pistons. The most common type of micrometer reads in 1/1000 of an inch. Micrometers that use a vernier scale can estimate to 1/10 of an inch.



**Fig. 62** Outside micrometers measure thickness, like shims or a shaft diameter



**Fig. 63** Calipers are the fast and easy way to make precise measurements



**Fig. 64** Calipers can also be used to measure depth . . .

Inside micrometers are used to measure the distance between two parallel surfaces. For example, in powerhead rebuilding work, the "inside mike" measures cylinder bore wear and taper. Inside mikes are graduated the same way as outside mikes and are read the same way as well.

Remember that an inside mike must be absolutely perpendicular to the work being measured. When you measure with an inside mike, rock the mike gently from side to side and tip it back and forth slightly so that you span the widest part of the bore. Just to be on the safe side, take several readings. It takes a certain amount of experience to work any mike with confidence.

Metric micrometers are read in the same way as inch micrometers, except that the measurements are in millimeters. Each line on the main scale equals 1mm. Each fifth line is stamped 5, 10, 15 and so on. Each line on the thimble scale equals 0.01 mm. It will take a little practice, but if you can read an inch mike, you can read a metric mike.

#### Calipers

- ◆ See Figures 63, 64 and 65

Inside and outside calipers are useful devices to have if you need to measure something quickly and absolute precise measurement is not necessary. Simply take the reading and then hold the calipers on an accurate steel rule. Calipers, like micrometers, will often contain a thumbwheel to help ensure accurate measurement.

### DIAL INDICATORS

- ◆ See Figure 66

A dial indicator is a gauge that utilizes a dial face and a needle to register measurements. There is a movable contact arm on the dial indicator. When the arm moves, the needle rotates on the dial. Dial indicators are calibrated to show readings in thousandths of an inch and typically, are used to measure end-play and runout on various shafts and other components.

Dial indicators are quite easy to use, although they are relatively expensive. A variety of mounting devices are available so that the indicator can be used in a number of situations. Make certain that the contact arm is always parallel to the movement of the work being measured.

# 1-26 GENERAL INFORMATION, SAFETY AND TOOLS

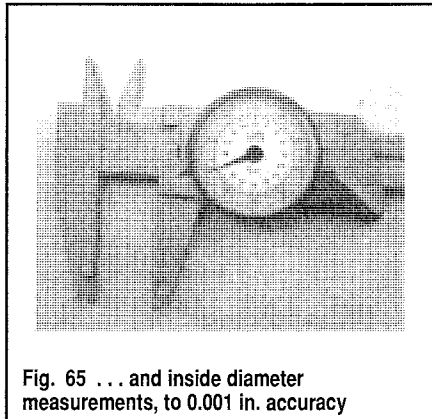


Fig. 65 . . . and inside diameter measurements, to 0.001 in. accuracy

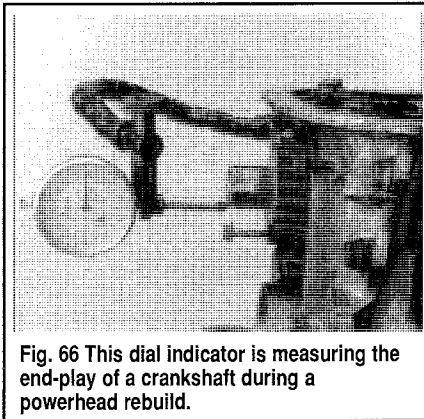


Fig. 66 This dial indicator is measuring the end-play of a crankshaft during a powerhead rebuild.

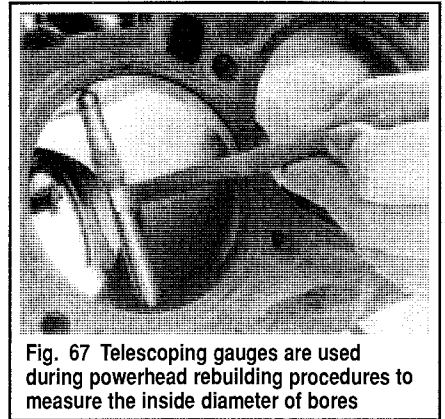


Fig. 67 Telescoping gauges are used during powerhead rebuilding procedures to measure the inside diameter of bores

## TELESCOPING GAUGES

◆ See Figure 67

A telescope gauge is really only used during rebuilding procedures (NOT during basic maintenance or routine repairs) to measure the inside of bores. It can take the place of an inside mike for some of these jobs. Simply insert the gauge in the hole to be measured and lock the plungers after they have contacted the walls. Remove the tool and measure across the plungers with an outside micrometer.

## DEPTH GAUGES

◆ See Figure 68

A depth gauge can be inserted into a bore or other small hole to determine exactly how deep it is. One common use for a depth gauge is measuring the distance the piston sits below the deck of the block at top dead center. Some outside calipers contain a built-in depth gauge so you can save money and buy just one tool.

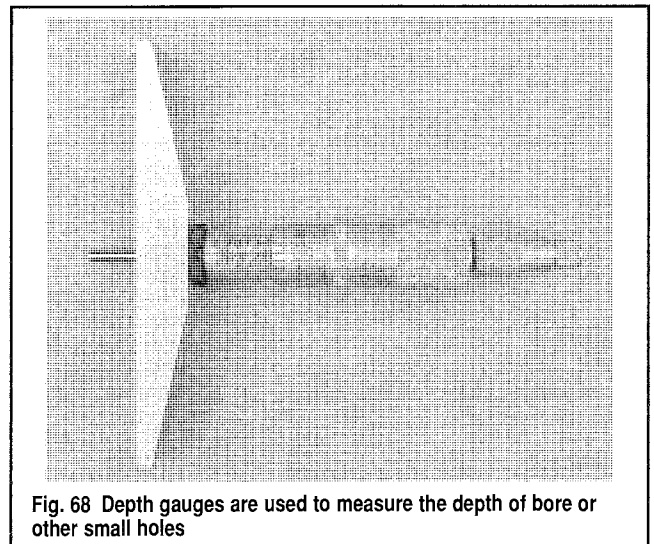


Fig. 68 Depth gauges are used to measure the depth of bore or other small holes

## FASTENERS, MEASUREMENTS AND CONVERSIONS

### Bolts, Nuts and Other Threaded Retainers

◆ See Figures 69 and 70

Although there are a great variety of fasteners found in the modern boat engine, the most commonly used retainer is the threaded fastener (nuts, bolts, screws, studs, etc). Most threaded retainers may be reused, provided that they are not damaged in use or during the repair.

■ Some retainers (such as stretch bolts or torque prevailing nuts) are designed to deform when tightened or in use and should not be reused.

Whenever possible, we will note any special retainers which should be replaced during a procedure. But you should always inspect the condition of a retainer when it is removed and you should replace any that show signs of damage. Check all threads for rust or corrosion that can increase the torque necessary to achieve the desired clamp load for which that fastener was originally selected. Additionally, be sure that the driver surface itself (on the fastener) is not compromised from rounding or other damage. In some cases a driver surface may become only partially rounded, allowing the driver to catch in only one direction. In many of these occurrences, a fastener may be installed and tightened, but the driver would not be able to grip and loosen the fastener again. (This could lead to frustration down the line should that component ever need to be disassembled again).

If you must replace a fastener, whether due to design or damage, you must always be sure to use the proper replacement. In all cases, a retainer of the same design, material and strength should be used. Markings on the heads of most bolts will help determine the proper strength of the fastener. The same material, thread and pitch must be selected to assure proper installation and safe operation of the motor afterwards.

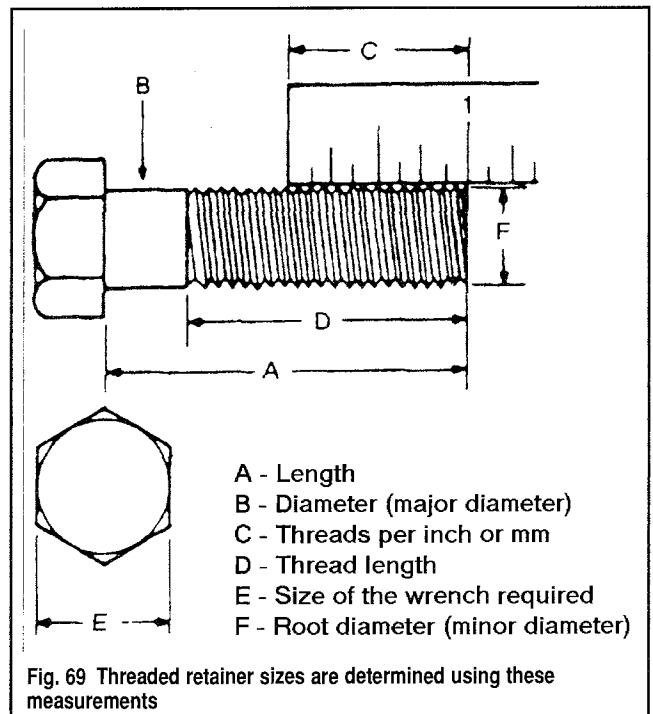


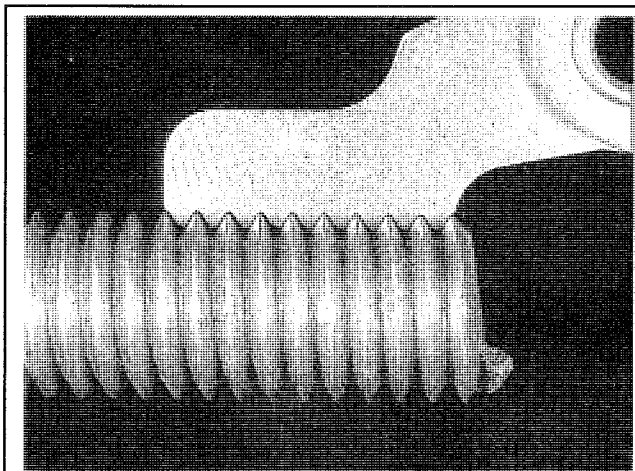
Fig. 69 Threaded retainer sizes are determined using these measurements

Thread gauges are available to help measure a bolt or stud's thread. Most part or hardware stores keep gauges available to help you select the proper size. In a pinch, you can use another nut or bolt for a thread gauge. If the bolt you are replacing is not too badly damaged, you can select a match by finding another bolt that will thread in its place. If you find a nut that will thread properly onto the damaged bolt, then use that nut as a gauge to help select the replacement bolt. If however, the bolt you are replacing is so badly damaged (broken or drilled out) that its threads cannot be used as a gauge, you might start by looking for another bolt (from the same assembly or a similar location) which will thread into the damaged bolt's mounting. If so, the other bolt can be used to select a nut; the nut can then be used to select the replacement bolt.

In all cases, be absolutely sure you have selected the proper replacement. Don't be shy, you can always ask the store clerk for help.

### \*\* WARNING

**Be aware that when you find a bolt with damaged threads, you may also find the nut or tapped bore into which it was threaded has also been damaged. If this is the case, you may have to drill and tap the hole, replace the nut or otherwise repair the threads. Never try to force a replacement bolt to fit into the damaged threads.**



**Fig. 70** Thread gauges measure the threads-per-inch and the pitch of a bolt or stud's threads

## Torque

Torque is defined as the measurement of resistance to turning or rotating. It tends to twist a body about an axis of rotation. A common example of this would be tightening a threaded retainer such as a nut, bolt or screw. Measuring torque is one of the most common ways to help assure that a threaded retainer has been properly fastened. When tightening a threaded fastener, torque is applied in three distinct areas, the head, the bearing surface and the clamp load. About 50 percent of the measured torque is used in overcoming bearing friction. This is the friction between the bearing surface of the bolt head, screw head or nut face and the base material or washer (the surface on which the fastener is rotating). Approximately 40 percent of the applied torque is used in overcoming thread friction. This leaves only about 10 percent of the applied torque to develop a useful clamp load (the force that holds a joint together). This means that friction can account for as much as 90 percent of the applied torque on a fastener.

## Standard and Metric Measurements

Specifications are often used to help you determine the condition of various components, or to assist you in their installation. Some of the most common measurements include length (in. or cm/mm), torque (ft. lbs., inch lbs. or Nm) and pressure (psi, in. Hg, kPa or mm Hg).

In some cases, that value may not be conveniently measured with what is available in your toolbox. Luckily, many of the measuring devices that are available today will have two scales so U.S. or Metric measurements may easily be taken. If any of the various measuring tools that are available to you do not contain the same scale as listed in your specifications, use the conversion factors that are provided in the Specifications section to determine the proper value.

The conversion factor chart is used by taking the given specification and multiplying it by the necessary conversion factor. For instance, looking at the first line, if you have a measurement in inches such as "free-play should be 2 in." but your ruler reads only in millimeters, multiply 2 in. by the conversion factor of 25.4 to get the metric equivalent of 50.8mm. Likewise, if a specification was given only in a Metric measurement, for example in Newton Meters (Nm), then look at the center column first. If the measurement is 100 Nm, multiply it by the conversion factor of 0.738 to get 73.8 ft. lbs.

## SPECIFICATIONS

Metric Bolts		SAE Bolts	
Relative Strength Marking	4.5, 4.8	5	6 or 7
<b>Bolt Markings</b>			
<b>Usage</b>	Frequent	Frequent	Infrequent
<b>Bolt Size</b>	Maximum Torque	Maximum Torque	Maximum Torque
<b>Thread Size x Pitch (mm)</b>	Fl-Lb	Nm	Fl-Lb
6 x 1.0	2-3	2-4	3-6
8 x 1.25	6-8	8-11	9-14
10 x 1.25	12-17	15-23	20-29
12 x 1.25	21-32	29-43	35-53
14 x 1.5	35-52	48-71	57-85
16 x 1.5	51-77	70-106	90-120
18 x 1.5	74-110	102-151	130-170
20 x 1.5	110-140	151-193	190-240
22 x 1.5	150-190	220-262	250-320
24 x 1.5	190-240	262-469	310-410

Metric Bolts		SAE Bolts	
Relative Strength Marking	4.5, 4.8	5	6 or 7
<b>Bolt Markings</b>			
<b>Usage</b>	Frequent	Frequent	Infrequent
<b>Bolt Size</b>	Maximum Torque	Maximum Torque	Maximum Torque
<b>Thread Size x Pitch (mm)</b>	Fl-Lb	Nm	Fl-Lb
6 x 1.0	2-3	2-4	3-6
8 x 1.25	6-8	8-11	9-14
10 x 1.25	12-17	15-23	20-29
12 x 1.25	21-32	29-43	35-53
14 x 1.5	35-52	48-71	57-85
16 x 1.5	51-77	70-106	90-120
18 x 1.5	74-110	102-151	130-170
20 x 1.5	110-140	151-193	190-240
22 x 1.5	150-190	220-262	250-320
24 x 1.5	190-240	262-469	310-410

## CONVERSION FACTORS

### LENGTH-DISTANCE

Inches (in.)	x 25.4	=	Millimeters (mm)
Feet (ft.)	x 3.281	=	Meters (m)
Miles	x 1.609	=	Kilometers (km)

### VOLUME

Cubic Inches (in <sup>3</sup> )	x 16.387	=	Cubic Centimeters
IMP Pints (IMP pt.)	x .568	=	Liters (L)
IMP Quarts (IMP qt.)	x 1.137	=	Liters (L)
IMP Gallons (IMP gal.)	x 4.546	=	Liters (L)
IMP Quarts (IMP qt.)	x 1.201	=	US Quarts (US qt.)
IMP Gallons (IMP gal.)	x 1.201	=	US Gallons (US gal.)
Fl. Ounces	x 29.573	=	Milliliters
US Pints (US pt.)	x .473	=	Liters (L)
US Quarts (US qt.)	x .946	=	Liters (L)
US Gallons (US gal.)	x 3.785	=	Liters (L)

### MASS-WEIGHT

Ounces (oz.)	x 28.35	=	Grams (g)
Pounds (lb.)	x 4.54	=	Kilograms (kg)

### PRESSURE

Pounds Per Sq. In. (psi)	x 6.895	=	Kilopascals (kPa)
Inches of Mercury (Hg)	x .4912	=	psi
Inches of Water (H <sub>2</sub> O)	x .0337	=	Kilopascals (kPa)
Inches of Water (H <sub>2</sub> O)	x .07355	=	Inches of Mercury
Inches of Water (H <sub>2</sub> O)	x .03613	=	psi
Inches of Water (H <sub>2</sub> O)	x .248	=	Kilopascals (kPa)

### TORQUE

Pounds-Force Inches (in-lb)	x .113	=	Newton Meters (N·m)
Pounds-Force Feet (ft-lb)	x 1.356	=	Newton Meters (N·m)

### VELOCITY

Miles Per Hour (MPH)	x 1.609	=	Kilometers Per Hour (KPH)
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### POWER

Horsepower (Hp)	x .745	=	Kilowatts
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### FUEL CONSUMPTION\*

Miles Per Gallon IMP (MPG)	x .354	=	Kilometers Per Liter (Km/L)
Kilometers Per Liter (Km/L)	x 2.352	=	IMP MPG
Miles Per Gallon US (MPG)	x .425	=	Kilometers Per Liter (Km/L)
Kilometers Per Liter (Km/L)	x 2.352	=	US MPG

\*It is common to convert from miles per gallon (mpg) to liters/100 kilometers (l/100 km), where mpg (IMP) x 1/100 km = 282 and mpg (US) x 1/100 km = 235.

### TEMPERATURE

Degree Fahrenheit (°F)	= (°C x 1.8) + 32
Degree Celsius (°C)	= (°F - 32) x .56

Relative Strength Marking

Metric Bolts

4.5, 4.8

8.8



Bolt Markings

Usage

Bolt Size

Thread Size x Pitch (mm)

6 x 1.0

8 x 1.25

10 x 1.25

12 x 1.25

14 x 1.5

16 x 1.5

18 x 1.5

20 x 1.5

22 x 1.5

24 x 1.5

SAE Grade Number

1 or 2

5

6 or 7

Bolt Markings

Manufacturers' marks may vary—number of lines always two less than the grade number.

Usage

Bolt Size

(inches)—(Thread)

1/4—20

—28

5/16—18

—24

3/8—16

—24

7/16—14

—20

1/2—13

—20

9/16—12

—18

5/8—11

—18

3/4—10

—16

7/8—9

—14

1—8

—14



Fl-Lb

kgm

Nm

Fl-Lb

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# 2

## MAINTENANCE & TUNE-UP

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## 2-2 MAINTENANCE & TUNE-UP

### GENERAL INFORMATION (WHAT EVERYONE SHOULD KNOW ABOUT MAINTENANCE)

At Seloc, we estimate that 75% of engine repair work can be directly or indirectly attributed to lack of proper care for the engine. This is especially true of care during the off-season period. There is no way on this green earth for a mechanical engine, particularly an outboard motor, to be left sitting idle for an extended period of time, say for six months, and then be ready for instant satisfactory service.

Imagine, if you will, leaving your car or truck for six months, and then expecting to turn the key, having it roar to life, and being able to drive off in the same manner as a daily occurrence.

Therefore it is critical for an outboard engine to either be run (at least once a month), preferably, in the water and properly maintained between uses or for it to be specifically prepared for storage and serviced again immediately before the start of the season.

Only through a regular maintenance program can the owner expect to receive long life and satisfactory performance at minimum cost.

Many times, if an outboard is not performing properly, the owner will "nurse" it through the season with good intentions of working on the unit once it is no longer being used. As with many New Year's resolutions, the good intentions are not completed and the outboard may lie for many months before the work is begun or the unit is taken to the marine shop for repair.

Imagine, if you will, the cause of the problem being a blown head gasket. And let us assume water has found its way into a cylinder. This water, allowed to remain over a long period of time, will do considerably more damage than it would have if the unit had been disassembled and the repair work performed immediately. Therefore, if an outboard is not functioning properly, do not stow it away with promises to get at it when you get time, because the work and expense will only get worse the longer corrective action is postponed. In the example of the blown head gasket, a relatively simple and inexpensive repair job could very well develop into major overhaul and rebuild work.

### Maintenance Equals Safety

OK, perhaps no one thing that we do as boaters will protect us from risks involved with enjoying the wind and the water on a powerboat. But, each time we perform maintenance on our boat or motor, we increase the likelihood that we will find a potential hazard before it becomes a problem. Each time we inspect our boat and motor, we decrease the possibility that it could leave us stranded on the water.

In this way, performing boat and engine service is one of the most important ways that we, as boaters, can help protect ourselves, our boats, and the friends and family that we bring aboard.

### Outboards On Sail Boats

Owners of sailboats pride themselves in their ability to use the wind to clear a harbor or for movement from Port A to Port B, or maybe just for a day sail on a lake. For some, the outboard is carried only as a last resort—in case the wind fails completely, or in an emergency situation or for ease of docking.

Therefore, in some cases, the outboard is stowed below, usually in a very poorly ventilated area, and subjected to moisture and stale air—in short, an excellent environment for "sweating" and corrosion.

If the owner could just take the time at least once every month, to pull out the outboard, clean it up, and give it a short run, not only would he/she have "peace of mind" knowing it will start in an emergency, but also maintenance costs will be drastically reduced.

### Maintenance Coverage In This Manual

At Seloc, we strongly feel that every boat owner should pay close attention to this section. We also know that it is one of the most frequently used portions of our manuals. The material in this section is divided into sections to help simplify the process of maintenance. Be sure to read and thoroughly understand the various tasks that are necessary to keep your outboard in tip-top shape.

Topics covered in this section include:

1. General Information (What Everyone Should Know About Maintenance)—an introduction to the benefits and need for proper maintenance. A guide to tasks that should be performed before and after each use.

2. Lubrication Service—after the basic inspections that you should perform each time the motor is used, the most frequent form of periodic maintenance you will conduct will be the Lubrication Service. This section takes you through each of the various steps you must take to keep corrosion from slowly destroying your motor before your very eyes.

3. Engine Maintenance—the various procedures that must be performed on a regular basis in order to keep the motor and all of its various systems operating properly.

4. Boat Maintenance—the various procedures that must be performed on a regular basis in order to keep the boat hull and its accessories looking and working like new.

5. Tune-Up—also known as the pre-season tune-up, but don't let the name fool you. A complete tune-up is the best way to determine the condition of your outboard while also preparing it for hours and hours of hopefully trouble-free enjoyment.

6. Winter Storage and Spring Commissioning Checklists—use these sections to guide you through the various parts of boat and motor maintenance that protect your valued boat through periods of storage and return it to operating condition when it is time to use it again.

7. Specification Charts—located at the end of the section are quick-reference, easy to read charts that provide you with critical information such as General Engine Specifications, Maintenance Intervals, Lubrication Service (intervals and lubricant types) and Capacities.

### Engine Identification

◆ See Figures 1, 2, 3, 4 and 5

From 1984 to 1996 Yamaha produced an extremely large number of models with regards to horsepower ratings, as well a large number of trim and option variances on each of those models. In this service guide, we've included all of the 1-3 cylinder inline models (of both 2 and 4-stroke designs), as well as the V4 and V6 2-strokes. We chose to do this because of the many similarities these motors have to each other. But, enough differences exist that many procedures will apply only to a sub-set of these motors. When this occurs, we'll either refer to the differences within a procedure or, if the differences are more significant, we'll break the motors out and give separate procedures. In order to prevent confusion, we try to sort and name the models in a way that is most easily understood.

In many cases, it is simply not enough to refer to a motor as a 25 hp model, since in these years Yamaha produced as many as 4 different motors with that rating (the 395cc 2-cylinder, the 430cc 2-cylinder, the 496cc 2-cylinder AND the 496cc 3-cylinder). This makes proper engine identification important for everything from ordering parts to even just using the procedures in this manual.

Throughout this manual we will make reference to motors the easiest way possible. In some cases procedures will apply to all 2-strokes or all 4-strokes, in other cases, they will apply to all 1-cylinder or all 2-cylinder motors (or all 3 or 4-cylinder motors, or perhaps all V6 motors, as applicable). When it is necessary to distinguish between different types of motors with the same number of cylinders, we'll differentiate using the Hp rating or, since different motors may have the same rating, we'll use the Hp rating plus the size (and in the case of the 496cc 25hp motor, the number of cylinders).

In most cases, mechanical procedures will be similar or the same across different Hp ratings of the same engine family (of the same size). So it won't be uncommon to see a title or a procedure refer to 9.9/15 hp (246cc) motors or 105J-225 hp (2596cc) motors. In both cases, we would be referring to all the motors of a particular family, including all B (Inshore), C, P (Pro), S (Saltwater) or V (V-Max) motors or other special models.

To help with proper engine identification, all of the engines covered by this manual are listed in the General Engine and General Engine System Specifications charts at the end of this section. In these charts, the engines are listed with their respective engine families, by horsepower rating, number of cylinders, engine type (2- or 4-stroke), years of production and displacement (cubic inches and cubic centimeters or CCs).

But, whether you are trying to tell which version of a particular horsepower rated motor you have in order to follow the correct procedure or are trying to order replacement parts, the absolute best method is to start by referring to the engine serial number tag. For all models covered here this ID tag (in the accompanying figure) is located on the side of the engine clamp or swivel/tilt brackets (port or starboard side depending upon the year and



model). Most models are also equipped with a date of manufacture tag (located on the opposite side of the clamp or swivel/tilt bracket). Lastly, some models, mostly larger and later-model motors are also equipped with an Emissions Control Information label as well.

## ENGINE MODEL & SERIAL NUMBERS

### ◆ See Figures 1, 2 and 3

The engine model numbers are the manufacturer's key to engine changes. These alpha-numeric codes identify the year of manufacture, the horsepower rating, gearcase shaft length and various model/option differences (such as Saltwater, Pro-Series or V-max and starting/trim tilt options such as manual start/manual tilt or electric start power trim/tilt). If any correspondence or parts are required, the engine model number must be used for proper identification.

Remember that the model number establishes the model year for which the engine was produced, which is often not the year of first installation. Also, keep in mind that a date of manufacture may be the year prior to the designated model year.

The engine model number tag also contains information used by the manufacturer internally as an engine family designation and a serial number (a unique sequential identifier given ONLY to that one motor).

When present, the emissions control information label states that the motor is in compliance with EPA emissions regulations for the model year of that engine. And, more importantly, it gives tune-up specifications that are vital to proper engine performance (that minimize harmful emissions). The specifications on this label may reflect changes that are made during

production runs and are often not later reflected in a company's service literature. For this reason, specifications on the label always supercede those of a print or electronic manual. Typical specifications that are found on this label will include:

- Spark plug type and gap.
- Fuel recommendations.
- Idle speed settings
- Possibly engine ignition timing (such as wide-open throttle and/or idle timing) specifications

### Deciphering The Model Code on 1986-90 Engines

#### ◆ See Figure 6

Engines built for the 1984-90 model years contain a 5-11 digit code for identification. If the code begins with an alpha designation, it represents a model that is part of a variation family (such as CV, Pro, counter-rotating L models and F or FT 4-stroke models). The next one, two or three digits will be numbers, representing the horsepower rating. The digit following the horsepower rating will be a one, two or three digit alpha code identifying the various trim/model types (such as E for electric start, T for power trim or power trim and tilt or M for tiller controls). Following the model identifier may be a single alpha identifier (S, L, or X in these years) representing gearcase shaft length. Next, a single-digit, alpha identifier is used for the year. And lastly, a code variant of JD is used on Jet Drive models during this year span.

Refer to the accompanying illustration to interpret the various alpha identifiers found throughout the model code.

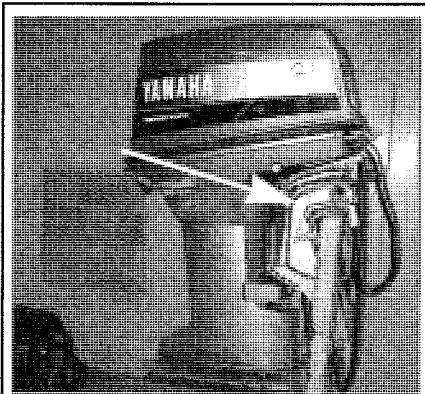


Fig. 1 A model ID tag, and often a date of manufacture tag, is found on the starboard ...



Fig. 2 ... and/or port side of most engine clamp or swivel/tilt brackets

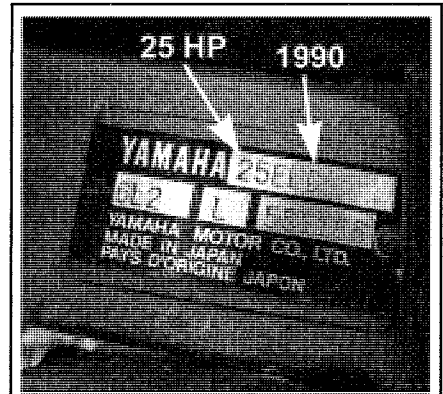


Fig. 3 The model ID tag provides critical information to identify and service the engine

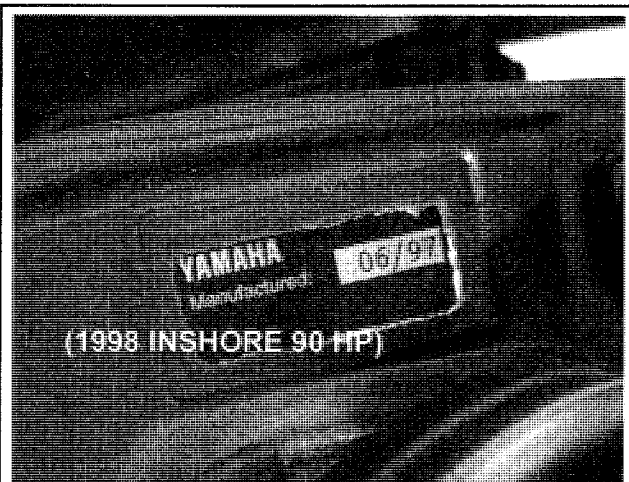


Fig. 4 Keep in mind that the date of manufacture is often the year BEFORE the model year

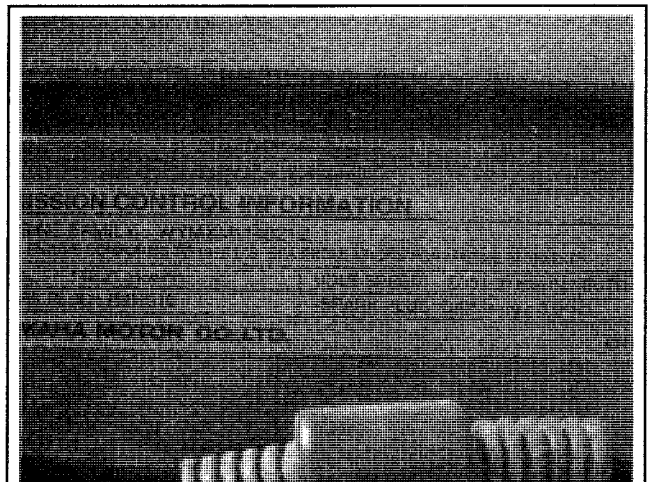


Fig. 5 When present, the emission control information label supercedes specifications listed elsewhere

## 2-4 MAINTENANCE & TUNE-UP

### Deciphering The Model Code on 1991 and later Engines

◆ See Figure 6

Engines built for the 1991 and later model years contain a model code similar to that of earlier year production models, however there are more variations and therefore more possible codes. Most 1991 and later models will contain a 6-9 digit code. The code may or may not begin with a one or two digit alpha model description. This tells you what series (Inshore, C, Pro, Saltwater, etc) to which the engine belongs. The next one, two or three digits will be numbers, representing the horsepower rating. The digit following the horsepower rating will be a single digit alpha code identifying the starting and trim/tilt system on the motor (E, M, T or P). Following the starting and trim/tilt system identifier will be a single alpha identifier (S, L, X, U or J) representing gearcase shaft length (or type in the case of J for Jet Drive). Next, a single-digit, alpha identifier is used for the year. Finally, in some cases, a single check digit is used by the manufacturer to designate the 3-cylinder version of the 25 hp motor.

Refer to the accompanying illustration to interpret the various alpha digits found throughout the model code.

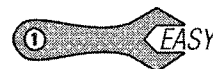
### Before/After Each Use

As stated earlier, the best means of extending engine life and helping to protect yourself while on the water is to pay close attention to boat/engine maintenance. This starts with an inspection of systems and components before and after each time you use your boat.

A list of checks, inspections or required maintenance can be found in the Maintenance Intervals Chart at the end of this section. Some of these inspections or tasks are performed before the boat is launched, some only after it is retrieved and the rest, both times.

### VISUALLY INSPECTING THE BOAT AND MOTOR

◆ See Figures 7 and 8



Both before each launch and immediately after each retrieval, visually inspect the boat and motor as follows:

1. **Check the fuel and oil levels** according to the procedures in this manual. Do NOT launch a boat without properly topped off fuel and oil tanks

### YAMAHA MODEL IDENTIFICATION DECODER

Model Description (1 or 2 digits / Alpha)	Prop Shaft HP (1-3 digits / Numerals)	Trim/Tilt Starting Method (1 digit - Alpha)	Shaft Length (1 digit - Alpha)	Method of Control (1 digit - Alpha)	Model Year (1 digit - Alpha)	Code Variant ① (1 digit / Numeral)
B = Inshore Series						
C = C Series	A number between	1986-90 ②	S = 15" (38cm)	1991-03 only	N = 1984	2 = 3 cyl (1997)
D = Twin Prop	2 = 2 hp	E = Electric Start		H = Tiller	K = 1985	
DX = Twin Prop / EFI	and		L = 20" (51cm)		J = 1986	3 = 3 cyl
E = Enduro Series	250 = 250 hp	T = Power Trim or		R = Remote	H = 1987	
F = 4-Stroke		Power Trim/Tilt	X = 25" (64cm)		G = 1988	1984-90
FT = 4-Stroke / High Thrust					F = 1989	JD = Jet Drive
L = Left-Hand Rotation		M = Tiller	U = 30" (76cm)		D = 1990	
LF = Left-Hand / 4-Stroke					P = 1991	
LX = Left-Hand / EFI		1991-03 ②	1991-03		Q = 1992	
LZ = Left-Hand / HPDI		E = Manual Tilt	J = Jet Drive		R = 1993	
P = Pro Series Model		w/ Electric Start			S = 1994	
PX = Pro Series / EFI					T = 1995	
S = Saltwater Series		M = Manual Tilt			U = 1996	
SX = Saltwater Series / EFI		w/ Manual Start			V = 1997	
T = 4-Stroke / High Thrust					W = 1998	
V = V-Max Series		T = Power Trim/Tilt			X = 1999	
VX = V-Max / EFI		w/ Electric Start			Y = 2000	
VZ = V-Max / HPDI					Z = 2001	
Z = HPDI		P = Power Tilt			A = 2002	
		w/ Electric Start			B = 2003	

① A special model variation code is used on 25 hp motors to distinguish between 2 cyl models (no code) and 3 cyl models (code present)

② For models through 1990 this portion of the code may be 1, 2 or 3 Alpha designators, all 1991 or later use only 1 digit at this part of the code

Fig. 6 Yamaha Model codes—1984-03 models

(or without the proper crankcase oil level on 4-stroke motors). It is not worth the risk of getting stranded or of damage to the motor. Likewise, upon retrieval, check the oil and fuel levels while it is still fresh in your mind. This is a good way to track fuel consumption (one indication of engine performance). For 2-stroke motors, compare the fuel consumption to the oil consumption (a dramatic change in proportional use may be an early sign of trouble). For 4-stroke motors, oil consumption should be minimal, but all 4-stroke engines allow a small portion of oil to burn. Watch for sudden increases in the amount of oil burned and investigate further if found.

2. **Check for signs of fuel or oil leakage.** Probably as important as making sure enough fuel and oil is onboard, is the need to make sure that no dangerous conditions might arise due to leaks. Thoroughly check all hoses, fittings and tanks for signs of leakage. Oil leaks may cause the boat to become stranded, or worse, could destroy the motor if undetected for a significant amount of time. Fuel leaks can cause a fire hazard, or worse, an explosive condition. This check is not only about properly maintaining your boat and motor, but about helping to protect your life.

3. **Inspect the boat hull and engine cases** for signs of corrosion or damage. Don't launch a damaged boat or motor. And don't surprise yourself dockside or at the launch ramp by discovering damage that went unnoticed last time the boat was retrieved. Repair any hull or case damage now.

4. **Check the battery connections** to make sure they are clean and tight. A loose or corroded connection will cause charging problems (damaging the system or preventing charging). There's only one thing worse than a dead battery dockside/launch ramp and that's a dead battery in the middle of a bay, river or worse, the ocean. Whenever possible, make a quick visual check of battery electrolyte levels (keeping an eye on the level will give some warning of overcharging problems). This is especially true if the engine is operated at high speeds for extended periods of time.

5. **Check the propeller (impeller on jet drives) and gearcase.** Make sure the propeller shows no signs of damage. A broken or bent propeller may allow the engine to over-rev and it will certainly waste fuel. The gearcase should be checked before and after each use for signs of leakage. Check the gearcase oil for signs of contamination if any leakage is noted. Also, visually check behind the propeller for signs of entangled rope or fishing lines that could cut through the lower gearcase propeller shaft seal. This is a common cause of gearcase lubricant leakage, and eventually, water contamination that can lead to gearcase failure. Even if no gearcase leakage is noted when the boat is first retrieved, check again next time before launching. A nicked seal might not seep fluid right away when still swollen from heat immediately after use, but might begin seeping over the next day, week or month as it sat, cooled and dried out.

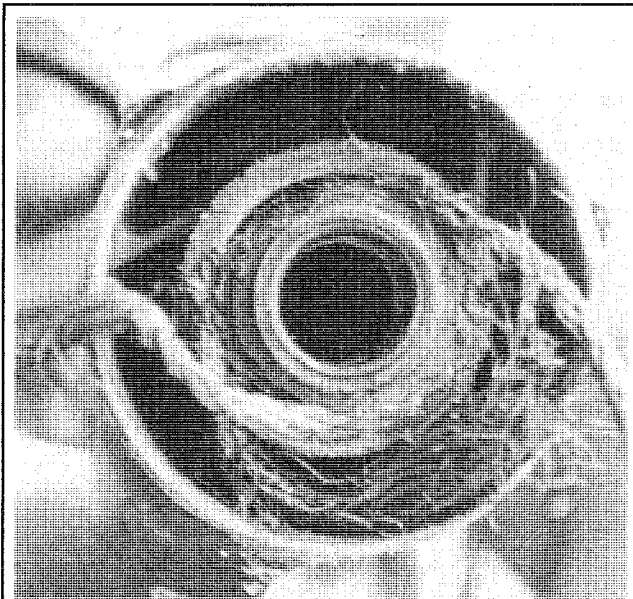


Fig. 7 Rope or fishing line entangled behind the propeller can cut through the seal, allowing water in or lubricant out

6. **Check all accessible fasteners for tightness.** Make sure all easily accessible fasteners appear to be tight. This is especially true for the propeller nut, any anode retaining bolts, all steering or throttle linkage fasteners and the engine clamps or mounting bolts. Don't risk losing control or becoming stranded due to loose fasteners. Perform these checks before heading out, and immediately after you return (so you'll know if anything needs to be serviced before you want to launch again.)

7. **Check operation of all controls including the throttle/shifter, steering and emergency stop/start switch and/or safety lanyard.** Before launching, make sure that all linkage and steering components operate properly and move smoothly through their range of motion. All electrical switches (such as power trim/tilt) and especially the emergency stop system(s) must be in proper working order. While underway, watch for signs that a system is not working or has become damaged. With the steering, shifter or throttle, keep a watchful eye out for a change in resistance or the start of jerky/notchy movement.

8. **Check the water pump intake grate and water indicator.** The water pump intake grate should be clean and undamaged before setting out. Remember that a damaged grate could allow debris into the system that could destroy the impeller or clog cooling passages. Once underway, make sure the cooling indicator stream is visible at all times. Make periodic checks, including one final check before the motor is shut down each time. If a cooling indicator stream is not present at any point, troubleshoot the problem before further engine operation.

9. **If used in salt, brackish or polluted waters thoroughly rinse the engine (and hull), then flush the cooling system** according to the procedure in this section.

■ **Keep in mind that the cooling system can use attention, even if used in fresh waters. Sand, silt or other deposits can help clog passages, chemicals or pollutants can speed corrosion. It's a good idea to flush your motor after every use, regardless of where you use it.**

10. **Visually inspect all anodes** after each use for signs of wear, damage or to make sure they just plain didn't fall off (especially if you weren't careful about checking all the accessible fasteners the last time you launched).

11. **For Pete's sake, make sure the plug is in!** We shouldn't have to say it, but unfortunately we do. If you've been boating for any length of time, you've seen or heard of someone whose backed a trailer down a launch ramp, forgetting to check the transom drain plug before submerging (literally) the boat. Always make sure the transom plug is installed and tight before a launch.

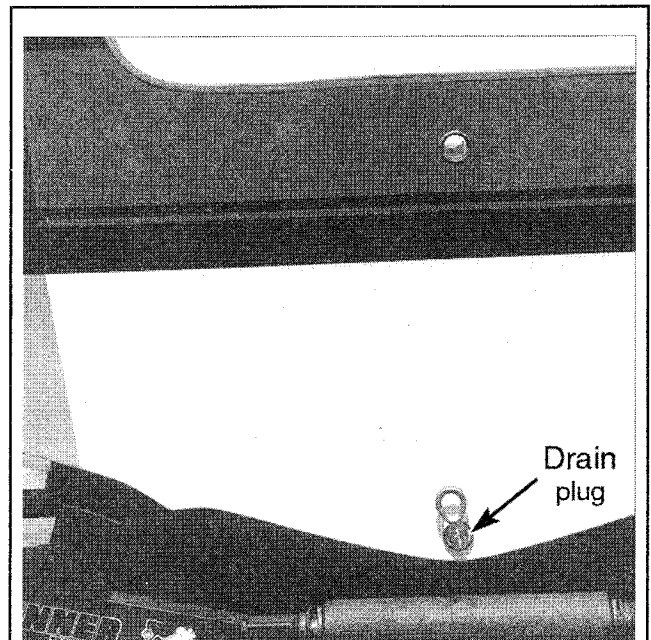


Fig. 8 Always make sure the transom plug is installed and tightened securely before a launch

## 2-6 MAINTENANCE & TUNE-UP

### LUBRICATION

An outboard motor's greatest enemy is corrosion. Face it, oil and water just don't mix and, as anyone who has visited a junkyard knows, metal and water aren't the greatest of friends either. To expose an engine to a harsh marine environment of water and wind is to expect that these elements will take their toll over time. But, there is a way to fight back and help prevent the natural process of corrosion that will destroy your beloved boat motor.

Various marine grade lubricants are available that serve two important functions in preserving your motor. Lubricants reduce friction on metal-to-metal contact surfaces and, they also displace air and moisture, therefore slowing or preventing corrosion damage. Periodic lubrication services are your best method of preserving an outboard motor.

Lubrication takes place through various forms. For all engines, internal moving parts are lubricated by engine oil, either through oil contained in the fuel/oil mixture on 2-stroke motors, or the oil contained in the engine crankcase and pumped through oil passages in 4-stroke motors. On all motors (both 2 and 4-stroke) the gearcase is filled with gear oil that lubricates the driveshaft, propshaft, gears and other internal gearcase components. The gear oil for all motors and the engine crankcase oil on 4-stroke motors should be periodically checked and replaced following the appropriate Engine Maintenance procedures. Perform these services based on time or engine use, as outlined in the Maintenance Intervals chart at the end of this section.

For motors equipped with power trim/tilt, the fluid level and condition in the reservoir should be checked periodically to ensure proper operation. Proper fluid level not only ensures that the system will function properly, but also helps lubricate and protect the internal system components from corrosion.

Most other forms of lubrication occur through the application of grease (Yamaha all-purpose Marine grease, either applied by hand (an old toothbrush can be helpful in preventing a mess) or using a grease gun to pump the lubricant into grease fittings (also known as zerk fittings). When using a grease gun, do not pump excessive amounts of grease into the fitting. Unless otherwise directed, pump until either the rubber seal (if used) begins to expand or until the grease just begins to seep from the joints of the component being lubricated (if no seal is used).

To ensure your motor is getting the protection it needs, perform a visual inspection of the various lubrication points at least once a week during regular seasonal operation (this assumes that the motor is being used at least once a week). Follow the recommendations given in the Lubrication Chart at the end of this section and perform the various lubricating services at least every 60 days when the boat is operated in fresh water or every 30 days when the boat is operated in salt, brackish or polluted waters. We said **at least** meaning you should perform these services more often, if a need is discovered by your weekly inspections.

■ Jet drive models require one form of lubrication EVERY time that they are used. The jet drive bearing should be greased, following the procedure given in this section, after every day of boating. But don't worry, it only takes a minute once you've done it before.

#### Lubricants

◆ See Figures 9 and 10

#### \*\* WARNING

Lubricants recommended in the lubrication procedures in this manual are NOT interchangeable as each is designed to perform under different conditions.

#### Yamaha or Yamalube All Purpose Marine Grease

All-purpose marine grease is a general outboard lubricant/grease, chemically formulated to resist salt water. This lubricant is recommended for application to bearings, bushings, and oil seals.

#### Yamalube Lubricant

Yamalube lubricant is a two-stroke engine oil. It is a petroleum based, clean burning lubricant. Yamalube reduces carbon deposits and ensures maximum protection against engine wear. No oil additives are recommended by the manufacturer. Yamalube contains ashless detergent to minimize piston rings from sticking.

#### Yamaha or Yamalube Gearcase Lubricant

Yamaha or Yamalube Gearcase Lubricant contains high viscosity additives to protect the lower unit gears at high speed operation. The lubricant will extend gear life, reduce gear noise, minimize friction, and has a cooling affect on the lower unit moving parts.

#### Yamaha or Yamalube Power Trim and Tilt Fluid

Yamaha or Yamalube power trim and tilt fluid is a highly refined hydraulic fluid. This product has a high detergent content and additives to keep seals pliable. A high grade automatic transmission fluid, Dexron® or Type F, may be substituted if the Yamalube fluid is not available.

■ If a substitute fluid is used to top off the reservoir, the system should be drained and filled with a single product at the first opportunity. Brand names should never be mixed, if it's possible to avoid.



Fig. 9 Yamaha recommended lubricants and additives will not only keep the unit within the limits of the warranty but will also contribute to dependable performance and reduced maintenance costs



Fig. 10 Yamaha products, available from your local dealer, will do much to keep the outboard unit looking sharp and running right

## Lubricating the Motor

◆ See Figures 11 thru 16

The first thing you should do upon purchasing a new or "new to you" motor is to remove the engine top cover and look for signs of grease. Note all components that have been freshly greased (or if the motor has been neglected that shows signs of wear or dirt/contamination that have collected on the remnants of old applied grease). If the motor shows signs of dirt, corrosion or wear, clean those components thoroughly and apply a fresh coat of grease.

Thereafter, follow the recommendations in the accompanying lubrication chart (as they apply to the motor on which you are working) and grease all necessary surfaces regularly to keep them clean and well lubricated. As a general rule of them any point where two metallic mechanical parts connect and push, pull, turn, slide, pivot on each other should be greased. For most motors this will include shift and throttle cables and/or linkage, steering and swiveling points and items such as the cowl clamp bolts (on smaller motors) and top cover or cowling clamp levers.

■ For more information on greasing and lubrication points, check your owner's manual. Most Yamaha owner's manuals will provide one or more illustrations to help you properly identify all necessary greasing points.

Points such as the swivel bracket and/or the tilt tube will normally be equipped with grease (zerk) fittings. For these, use a grease gun to carefully pump small amounts of grease into the fittings, displacing some of the older grease and lubricating the internal surfaces of the swivel and tilt tubes. Some engine cowl levers require a dab of lubricant be applied manually over sliding surfaces, but many are also equipped with grease fittings for lubrication using a grease gun.

Items without a grease fitting, such as the steering ram, cable ends, shifter and carburetor linkage all must normally be greased by hand using a small dab of lubricant. Be sure not to over apply grease as it is just going to get over everything and exposed grease will tend to attract and hold dirt or other particles of general crud. For this reason it is always a good idea to wipe away the old grease before applying fresh lubricant to these surfaces.

## Lubrication Inside the Boat

The following points inside the boat will also usually benefit from lubrication with Yamalube All Purpose lubricant:

- Remote control cable ends next to the hand nut. DO NOT over-lubricate the cable.
- Steering arm pivot socket.
- Exposed shaft of the cable passing through the cable guide tube.
- Steering link rod to steering cable.

## Gearcase (Lower Unit) Oil

◆ See Figures 17 and 18

Regular maintenance and inspection of the lower unit is critical for proper operation and reliability. A lower unit can quickly fail if it becomes heavily contaminated with water or excessively low on oil. The most common cause of a lower unit failure is water contamination.

Water in the lower unit is usually caused by fishing line or other foreign material, becoming entangled around the propeller shaft and damaging the seal. If the line is not removed, it will eventually cut the propeller shaft seal and allow water to enter the lower unit. Fishing line has also been known to cut a groove in the propeller shaft if left neglected over time. This area should be checked frequently.

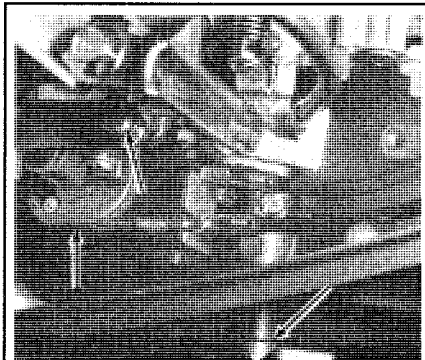


Fig. 11 Various lubrication points on the powerhead which should be maintained regularly to ensure a long service life with minimal downtime

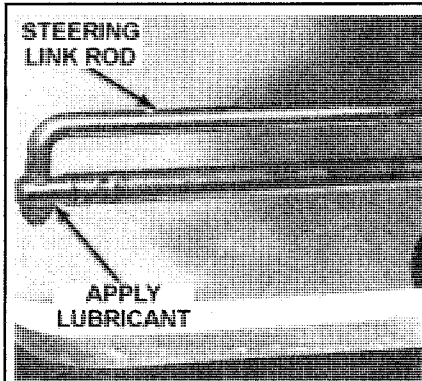


Fig. 12 Apply Yamaha All Purpose Grease to the steering link rod joint

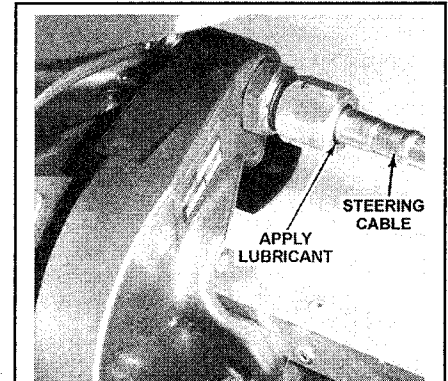


Fig. 13 The steering cable should be lubricated with Yamaha All Purpose Grease also

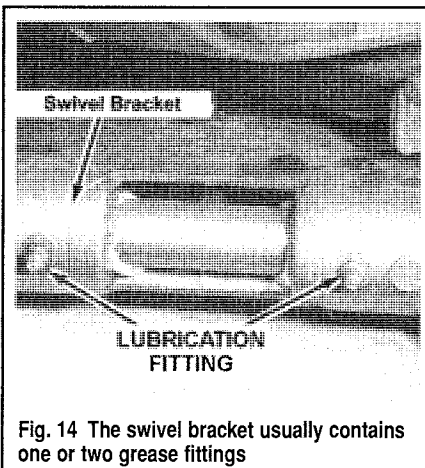


Fig. 14 The swivel bracket usually contains one or two grease fittings

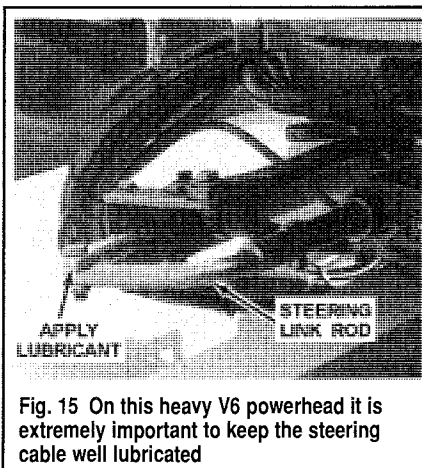


Fig. 15 On this heavy V6 powerhead it is extremely important to keep the steering cable well lubricated

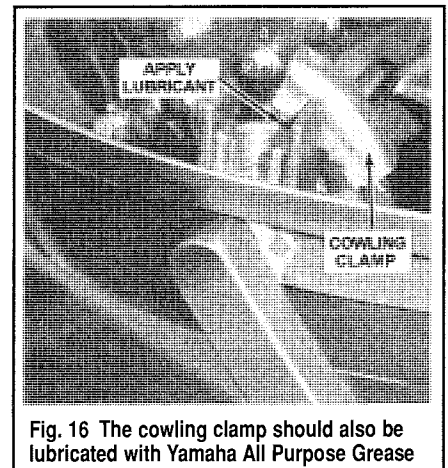


Fig. 16 The cowling clamp should also be lubricated with Yamaha All Purpose Grease

## 2-8 MAINTENANCE & TUNE-UP

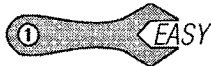
### OIL RECOMMENDATIONS

Use only Yamaha Gear Case Lube or an equivalent SAE-90W gearcase oil.

■ Remember, it is this lower unit lubricant that prevents corrosion and lubricates the internal parts of the drive gears. Lack of lubrication due to water contamination or the improper type of oil can cause catastrophic lower unit failure.

### CHECKING GEARCASE OIL LEVEL & CONDITION

◆ See Figure 19



Visually inspect the gearcase before and after each use for signs of leakage. At least monthly, or as needed, remove the gearcase level plug in order to check the lubricant level and condition as follows:

1. Position the engine in the upright position with the motor shut off for at least 1 hour. Whenever possible, checking the level overnight cold will give a true indication of the level without having to account for heat expansion.

2. Disconnect the negative battery cable or remove the propeller for safety.

#### \*\* CAUTION

Always observe extreme care when working anywhere near the propeller. Take steps to ensure that no accidental attempt to start the engine occurs while work is being performed or remove the propeller completely to be safe.

3. Position a small drain pan under the gearcase, then unthread the drain/filler plug at the bottom of the housing and allow a small sample (a teaspoon or less) to drain from the gearcase. Quickly install the drain/filler plug and tighten securely.

4. Examine the gear oil as follows:

a. Visually check the oil for obvious signs of water. A small amount of moisture may be present from condensation, especially if a motor has been stored for some time, but a milky appearance indicates that either the fluid has not been changed in ages or the gearcase allowing some water to intrude. If significant water contamination is present, the first suspect is the propeller shaft seal.

b. Dip an otherwise clean finger into the oil, then rub a small amount of the fluid between your finger and your thumb to check for the presence of debris. The lubricant should feel smooth. A **very** small amount of metallic shavings may be present, but should not really be felt. Large amounts of grit or metallic particles indicate the need to overhaul the gearcase looking for damaged/worn gears, shafts, bearings or thrust surfaces.

■ If a large amount of lubricant escapes when the level/vent plug is removed, either the gearcase was seriously overfilled on the last service, the crankcase is still too hot from the last use (and the fluid is expanded) or a large amount of water has entered the gearcase. If the latter is true, some water should escape before the oil and/or the oil will be a milky white in appearance (showing the moisture contamination).

5. Next, remove the level/vent plug from the top of the gearcase and ensure the lubricant level is up to the bottom of the level/vent plug opening. A very small amount of fluid may be added through the level plug, but larger amounts of fluid should be added through the drain/filler plug opening to make certain that the case is properly filled. If necessary, add gear oil until fluid flows from the level/vent opening. If much more than 1 oz. (29 ml) is required to fill the gearcase, check the case carefully for leaks. Install the drain/filler plugs and/or the level/vent plug, then tighten both securely.

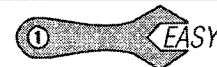
■ One trick that makes adding gearcase oil less messy is to install the level/vent plug **BEFORE** removing the pump from the drain/filler opening and threading the drain/filler plug back into position.

6. Once fluid is pumped into the gearcase, let the unit sit in a shaded area for at least 1 hour for the fluid to settle. Recheck the fluid level and, if necessary, add more lubricant.

7. Install the propeller and/or connect the negative battery cable, as applicable.

### DRAINING AND FILLING

◆ See Figures 20, 21 and 22



1. Place a suitable container under the lower unit. It is usually a good idea to place the outboard in the tilted position so the drain plug is at the lowest position on the gearcase, this will help ensure the oil drains fully.

2. Loosen the oil level/vent plug on the lower unit. This step is important! If the oil level/vent plug cannot be loosened or removed, you cannot complete lower unit lubricant service.

■ Never remove the vent or filler plugs when the lower unit is hot. Expanded lubricant will be released through the hole.

3. Remove the drain/filler plug from the lower end of the gear housing followed by the oil level/vent plug.

4. Allow the lubricant to completely drain from the lower unit.

5. If applicable, check the magnet end of the drain screw for metal particles. Some amount of metal is considered normal wear is to be expected but if there are signs of metal chips or excessive metal particles, the gearcase needs to be disassembled and inspected.

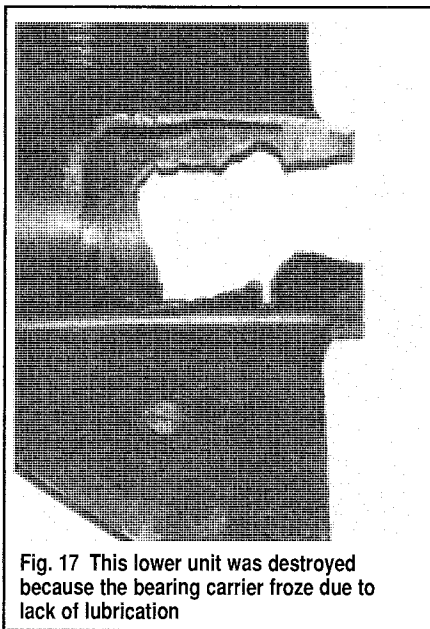


Fig. 17 This lower unit was destroyed because the bearing carrier froze due to lack of lubrication

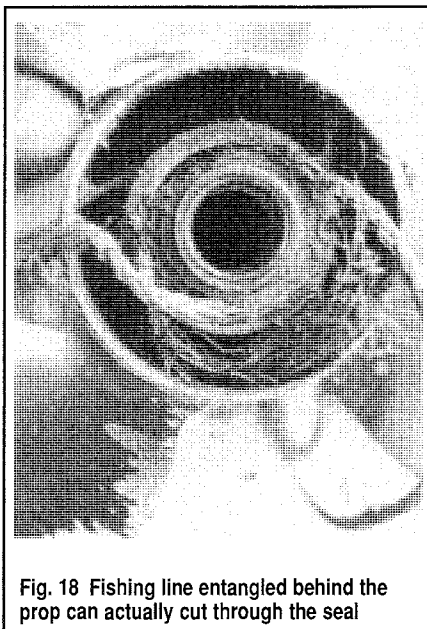


Fig. 18 Fishing line entangled behind the prop can actually cut through the seal

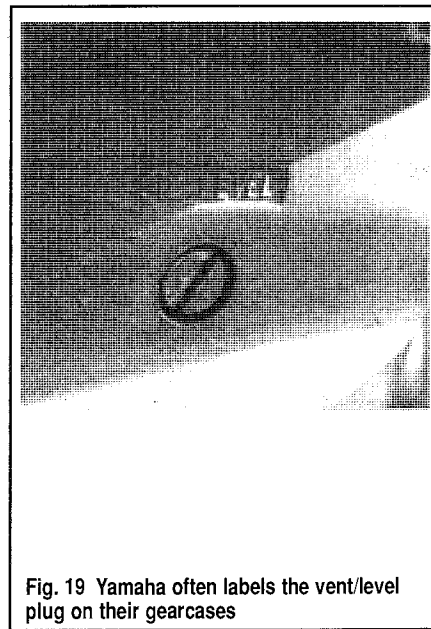
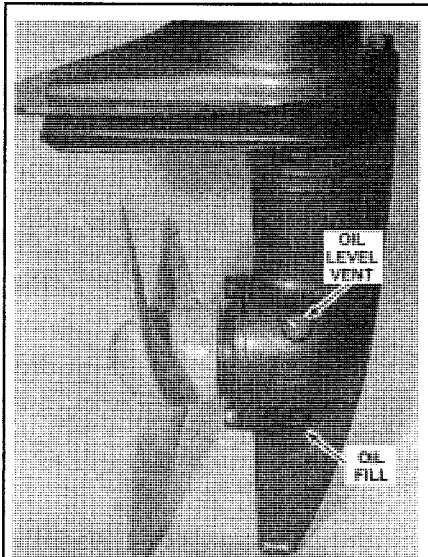
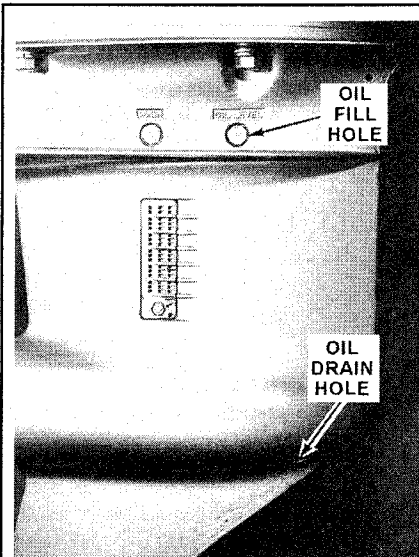


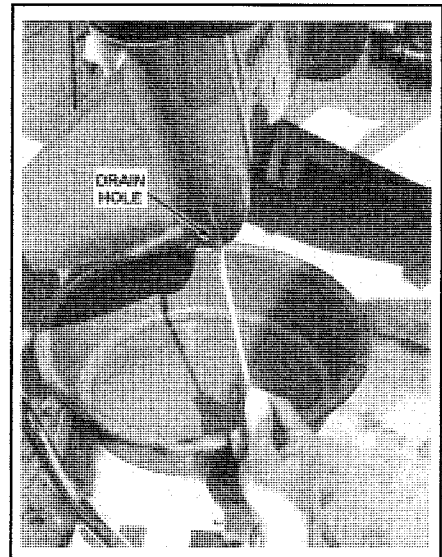
Fig. 19 Yamaha often labels the vent/level plug on their gearcases



**Fig. 20** On this single cylinder outboard the oil level and fill holes are close together, suggesting a small quantity of oil is used



**Fig. 21** While on this four cylinder outboard the oil level and fill holes are spread apart, suggesting a larger quantity of oil is used



**Fig. 22** When draining the lower unit, ensure it is fully tilted and a drain pan of adequate capacity is place to catch the lubricant

6. Inspect the lubricant for the presence of a milky white substance, water or metallic particles. If any of these conditions are present, the lower unit should be serviced immediately.

7. Place the outboard in the proper position for filling the lower unit (straight up and down). The lower unit should not list to either port or starboard and should be completely vertical.

8. Insert the lubricant tube into the oil drain hole at the bottom of the lower unit and inject lubricant until the excess begins to come out the oil level hole.

■ **The lubricant must be filled from the bottom to prevent air from being trapped in the lower unit. Air displaces lubricant and can cause a lack of lubrication or a false lubricant level in the lower unit.**

9. Oil should be squeezed in using a tube or with the larger quantities, by using a pump kit to fill the gearcase through the drain plug.

■ **One trick that makes adding gearcase oil less messy is to install the level/vent plug BEFORE removing the pump from the drain/filler opening and threading the drain/filler plug back into position.**

10. Using new gaskets/washers (if equipped) install the oil level/vent plug first, then install the oil fill plug.

11. Wipe the excess oil from the lower unit and inspect the unit for leaks.

12. Place the used lubricant in a suitable container for transportation to an authorized recycling facility.

## Jet Drive Bearing

◆ See Figure 23

Jet drive models covered by this manual require special attention to ensure that the driveshaft bearing remains properly lubricated.

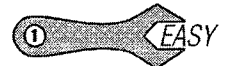
Yamaha recommends that you lubricate the jet drive bearing using a grease gun after EACH days use. However, at an absolute minimum, use the grease fitting every 10 hours (in fresh water) or 5 hours (in salt water). Also, after every 50 hours of fresh water operation or every 25 hours of salt/brackish/polluted water operation, the drive bearing grease must be replaced. Follow the appropriate procedure:

## RECOMMENDED LUBRICANT

Use Yamaha All-Purpose Marine grease or an equivalent water-resistant NLGI No. 1 lubricant.

## DAILY BEARING LUBRICATION

◆ See Figures 24 and 25

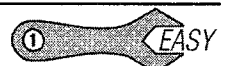


A grease fitting is located under a vent hose on the lower port side of the jet drive. Disconnect the hose from the fitting, then use a grease gun to apply enough grease to the fitting to just fill the vent hose. Basically, grease is pumped into the fitting until the old grease just starts to come out from the passages through the hose coupling, then reconnect the hose to the fitting.

■ **Do not attempt to just grasp the vent hose and pull, as it is a tight fit and when it does come off, you'll probably go flying if you didn't prepare for it. The easier method of removing the vent hose from the fitting is to deflect the hose to one side and snap it free from the fitting.**

## GREASE REPLACEMENT

◆ See Figures 24, 25 and 26



A grease fitting is located under a vent hose on the lower port side of the jet drive. This grease fitting is utilized at the end of each day's use to add fresh grease to the jet drive bearing. But, every 50 or 25 hours and/or 30 or 15 days (depending if use is in fresh or salt/brackish/polluted waters), the grease should be completely replaced. This is very similar to the daily greasing, except that a lot more grease is used. Disconnect the hose from the fitting (by deflecting it to the side until it snaps free from the fitting), then use a grease gun to apply enough grease to the fitting until grease exiting the assembly fills the vent hose. Then, continue to pump grease into the fitting to force out all of the old grease (you can tell this has been accomplished when fresh grease starts to come out of the vent instead of old grease, which will be slightly darker due to minor contamination from normal use). When nothing but fresh grease comes out of the vent the fresh grease has completely displaced the old grease and you are finished. Be sure to securely connect the vent hose to the fitting.

Each time this is performed, inspect the grease for signs of moisture contamination or discoloration. A gradual increase in moisture content over a few services is a sign of seal wear that is beginning to allow some seepage. Very dark or dirty grease may indicate a worn seal (inspect and/or replace the seal, as necessary to prevent severe engine damage should the seal fail completely).

■ **Keep in mind that some discoloration of the grease is expected when a new seal is broken-in. The discoloration should go away gradually after one or two additional grease replacement services.**

## 2-10 MAINTENANCE & TUNE-UP

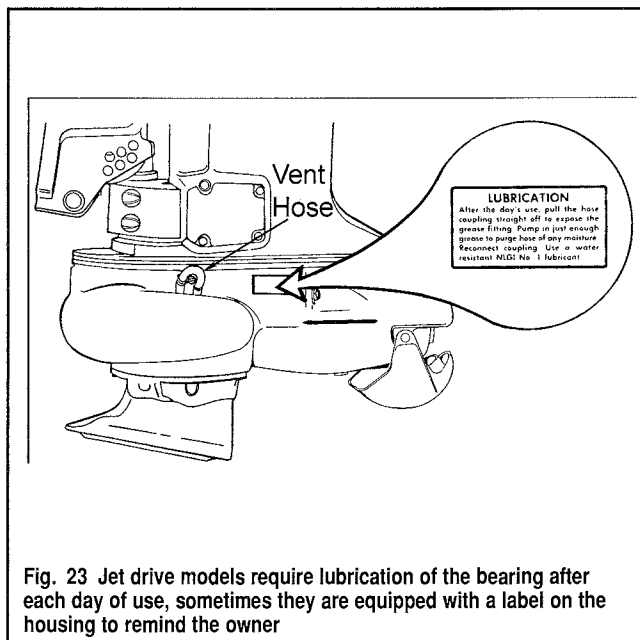


Fig. 23 Jet drive models require lubrication of the bearing after each day of use, sometimes they are equipped with a label on the housing to remind the owner

Whenever the jet drive bearing grease is replaced, take a few minutes to apply some of that same water-resistant marine grease to the pivot points of the jet linkage.

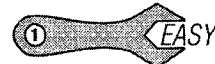
### Power Trim/Tilt Reservoir

#### RECOMMENDED LUBRICANT

Yamaha or Yamalube power trim and tilt fluid is a highly refined hydraulic fluid. This product has a high detergent content and additives to keep seals pliable. A high grade automatic transmission fluid, Dexron® or Type F, may be substituted if the Yamalube fluid is not available.

#### CHECKING FLUID LEVEL/CONDITION

◆ See Figures 27, 28 and 29



The fluid in the power trim/tilt reservoir should be checked periodically to ensure it is full and is not contaminated. To check the fluid, tilt the motor upward to the full tilt position, then manually engage the tilt support for safety and to prevent damage. Loosen and remove the filler plug using a suitable socket or wrench and make a visual inspection of the fluid. It should seem clear and not milky. The level is proper if, with the motor at full tilt, the level is even with the bottom of the filler plug hole.

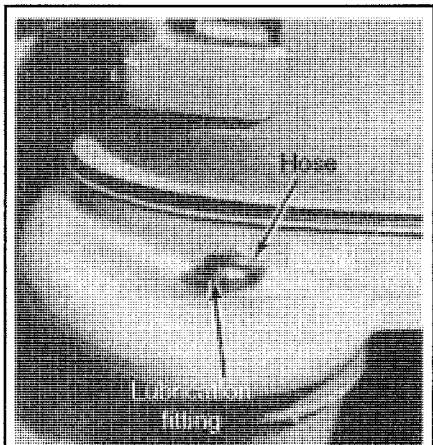


Fig. 24 The jet drive lubrication fitting is found under the vent hose

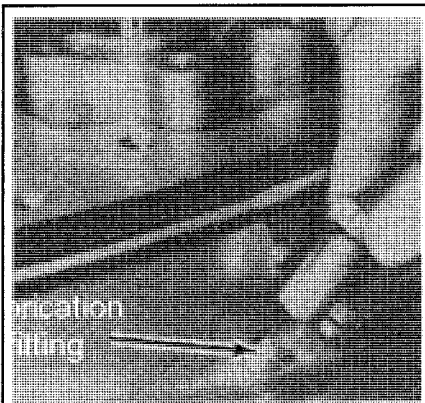


Fig. 25 Attach a grease gun to the fitting for lubrication

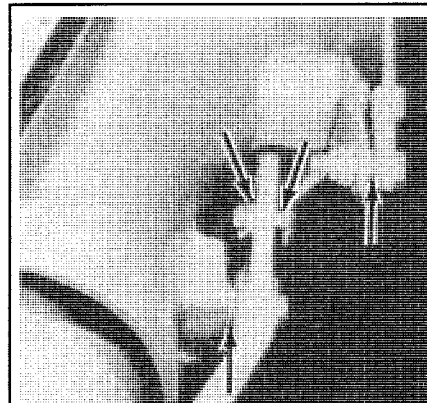


Fig. 26 Also, coat the pivot points of the jet linkage with grease periodically

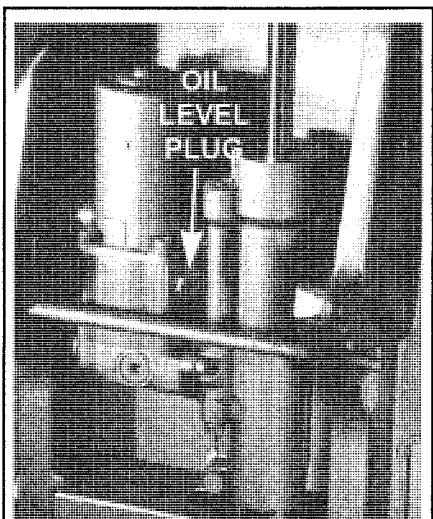


Fig. 27 The power tilt only system uses a single tilt rod

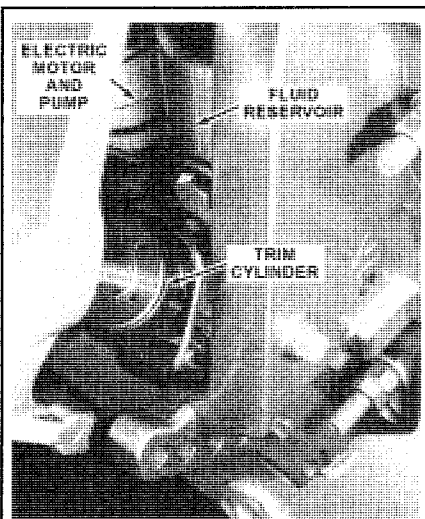


Fig. 28 More common, is the power trim and tilt system which uses one tilt and two trim rods...

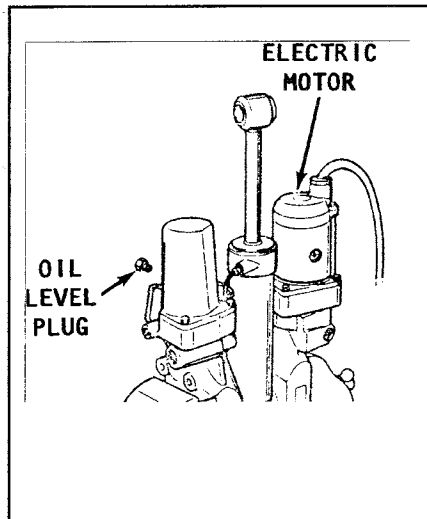


Fig. 29 ... the fill plug is on the front of the reservoir

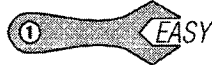


**ENGINE MAINTENANCE**

**Engine Covers (Top Cover and Cowling)**

**REMOVAL & INSTALLATION**

◆ See Figures 30, 31, 32, 33, 34 and 35



Removal of the top cover is necessary for the most basic of maintenance and inspection procedures. The cover should come off before and after each use in order to perform these basic safety checks. Unlike some outboard manufacturers that use large and intricate multi-piece lower covers/cowlings, most Yamaha outboards simple use a low profile 1-piece cowling that does not require removal except during powerhead R&R. However there are a few exceptions on larger motors that are equipped with fore or aft lower covers that cover the intermediate housing or part of the steering bracket. Removal of those lower covers is normally pretty straight forward in that most fasteners are exposed and obvious.

Although top cover removal will vary slightly from motor to motor, most have one or two latches which must be released in order to free the cover from the cowling. On smaller motors, if only one lever is used either the other end of the cover is secured by a tab that is held in place by friction once the lever is secured. On larger motors (mostly V6 models) one lever may be connected by cable to a release mechanism at both ends of the top cover.

Probably the most common form of cover retention on Yamaha outboards is the use of 2 separate levers, one at the front and one at the rear of the outboard. These levers are horizontal when latched and rotated 1/4 turn downward to release.

As mentioned in the lubrication section all cover latch mechanisms should be wiped clean and re-greased periodically to ensure proper operation and to prevent un-necessary wear or damage.

Whenever the top cover is removed, check the cover seal (a rubber insulator normally used between the cover and cowling) for wear or damage.

Take the opportunity to perform a quick visual inspection for leaking hoses, chaffing wires etc. Get to know where things are placed under the cover so you'll recognize instantly if something is amiss. When installing the cover, care must be taken to ensure wiring and hoses are in their original positions to prevent damage. Once the cover is installed, make sure the latches grab it securely to prevent it from coming loose and flying off while underway.

**Cooling System**

**FLUSHING THE COOLING SYSTEM**

◆ See Figures 36, 37 and 38



The most important service that you can perform on your motor's cooling system is to flush it periodically using fresh, clean water. This should be done immediately following any use in salt, brackish or polluted waters in order to prevent mineral deposits or corrosion from clogging cooling passages. Even if you do not always boat in salt or polluted waters, get used to the flushing procedure and perform it often to ensure no silt or debris clogs your cooling system over time.

■ Flush the cooling system after any use in which the motor was operated through suspended/churned-up silt, debris or sand.

Although the flushing procedure should take place right away (dockside or on the trailer), be sure to protect the motor from damage due to possible thermal shock. If the engine has just been run under high load or at continued high speeds, allow time for it to cool to the point where the powerhead can be touched. Do not pump very cold water through a very hot

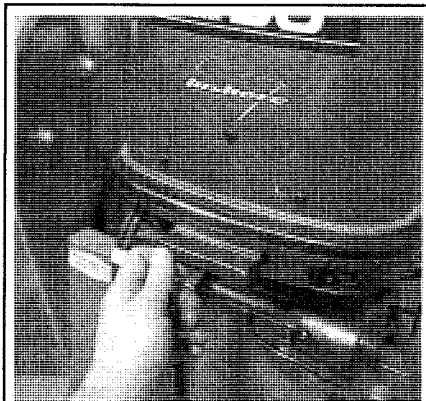


Fig. 30 Most covers are secured by 1 or 2 latches...

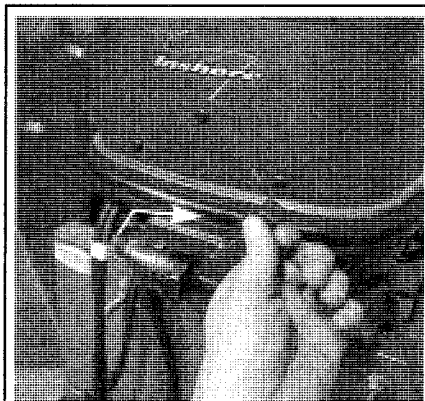


Fig. 31 which are rotated 1/4 upward...



Fig. 32 ... or downward to release

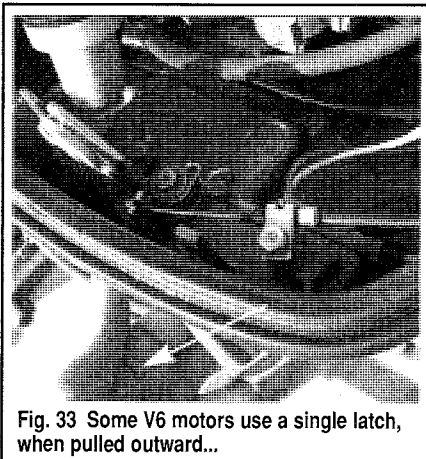


Fig. 33 Some V6 motors use a single latch, when pulled outward...

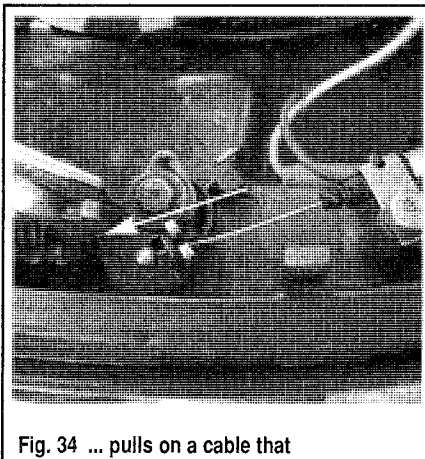


Fig. 34 ... pulls on a cable that

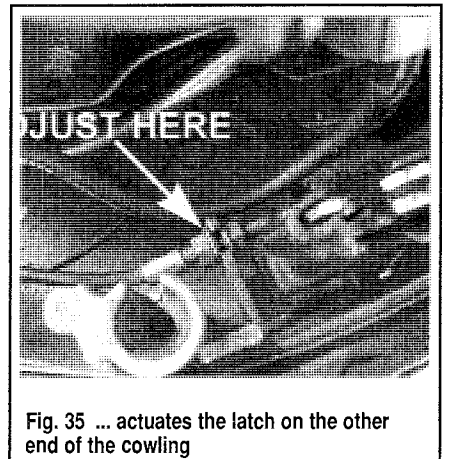


Fig. 35 ... actuates the latch on the other end of the cowling

## 2-12 MAINTENANCE & TUNE-UP

engine, or you are just asking for trouble. If you trailer your boat short distances, the flushing procedure can probably wait until you arrive home or wherever the boat is stored, but ideally it should occur within an hour of use in salt water. Remember that the corrosion process begins as soon as the motor is removed from the water and exposed to air.

The flushing procedure is not used only for cooling system maintenance, but it is also a tool with which a technician can provide a source of cooling water to protect the engine (and water pump impeller) from damage anytime the motor needs to be run out of the water. **Never** start or run the engine out of the water, even for a few seconds, for any reason. Water pump impeller damage can occur instantly and damage to the engine from overheating can follow shortly thereafter. If the engine must be run out of the water for tuning or testing, always connect an appropriate flushing device **before** the engine is started and leave it turned on until **after** the engine is shut off.

### \*\* WARNING

**ANYTIME the engine is run, the first thing you should do is check the cooling stream or water indicator. All Yamahas are equipped with some form of a cooling stream indicator towards the aft portion of the lower engine cover. Anytime the engine is operating, a steady stream of water should come from the indicator, showing that the pump is supplying water to the engine for cooling. If the stream is ever absent, stop the motor and determine the cause before restarting.**

As we stated earlier, flushing the cooling system consists of supplying fresh, clean water to the system in order to clean deposits from the internal passages. If the engine is running, the water does not normally have to be pressurized, as it is delivered through the normal water intake passages and the water pump (the system can self flush if supplied with clean water). Smaller, portable engines can be flushed by mounting them in a test tank (a sturdy, metallic 30 gallon drum or garbage pail filled with clean water).

Although a few late-model Yamahas (mostly V models in 1995 and 1996) are equipped with built-in flushing adapters, all motors will also accept a generic (ear-muff type) flush adapters. The generic adapters fit over the engine water intakes on the gearcase (and resemble a pair of strange earmuffs with a hose fitting on one side).

■ Most jet drive models are equipped with a flushing port mounted under a flat head screw directly above the jet drive bearing grease fitting. For more information, please refer to **FLUSHING JET DRIVES**, later in this section.

■ When running the engine on a flushing adapter using a garden hose, make sure the hose delivers about 20-40 psi (140-300 kPa) of pressure.

Some of the smaller, portable motors covered by this manual utilize a water intake that is directly above the propeller. On these models the propeller must usually be removed before a clamp style flush adapter can be connected to the motor (unless the adapter is very thin and mounted so close to the anti-ventilation plate that it will not be hit by the propeller).

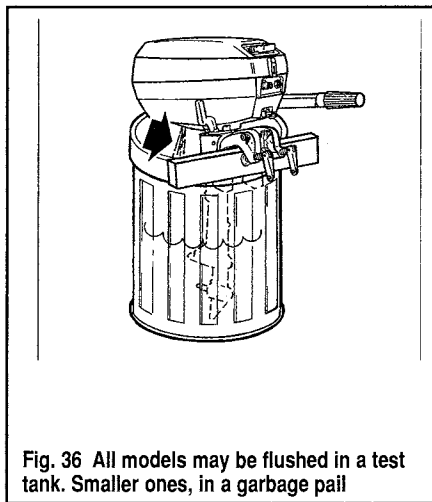


Fig. 36 All models may be flushed in a test tank. Smaller ones, in a garbage pail

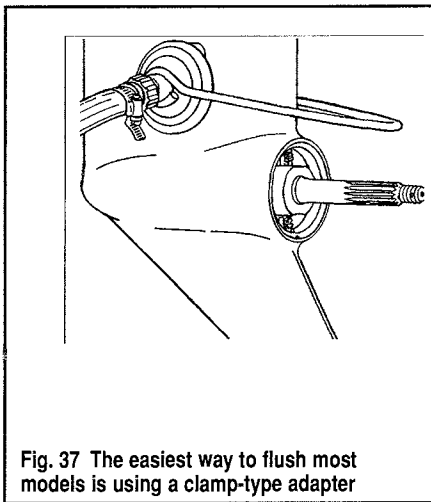


Fig. 37 The easiest way to flush most models is using a clamp-type adapter

### \*\* CAUTION

**For safety, the propeller should be removed ANYTIME the motor is run on the trailer or on an engine stand. We realize that this is not always practical when flushing the engine on the trailer, but cannot emphasize enough how much caution must be exercised to prevent injury to you or someone else. Either take the time to remove the propeller or take the time to make sure no-one or nothing comes close enough to it to become injured. Serious personal injury or death could result from contact with the spinning propeller.**

1. Check the engine top case and, if necessary remove it to check the powerhead, to ensure it is cooled enough to flush without causing thermal shock.

2. Prepare the engine for flushing depending on the method you are using as follows:

a. If using a test tank, make sure the tank is made of sturdy material, then securely mount the motor to the tank. If necessary, position a wooden plank between the tank and engine clamp bracket for thickness. Fill the tank so the water level is at least 4 in. (10cm) above the anti-ventilation plate (above the water inlet).

b. If using a flushing adapter of either the generic clamp-type or specific port-type for your model attach the water hose to the flush test adapter and connect the adapter to the motor following the instructions that came with the adapter. If the motor is to be run (for flushing or testing), position the outboard vertically and remove the propeller, for safety. Also, be sure to position the water hose so it will not contact with moving parts (tie the hose out of the way with mechanic's wire or wire ties, as necessary).

### \*\* WARNING

**If using the built-in adapter for flushing, check your owner's manual or with a dealer to determine if your particular motor may be run when using this device. If not, use it only for flushing the cooling system and use ear-muff style adapters for a cooling water source if the motor is to be run out of the water.**

■ When using a clamp-type adapter, position the suction cup(s) over water intake grate(s) in such a way that they form tight seals. A little pressure seepage should not be a problem, but look to the water stream indicator once the motor is running to be sure that sufficient water is reaching the powerhead.

3. Unless using a test tank, turn the water on, making sure that pressure does not exceed 45 psi (300 kPa).

4. If using a test tank or if the motor must be run for testing/tuning procedures, start the engine and run in neutral until the motor reaches operating temperature. The motor will continue to run at fast idle until warmed.

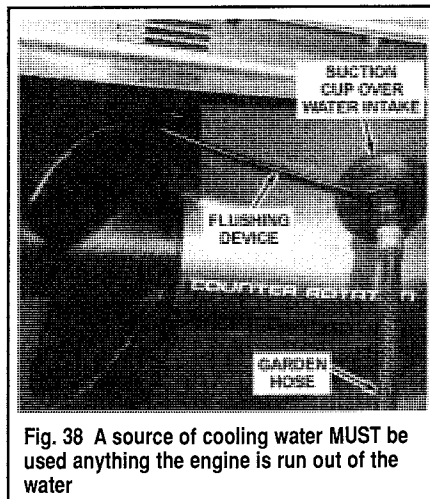


Fig. 38 A source of cooling water **MUST** be used anything the engine is run out of the water

## \*\* WARNING

As soon as the engine starts, check the cooling system indicator stream. It must be present and strong as long as the motor is operated. If not, stop the motor and rectify the problem before proceeding. Common problems could include insufficient water pressure or incorrect flush adapter installation.

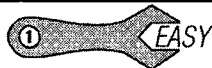
5. Flush the motor for at least 5-10 minutes or until the water exiting the engine is clear. When flushing while running the motor, check the engine temperature (using a gauge or carefully by touch) and stop the engine immediately if steam or overheating starts to occur. Make sure that carbureted motors slow to low idle for the last few minutes of the flushing procedure.

6. Stop the engine (if running), then shut the water off.

7. Remove the adapter from the engine or the engine from the test tank, as applicable.

8. If flushing did not occur with the motor running (so the motor would already be vertical), be sure to place it in the full vertical position allowing the cooling system to drain. This is especially important if the engine is going to be placed into storage and could be exposed to freezing temperatures. Water left in the motor could freeze and crack the powerhead or gearcase.

## FLUSHING JET DRIVES



Regular flushing of the jet drive will prolong the life of the powerhead, by clearing the cooling system of possible obstructions.

### Models With a Flushing Plug

#### ◆ See Figure 39

Most jet drives are equipped with a plug on the port side just above the lubrication hose.

1. Remove the plug and gasket, install the flush adapter, connect the garden hose and turn on the water supply.

2. Start and operate the powerhead at a fast idle for about 15 minutes. Disconnect the flushing adapter and replace the plug.

■ The procedure just described will only flush the powerhead cooling system, not the jet drive and impeller. To flush the jet drive unit, direct a stream of high pressure water through the intake grille.

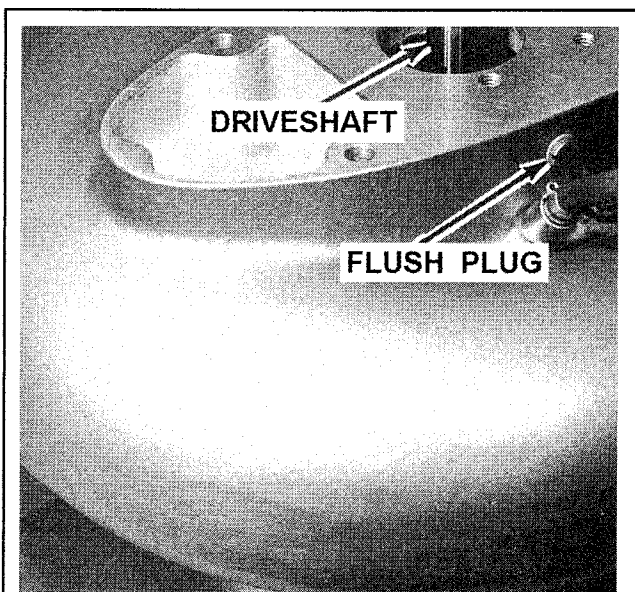


Fig. 39 Most jet drives are equipped with a flushing plug on the side of the unit

### Models Without a Flushing Plug

#### ◆ See Figure 40

Units not equipped with a flushing plug can be suitably modified by drilling and tapping a small hole in the port side of the jet drive unit to accept a flush adapter. Proceed as follows:

1. The jet drive must be dropped from the intermediate housing and disassembled.

2. Deflect the lubrication hose coupler sideways to remove it from the grease fitting and secure the hose out of the way.

3. Drill a 15/64 in. hole above the grease fitting, as illustrated. Using an 8mm x 1.25 tap thread the hole. Blow away all metal chips from the interior and exterior of the housing, using compressed air.

4. Install the plug and gasket (available at the local Yamaha dealer). Assemble and install the jet drive to the intermediate housing.

5. The powerhead may now be flushed as described in the previous section for units with the flush plug.

## Engine Oil (2-Stroke)

### OIL RECOMMENDATIONS

#### ◆ See Figure 41

Use only an NMMA (National Marine Manufacturers Association) certified TC-W3 or equivalent 2-stroke lubricant. Of course, Yamaha recommends Yamalube 2-stroke engine oil lubricant, since it is specially formulated to match the needs of Yamaha motors. Yamalube is a petroleum based, clean burning lubricant that reduces carbon deposits and ensures maximum protection against engine wear. Yamalube contains ashless detergent to minimize piston rings from sticking.

■ Yamaha does not recommend the use of any oil additives.

In all cases, use a high quality TC-W3 oils designed to ensure optimal engine performance and to minimize combustion chamber deposits, to avoid detonation and prolong spark plug life. Use only 2-stroke type outboard oil. Never use automotive motor oil.

■ Remember, it is this oil, mixed with the gasoline that lubricates the internal parts of the 2-stroke engine. Lack of lubrication due to the wrong mix or improper type of oil can cause catastrophic powerhead failure.

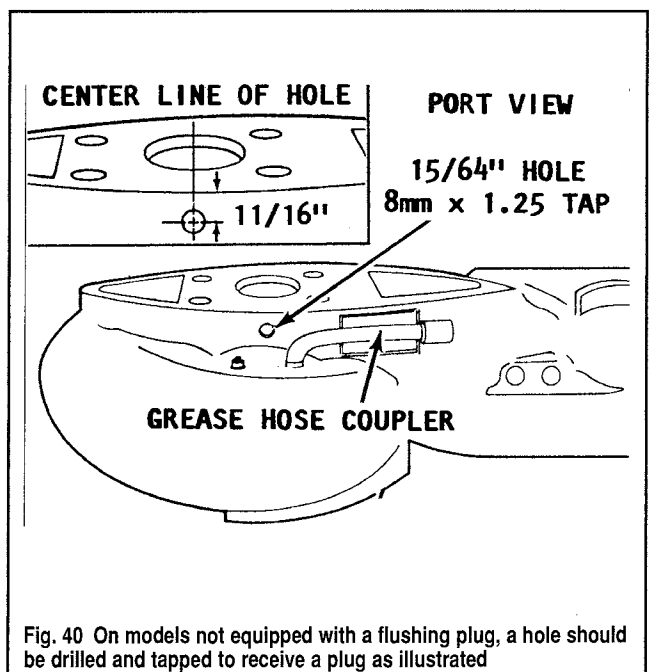
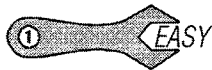


Fig. 40 On models not equipped with a flushing plug, a hole should be drilled and tapped to receive a plug as illustrated

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### FILLING



There are two methods of adding 2-stroke oil to an outboard. The first is the pre-mix method used on most low horsepower and on some commercial outboards. The second is the Precision Blend system that automatically injects the correct quantity of oil into the engine based on throttle position and operating conditions. In both cases, the fuel ratio should be considered. This is even true on automatic oiling systems for special operation, such as during break-in.

#### Fuel:Oil Ratio

The proper fuel:oil ratio will depend upon the engine and operating conditions. Most Yamahas above 15 hp are equipped (or may be equipped) with the Precision Blend oil injection system. The system is usually designed to maintain a 50:1 ratio without adding anything to the fuel tank. When the injection system is not used most Yamahas require either a fuel:oil ratio of 100:1 for smaller motors or 50:1 for larger motors.

■ **Check the Capacities Specifications chart at the end of this section for more details on your motor. But realize that these are the specs listed in Yamaha service literature. Because your engine may differ slightly from service manual specification, refer to your owner's manual or a reputable dealer to be certain that you use the proper mixture for your motor.**

Regardless of the normal operational fuel:oil ratio, it should be doubled during the first 10 hours of break-in for a new or rebuilt powerhead. That means motors which normally run 100:1 ratio should run 50:1 ratio for 10 hours. Subsequently, motors that normally run a 50:1 ratio should run a 25:1 ratio during this break-in period.

■ **Motors equipped with the precision blend oiling system should run a 50:1 ratio of pre-mix in the boat or portable fuel tank during break-in. This, added to the normal output of the oiling system will produce the proper 25:1 or 50:1 break-in ratio required to ensure proper seating of the pistons and rings during break-in. Pre-mix should be discontinued on Precision Blend motors once the 10 hour period has expired (as long as proper oil system operation is verified by a change in oil level before and after the 10 hour period).**

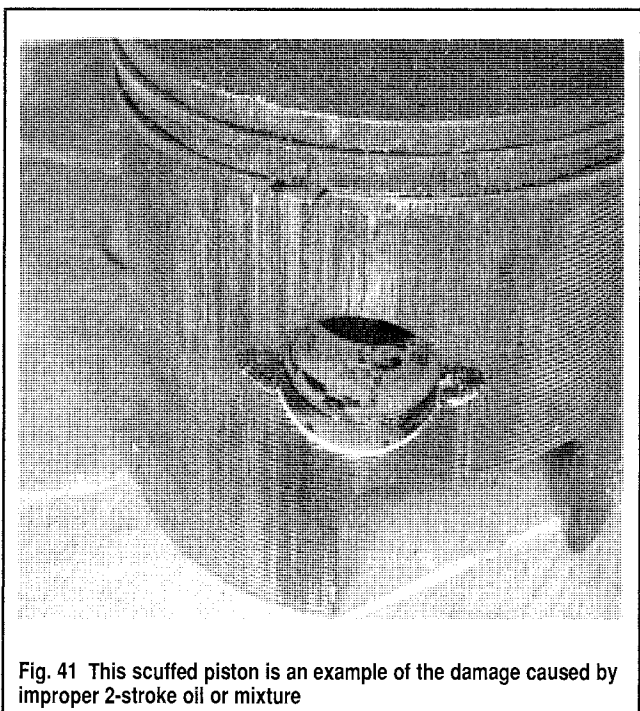


Fig. 41 This scuffed piston is an example of the damage caused by improper 2-stroke oil or mixture

#### Pre-Mix

◆ See Figure 42

Mixing the engine lubricant with gasoline before pouring it into the tank is by far the simplest method of lubrication for 2-stroke outboards. However, this method is the messiest and causes the most amount of harm to our environment.

The most important part of filling a pre-mix system is to determine the proper fuel/oil ratio. Yamaha motors normally either a 100:1 or a 50:1 ratio (that is 100 or 50 parts of fuel respectively to 1 part of oil). Consult the information in this section on Fuel:Oil Ratio and your owner's manual to determine what the appropriate ratio should be for your engine.

The procedure itself is uncomplicated, but you've got a couple options depending on how the fuel tank is set-up for your boat. To fill an empty portable tank, add the appropriate amount of oil to the tank, then add gasoline and close the cap. Rock the tank from side-to-side to gently agitate the mixture, thereby allowing for a thorough mixture of gasoline and oil. When just topping off built-in or larger portable tanks, it is best to use a separate 3 or 6 gallon (11.4 or 22.7 L) mixing tank in the same manner as the portable tank noted earlier. In this way a more exact measurement of fuel can occur in 3 or 6 gallon increments (rather than just directly adding fuel to the tank and realizing that you've just added 2.67 gallons of gas and need to add, uh, a little less than 8 oz of oil for a 50:1 ratio, but exactly how many ounces would that be?) Use of a mixture tank will prevent the need for such mathematical equations. Of course, the use of a mixing tank may be inconvenient or impossible under certain circumstances, so the next best method for topping off is to take a good guess (but be a little conservative to prevent an excessively rich oil ratio). Either add the oil and gasoline at the same time, or add the oil first, then add the gasoline to ensure proper mixing. For measurement purposes, it would obviously be more exact to add the gasoline first, then add a suitable amount of oil to match it. The problem with adding gasoline first is that unless the tank could be thoroughly agitated afterward (and that would be really difficult on built-in tanks), the oil might not mix properly with the gasoline. Don't take that unnecessary risk.

To determine the proper amount of oil to add to achieve the desired fuel:oil ratio, refer to the Fuel:Oil Ratio chart at the end of this section.

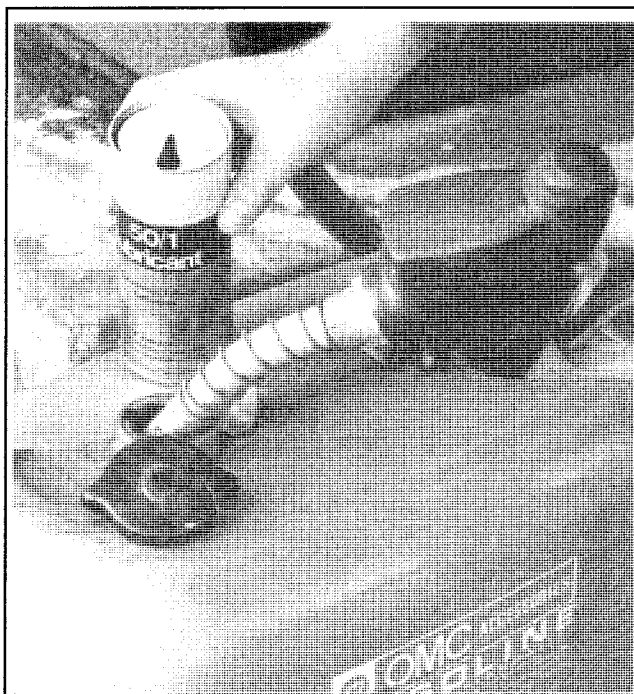


Fig. 42 For portable tanks, either add the oil and gasoline at the same time, or add the oil first, then add the gasoline to ensure proper mixing

## Oil Injection

◆ See Figures 43, 44 and 45

Most outboard manufacturers use a mechanically driven oil pump mounted to the powerhead that is connected to the throttle by way of a linkage arm. The system is powered by the crankshaft, which drives a gear in the pump, creating oil pressure. As the throttle lever is advanced to increase engine speed, the linkage arm also moves, opening a valve that allows more oil to flow into the oil pump.

Most mechanical-injection systems incorporate low-oil warning alarms that are also connected to an engine-overheating sensor. Also, these systems may have a built-in speed limiter. This sub-system is designed to reduce engine speed automatically when oil problems occur. This important feature goes a long way toward preventing severe engine damage in the event of an oil injection problem.

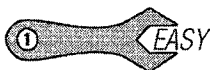
The procedure for filling these systems is simple. Most Yamaha motors, except some of the V6 engines, utilize a powerhead mounted oil reservoir. Many V6 motors are also equipped with a remote, boat mounted, oil tank (a larger tank designed to hold more oil than a powerhead mounted unit). In either case, the tank contains a filler cap that is removed in order to add oil to the tank. Be sure to check the oil level EVERY time the motor is operated. Whenever oil is added, place a piece of tape on the tank to mark the level and watch how fast it drops in relation to engine usage (hours and fuel consumption). Watch for changes in usage patterns that could indicate under or over oiling. Especially with a system that suddenly begins to deliver less oil, you could save yourself significant engine damage by discovering a problem that could have starved the motor for lubrication.

Should the oil hose become disconnected or suffer a break/leak, the oil prime might be lost. If so, the system should be primed **before** priming the fuel system and starting the engine. More details on servicing the oiling system are found in the Lubrication section of this manual.

■ It is highly advisable to carry a few spare bottles of 2-stroke oil with you onboard. Even in the event of an oil system failure, oil can be added to a fuel tank (in the proper ratio) in order to limp the boat and motor safely home.

## CHECKING FOR WATER OR CONTAMINANTS

◆ See Figure 46



To protect the powerhead from potential damage should contaminants enter the oil system (instead of oil), you should ALWAYS perform a quick check of the oil tank before every outing. Powerhead mounted oil tanks are normally equipped with a water and contaminant trap (usually a short length of dead-end hose on the bottom of the tank, but some models may be equipped with a drain hose that is run up and attached to the filler neck).

If water or contaminants are found, they must be removed in order to protect the motor. If large amounts are present, the tank should be drained and thoroughly cleaned. Also, if large amounts of water or contaminants are

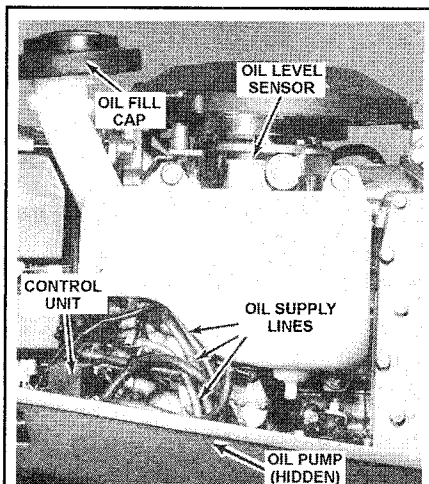


Fig. 43 Most Yamaha motors use a powerhead mounted oil reservoir...

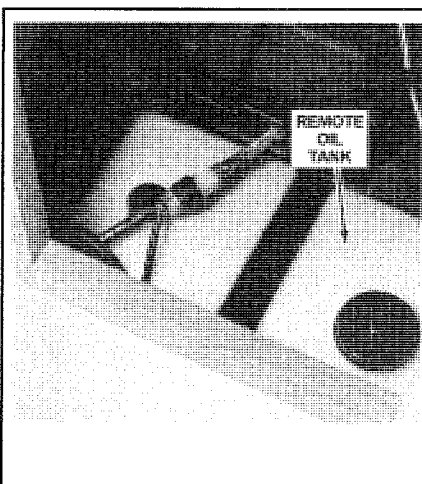


Fig. 44... but many V6 motors utilize a boat mounted remote oil tank

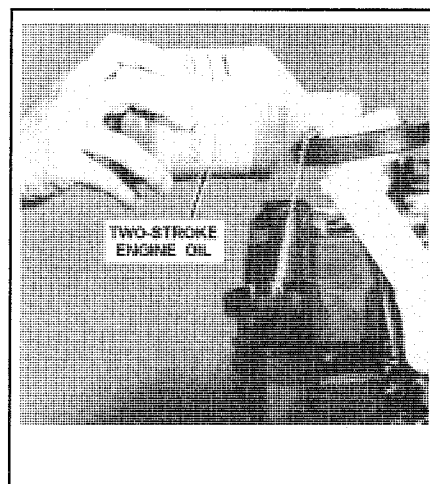


Fig. 45 In both cases, check the oil EVERY outing and add when necessary

present, you'd do well to discover the source. What gremlin is sneaking onto your boat at night, opening the cap and putting them there?

## Engine Oil and Filter (4-Stroke)

### OIL RECOMMENDATIONS

For all 4-stroke motors through 1995, Yamaha recommends the use of a high quality 4-stroke motor oil of SAE 10W-30 or 10W-40 viscosity with an API rating of SE or higher (SF, SG or SH is acceptable). However, if the engine is to be operated only in conditions of ambient temperatures above 68°F (20°C), using SAE 20W-40 is also acceptable.

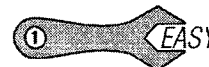
The Society of Automotive Engineers (SAE) grade number indicates the viscosity of the engine oil; its resistance to flow at a given temperature. The lower the SAE grade number, the lighter the oil. For example, the mono-grade oils begin with SAE 5 weight, which is a thin light oil, and continue in viscosity up to SAE 80 or 90 weight, which are heavy gear lubricants. These oils are also known as "straight weight", meaning they are of a single viscosity, and do not vary with engine temperature.

Multi-viscosity oils offer the important advantage of being adaptable to temperature extremes. These oils have designations such as 10W-40, 20W-50, etc. The 10W-40 means that in winter (the "W" in the designation) the oil acts like a thin 10 weight oil, allowing the engine to spin easily when cold and offering rapid lubrication. Once the engine has warmed up, however, the oil acts like a straight 40 weight, maintaining good lubrication and protection for the engine's internal components. A 20W-50 oil would therefore be slightly heavier than and not as ideal in cold weather as the 10W-40, but would offer better protection at higher rpm and temperatures because when warm it acts like a 50 weight oil. Whichever oil viscosity you choose when changing the oil, make sure you are anticipating the temperatures your engine will be operating in until the oil is changed again.

The American Petroleum Institute (API) designation indicates the classification of engine oil used under certain given operating conditions. Only oils designated for use "Service SG, SH" or greater should be used. Oils of the SG, SH or its superseding oil type perform a variety of functions inside the engine in addition to the basic function as a lubricant. Through a balanced system of metallic detergents and polymeric dispersants, the oil prevents the formation of high and low temperature deposits and also keeps sludge and particles of dirt in suspension. Acids, particularly sulfuric acid, as well as other by-products of combustion, are neutralized. Both the SAE grade number and the API designation can be found on top of the oil bottle.

### CHECKING OIL LEVEL

◆ See Figure 47, 48 and 49



One of the most important service items for a 4-stroke engine is maintaining the proper level of fresh, clean engine oil in the crankcase. Be certain to check the oil level both before and after each time the boat is used. In order to check the oil level the motor must be placed in the full

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vertical position. Because it takes some time for the oil to settle (and at least partially cool), the engine must be shut off for at least 30 minutes before truly accurate reading can be attained. If the boat is trailered, use the time for loading the boat onto the trailer and prepping the trailer for towing to allow the motor to cool. If the boat is kept in the water, take some time around the dock to secure lines, stow away items kept onboard and clean up the deck while waiting for the oil to settle/cool.

### \*\* WARNING

**Running an engine with an improper oil level can cause significant engine damage. Although it is typically worse to run an engine with abnormally low oil, it can be just as harmful to run an engine that is overfilled. Don't take that risk, make checking the engine oil a regular part of your launch and recovery/docking routine.**

All motors covered by this manual are equipped with an automotive-style dipstick and oil filler cap located on the powerhead. The engine cover must be removed for access, but once removed it should be easy to locate the dipstick and filler cap if you look in the right spot (as they vary with the engine size):

- For 9.9 hp (232cc) models, the oil dipstick is normally found under the engine top cover toward the center of the starboard side of the powerhead. The oil filler cap is found at the rear of the motor, toward the starboard side of the valve cover.

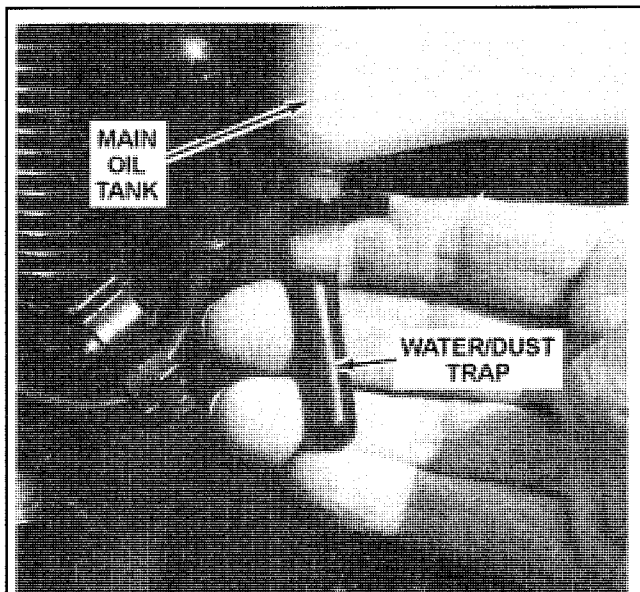


Fig. 46 Check the oil reservoir trap for water or contaminants before EVERY outing

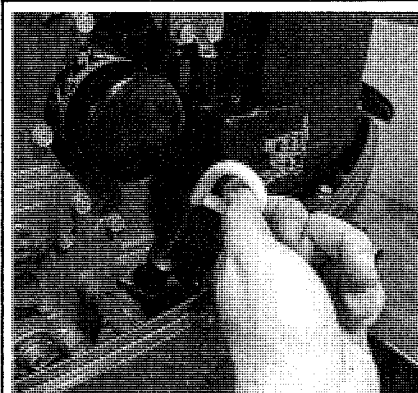


Fig. 47 Locate the dipstick on the side of the powerhead...

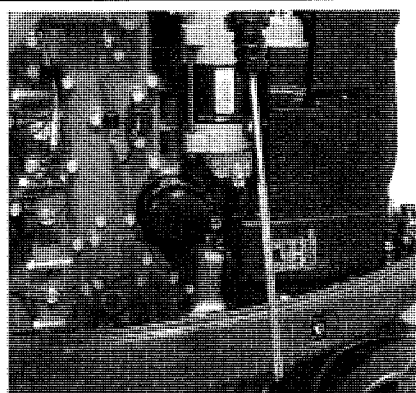


Fig. 48 ... and remove it, holding it vertically as shown

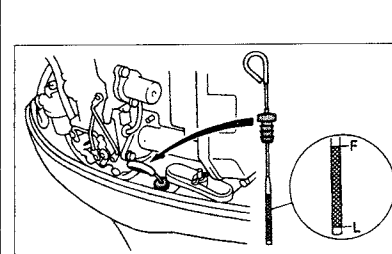


Fig. 49 Make sure the oil is in the acceptable range (45/50 hp shown)

- For 45/50 hp (935cc) models, the oil dipstick is normally found on the lower port side of the powerhead, while the oil filler cap is found at the rear of the engine, toward the bottom of the valve cover.

1. Make sure the engine is in the full vertical position and has been shut off for at least 30 minutes. If possible, get in the habit of checking the oil with the engine cold from sitting overnight

2. Remove the engine cover.

3. Carefully pull the engine crankcase oil dipstick from the side (port or starboard, depending upon the model) of the engine.

4. Wipe all traces of oil off the dipstick using a clean, lint free rag or cloth, then re-insert dipstick back into its opening until it is fully seated. Then, pull the dipstick out from the crankcase again and hold it vertically with the bottom end facing down in order to prevent a false oil reading.

■ Forget how your dad or buddy first taught you to read the level on a dipstick. It may be more convenient to hold it horizontally, but laying it down like that could allow oil to flow UPWARD giving a false high, or worse, false acceptable reading when in fact your engine needs oil. Last time we checked, oil won't flow UP a dipstick held vertically (but the high point of the oil will remain wet in contrast to the dry portion of the stick immediately above the wet line). So hold the dipstick vertically and you'll never run your engine with insufficient oil when you thought it was full.

5. If the oil level is at or slightly below the top of the hatch-marks or full level mark on the dipstick, the oil level is fine. If not, add small amounts of oil through the filler cap until the level is correct. Add oil slowly, giving it time to settle into the crankcase before rechecking and again, don't overfill it either.

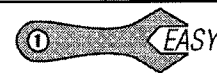
■ Dipstick markings on Yamaha outboards are normally two lines with a crosshatched area between them. The crosshatched area is the "acceptable" operating range, but you should try to maintain the level towards the top of the markings.

6. Visually check the oil on the dipstick for water (a milky appearance will result from contamination with moisture) or a significant fuel odor. Both are signs that the powerhead likely needs overhaul to prevent damage.

7. Insert and properly seat the oil dipstick into the powerhead when you are finished. If removed, install the oil fill cap and rotate it until it gently locks into position.

### OIL CHANGE & FILTER SERVICE

◆ See Figures 50, 50a, 51 and 52



Next to regular fluid level checks, the most important way to maintain a 4-stroke outboard motor is to change the engine crankcase oil (and change or clean the filter, as applicable) on a regular basis. The manufacturer recommends performing this service at every 100 hours or annually, right before storage, whichever comes first. For more information regarding engine oil, refer to OIL RECOMMENDATIONS earlier in this section.

Whenever the engine oil is drained, the oil filter should also be serviced. The models covered by this manual utilize two types of oil filters. 9.9 hp

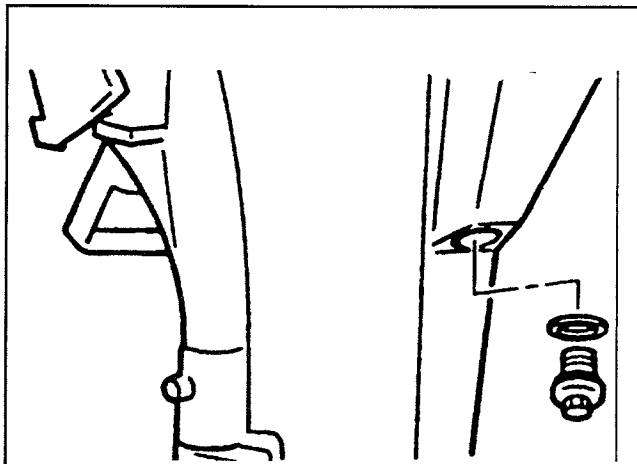


Fig. 50 On 9.9 hp motors, remove the oil drain plug (which is also the filter on early-model motors) from the rear of the powerhead (just underneath the cowling)...

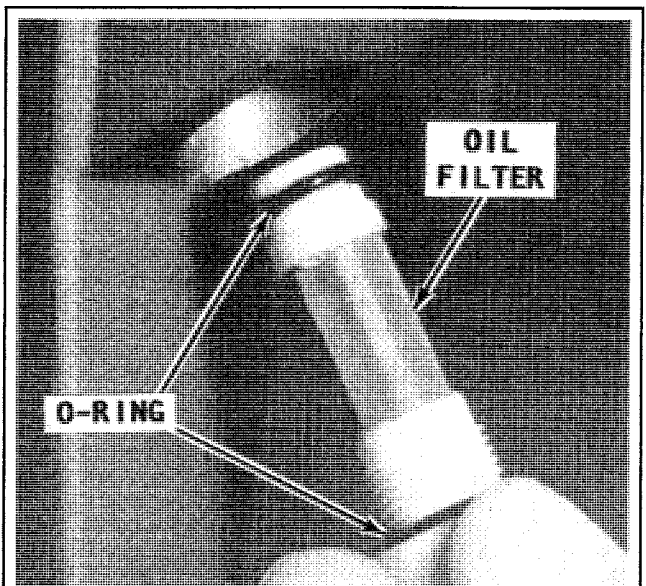


Fig. 50a ... the filter is threaded into position and seals with O-rings on either end

(232cc) models, utilize a reusable element mounted either at the lowest portion of the oil pan (under the powerhead at the rear of the motor on early-model engines) or in a housing on the starboard side of the powerhead just behind the oil level dipstick (late-models). Although this element is reusable, Yamaha recommends replacing it annually to ensure yourself of proper protections. The 45/50 hp (935cc) motors utilize a disposable, automotive style, spin-on filter mounted to the side of the powerhead. The best method to remove the spin-on filter (resulting in fewest skinned knuckles) is a filter wrench, and our preference is the cap style that fits over the end of the filter. When purchasing a replacement oil filter check your local marine dealer or automotive parts dealer for a cap wrench that fits the filter.

Most people who have worked on their own machines, whether that is tractors, motorcycles, cars/trucks or boat motors, will tell you that oil should be changed hot. This seems to have always been the popular method, and it works well since hot oil flows better/faster and may remove more deposits

that are still held in suspension. Of course, hot oil can be messy or even a bit dangerous to work with. Coupled with the sometimes difficult method of draining oil from an outboard, this might make it better in some instances to drain the oil cold. Of course, if this is desired, you'll have to leave more time for the oil to drain completely, thereby removing as much contaminants as possible from the crankcase. The choice is really yours, but be sure to take the appropriate steps to protect yourself either way.

■ If the engine is not being placed in storage after the oil change, it should be run to normal operating temperature (in a test tank or with a flushing device) and inspected for leaks before returning it to service. If the engine is being placed into storage it should also be run using a flush device, but be sure not to run it too long. Just start and run the engine for a few minutes to thoroughly circulate the fresh oil, then prepare it for storage by fogging the motor.

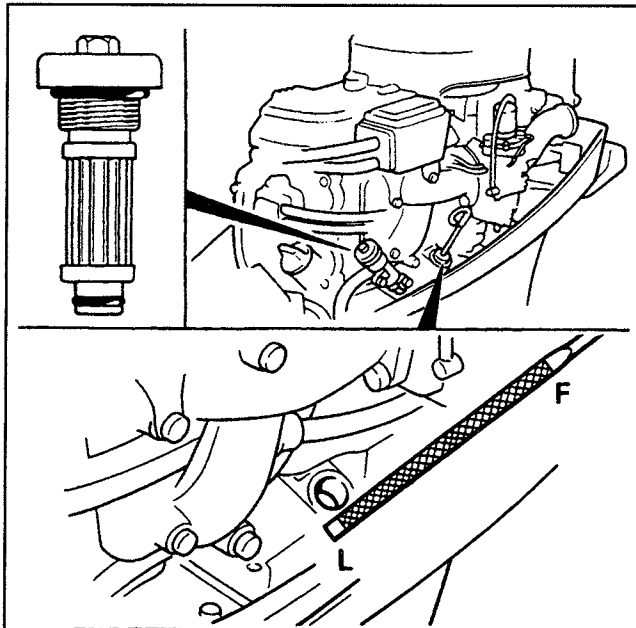


Fig. 51 On late-model 9.9's the oil filter is threaded into a bore just behind the dipstick

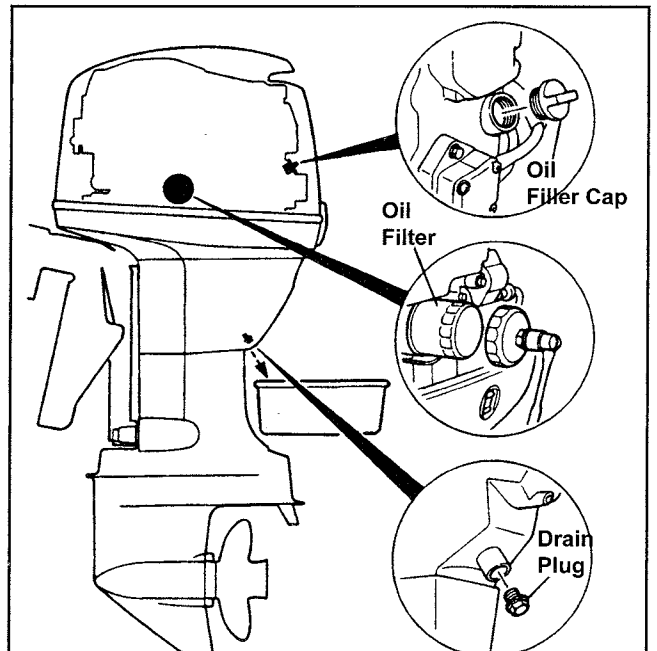


Fig. 52 Oil filler (1), drain (2) and filter locations (3) for the 45/50 hp 4-stroke engine

## 2-18 MAINTENANCE & TUNE-UP

If you decide to change oil with the engine hot, a source of cooling such as a test tank or flushing hose must be attached to the engine to prevent impeller or powerhead damage when running the engine to normal operating temperature. If you are lucky enough to store the boat (or live) close to waters in which to use the boat, you can simply enjoy a morning, evening or whole day on the water before changing the oil. The amount of time necessary to haul the boat and tow it to your work area should allow the oil to cool enough so that it won't be scalding hot, but still warm enough to flow well.

■ **Although it is not recommended for normal service, the oil CAN be drained without removing the engine cases or servicing the filter (of course, on early model 9.9 hp motors, you'll have to remove the filter to drain the oil since the filter assembly also acts as the drain plug). This might be desired if too much oil was added during a routine level check or if a small sample of oil is to be removed for inspection.**

1. Prepare the engine and work area for the oil change by placing the motor in a fully vertical position over a large, flattened cardboard box (which can be used to catch any dripping oil missed by the drain pan). Have a drain pan, a few quarts larger than the oil capacity of the motor (refer to the Capacities Chart in this section) and a lot of clean rags or disposable shop towels handy.

2. Remove the upper engine cover and loosen the oil filler cap. On all but early model 9.9 hp motors, locate the oil filler.

a. On early model 9.9 hp (232cc) motors the oil filter is found under the rear of the powerhead, below the engine cowling. The filter on these models acts as the oil pan drain bolt. Late-model 9.9 hp motors still contain an oil pan drain bolt in the same location, but the filter is found under a hex head cover threaded into a bore under the engine top cover.

b. On 45/50 hp (935cc) motors, the disposable spin-on oil filter is found at the center, port side of the powerhead.

3. Locate and remove the oil drain plug (filter on early 9.9 models) and gasket. For all models, engine oil is drained by removing the plug from the oil pan at the lower rear of the powerhead, just below the cowling. In order to improve oil flow, remove the oil fill cap.

4. Either hold the drain pan under the powerhead and just above the ventilation plate or, in some cases, it may be possible to trim the motor far enough in to place the pan on the ground. It may also be possible to secure the pan carefully above the ventilation plate using some bungee cords. But honestly, the least chance of a mess is just to be patient and hold it.

5. Inspect the drain plug (or filter on early 9.9's) and gasket for signs of damage. Replace the plug or gasket if any damage is found. Also, watch the draining oil for signs of contamination by moisture (a milky appearance will result), by fuel (a strong odor and thinner running oil would be present) or signs of metallic flakes/particles. A small amount of tiny metallic particles is a sign of normal wear, but large amounts or large pieces indicate internal engine damage and the need for an overhaul to determine and rectify the cause.

6. When it appears that the oil has drained, tilt the engine slightly and pivot it to one side or the other in order to ensure complete oil drainage.

7. For early model 9.9 hp motors service the filter as directed later in this procedure or install a new one. For all other motors, clean the drain plug, the engine and the gearcase. Place a new gasket onto the drain plug then carefully thread the plug into the opening. Tighten the plug securely.

■ **Although it is not absolutely necessary to replace the gasket each time, it is a cheap way to help protect against possible leaks. We think it is a good idea.**

8. For models equipped with a reusable filter element (9.9 hp motors) remove (if not done already) and service the filter as follows:

a. On late-model 9.9's where the filter is threaded into a boss on the powerhead instead of the oil pan, loosen it using a wrench or socket and carefully unthread it from the boss. Hold a small rag under the boss to catch oil as it drips from the element when you pull it out.

b. Rinse the element using solvent and dry it using low pressure compressed air. If compressed air is not available, allow it to air dry for at least 15 minutes. Inspect the element for signs of clogging or damage and replace, if found.

c. Apply a light coating of fresh 4-stroke engine oil to the filter element and O-rings, then install the element into the bore and thread it tightly into place. For 9.9 tighten both the oil pan drain plug and/or the filter (as applicable) and tighten to 71 inch. lbs. (8 Nm).

■ **Although the procedure for spin-on filters talks about placing a shop rag under the filter while it is removed, there is an alternate method to prevent a mess. If desired, loosen the filter slightly with a cap wrench, then slide a disposable Zip-Lock® or similar food storage bag completely over the filter and unthread it into the bag. Position a shop rag anyway, just to be sure to catch any stray oil that escapes. With a little practice, you'll find this method can be the best way to remove oil filters.**

9. For models equipped with a disposable, spin-on filter element (45/50 hp motors) remove and service the filter as follows:

a. Position a shop rag underneath, then place the oil filter wrench onto filter element.

b. Loosen the spin-on element by turning the filter wrench counterclockwise, then remove the wrench and finish unthreading the element by hand. Remove the filter from the powerhead and clean up any spilled oil.

c. Make sure the rubber gasket is not stuck to the oil filter mounting surface, then use a lint free shop rag to clean all dirt and oil from mounting surface.

d. Apply a thin coating of engine oil to the sealing ring of the new oil filter, then thread the filter onto the adapter until the sealing washer touches the mounting surface. If you've got a torque wrench and a cap-type oil filter wrench, tighten the filter to 13 ft. lbs. 17.5 Nm. If not, tighten the filter by hand an additional 1/4-2/3 turn.

10. Clean up any spilled oil.

11. Refill the engine through the oil filler cap as described under Checking Engine Oil in this section. Add the oil gradually, checking the oil level frequently. Add oil until the level reaches the upper level of the hatched area (full mark) on the dipstick.

12. Provide a temporary cooling system to the engine as detailed under Flushing The Cooling System, then start the engine and run it to normal operating temperature while visually checking for leakage.

■ **If the engine is being placed into storage, don't run the motor too long, just long enough to use a can of fogging spray. Between the fresh oil circulated through the motor and the fogging spray coating the inside of the intake and combustion chambers your motor should sleep like a baby until next season.**

13. Stop the motor and allow it to cool, then properly re-check the oil level after it has settled again into the crankcase.

### Fuel Filter

◆ See Figure 52a

A fuel filter is designed to keep particles of dirt and debris from entering the carburetor(s) and clogging the tiny internal passages of each. A small speck of dirt or sand can drastically affect the ability of the fuel system to deliver the proper amount of air and fuel to the engine. If a filter becomes clogged, the flow of gasoline will be impeded. This could cause lean fuel mixtures, hesitation and stumbling and idle problems in carburetors.

Regular cleaning or replacement of the fuel filter (depending on the type or types used) will decrease the risk of blocking the flow of fuel to the engine, which could leave you stranded on the water. It will also decrease the risk of damage to the small passages of a carburetor or fuel injector that could require more extensive and expensive replacement. Keep in mind that fuel filters are usually inexpensive and replacement is a simple task. Service your fuel filter on a regular basis to avoid fuel delivery problems.

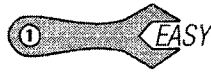
The type of fuel filter used on your engine will vary not only with the year and model, but also with the accessories and rigging. Because of the number of possible variations it is impossible to accurately give instructions based on model. Instead, we will provide instructions for the different types of filters the manufacturer used on various families of motors or systems with which they are equipped. To determine what filter(s) are utilized by your boat and motor rigging, trace the fuel line from the tank to the fuel pump and then from the pump to the carburetor(s). Most Yamaha outboards utilize a serviceable filter element that is placed inside a cap and housing found inline just before the fuel pump. However, some models may instead be equipped with a non-serviceable inline filter in a disposable housing which is replaced by simply removing the clamps, disconnecting the hoses and installing a new filter. When installing a new disposable inline filter, make sure the arrow on the filter points in the direction of fuel flow.



Some motors have a fuel filter mounted in the fuel tank itself. On small motors with integral fuel tanks the only fuel filter element is normally mounted on the fuel petcock both of which must be removed from the tank in order to service it. For larger motors, in addition to the fuel filter mounted on the engine, a filter is usually found inside or near the fuel tank. Because of the large variety of differences in both portable and fixed fuel tanks, it is impossible to give a detailed procedure for removal and installation. However, keep in mind that most in-tank filters are simply a screen on the pick-up line inside the fuel tank. Filters of this type rarely require service or attention, but if the tank is removed for cleaning the filter will usually only need to be cleaned and returned to service (assuming they are not torn or otherwise damaged).

Depending upon the boat rigging a fuel filter/water separator may be found inline between a boat mounted fuel tank and the motor. Boat mounted fuel filter/water separators are normally of the spin-on filter type (resembling automotive oil filters) but will vary greatly with boat rigging. Replacement of a filters/separators is the same as a typical automotive oil filter replacement, just make sure to have a small drain basin handy to catch escaping fuel and make sure to coat the rubber gasket with a small dab of engine oil during installation.

## FUEL FILTER SERVICE



### \*\* CAUTION

Observe all applicable safety precautions when working around fuel. Whenever servicing the fuel system, always work in a well-ventilated area. Do not allow fuel spray or vapors to come in contact with a spark or open flame. Do not smoke while working around gasoline. Keep a dry chemical fire extinguisher near the work area. Always keep fuel in a container specifically designed for fuel storage; also, always properly seal fuel containers to avoid the possibility of fire or explosion.

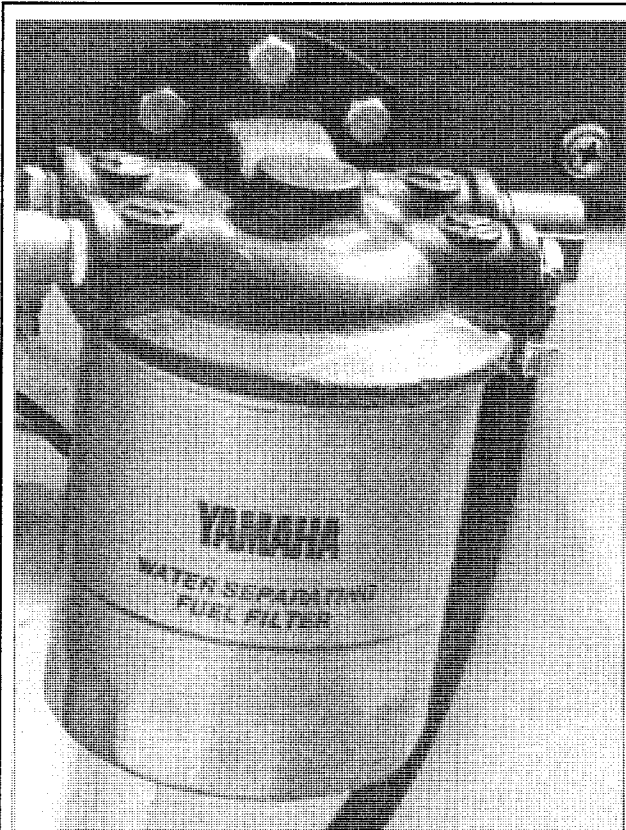


Fig. 52a Boats with integrated fuel tanks will usually be rigged with an automotive style spin-on fuel filter/water separator

## Integral Fuel Tank Models

1. Drain the fuel in the tank into a suitable container.
2. Remove the fuel tank to provide working room, as necessary.
3. Loosen the fuel petcock clamp screw or nut.
4. Remove the petcock from the clamp and tank, then disconnect the hose.
5. Clean the filter assembly in solvent and blow it dry with compressed air. If excessively dirty or contaminated with water, replace the filter.
6. Install the petcock on the clamp and tank, then connect the hose.
7. Tighten the fuel petcock clamp screw or nut.
8. Check the fuel filter installation for leakage.

## Disposable Inline Filters

### ◆ See Figure 53

As noted earlier, some Yamaha outboards may be equipped with a disposable inline filter. On some the filter is used in lieu of a fuel pump mounted or fuel tank mounted filter, but for many models the inline filter is used as an additional line of defense. This type of filter is a sealed canister type (usually plastic) and cannot be cleaned, so service is normally limited to replacement. Because of the relative ease and relatively low expense of a filter (when compared with the time and hassle of a carburetor overhaul) we encourage you to replace the filter at least annually.

When replacing the filter, release the hose clamps (they are usually equipped with spring-type clamps that are released by squeezing the tabs using a pair of pliers) and slide them back on the hose, past the raised portion of the filter inlet/outlet nipples. Once a clamp is released, position a small drain pan or a shop towel under the filter and carefully pull the hose from the nipple. Allow any fuel remaining in the filter and fuel line to drain into the drain pan or catch fuel with the shop towel. Repeat on the other side, noting which fuel line connects to which portion of the filter (for assembly purposes). Inline filters are usually marked with an arrow indicating fuel flow. The arrow should point towards the fuel line that runs to the motor (not the fuel tank).

Before installation of the new filter, make sure the hoses are in good condition and not brittle, cracking and otherwise in need of replacement. During installation, be sure to fully seat the hoses, then place the clamps over the raised portions of the nipples to secure them. Spring clamps will weaken over time, so replace them if they've lost their tension. If wire ties or adjustable clamps were used, be careful not to overtighten the clamp. If the clamp cuts into the hose, it's too tight; loosen the clamp or cut the wire tie (as applicable) and start again.

### \*\* CAUTION

Before returning the outboard to service, use the primer bulb to pressurize the system and check the filter/fittings for leaks.

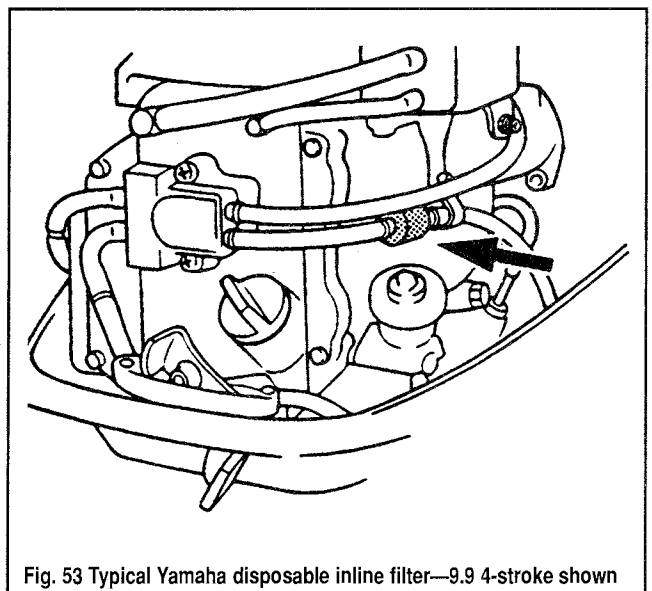


Fig. 53 Typical Yamaha disposable inline filter—9.9 4-stroke shown



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