

CONTENTS

1	GENERAL INFORMATION, SAFETY AND TOOLS	HOW TO USE THIS MANUAL BOATING SAFETY SAFETY IN SERVICE TROUBLESHOOTING TOOLS AND EQUIPMENT TOOLS FASTENERS, MEASUREMENTS AND CONVERSIONS SPECIFICATIONS	1-2 1-4 1-11 1-11 1-15 1-17 1-24 1-25
2	ENGINE AND DRIVE MAINTENANCE	ENGINE AND DRIVE MAINTENANCE FLUIDS AND LUBRICANTS LUBRICATION POINTS BOAT MAINTENANCE WINTER STORAGE FIRING ORDERS SPRING COMMISSIONING SPECIFICATIONS	2-2 2-29 2-45 2-47 2-51 2-52 2-52 2-55
3	ENGINE MECHANICAL FORD 4 CYLINDER ENGINES	ENGINE MECHANICAL SPECIFICATIONS	3-2 3-19
4	ENGINE MECHANICAL GM 4 CYLINDER ENGINES	ENGINE MECHANICAL EXPLODED VIEWS SPECIFICATIONS	4-2 4-18 4-21
5	ENGINE MECHANICAL GM V6 AND V8 ENGINES	ENGINE MECHANICAL EXPLODED VIEWS SPECIFICATIONS	5-2 5-35 5-39
6	ENGINE MECHANICAL FORD V8 ENGINES	ENGINE MECHANICAL EXPLODED VIEWS SPECIFICATIONS	6-2 6-24 6-26
7	ENGINE OVERHAUL	ENGINE RECONDITIONING	7-2
8	FUEL SYSTEMS CARBURETORS	FUEL AND COMBUSTION CARBURETED FUEL SYSTEM ROCHESTER 2 BBL ROCHESTER 4 BBL HOLLEY 2300 2 BBL HOLLEY 4150 14160 14175 4 BBL WIRING DIAGRAMS SPECIFICATIONS	8-2 8-3 8-5 8-10 8-16 8-22 8-34 8-37

FUEL AND COMBUSTION	9-2
FORD ELECTRONIC MULTI-POINT FUEL INJECTION (MFI)	9-3
SYSTEM DIAGNOSIS	9-14
GM THROTTLE BODY FUEL INJECTION (TBI)	9-22
GM MULTI-POINT FUEL INJECTION (MFI)	9-22
SPECIFICATIONS	9-20
WIRING SCHEMATICS	9-44
DIAGNOSTIC TROUBLE CODE (DTC) CHARTS	9-70
FUEL FLOW DIAGRAMS	9-71
COMPONENT LOCATIONS	9-73

FUEL SYSTEMS FUEL INJECTION

9

UNDERSTANDING AND TROUBLESHOOTING ELECTRICAL SYSTEMS	10-2
BATTERY	10-8
CHARGING SYSTEM	10-10
STARTER CIRCUIT	10-19
IGNITION SYSTEM	10-31
BREAKER POINT IGNITION SYSTEM	10-32
ELECTRONIC SPARK TIMING (EST) SYSTEM	10-39
DISTRIBUTOR IGNITION (DI) SYSTEM	10-39
PRESTOLITE INTEGRAL BREAKERLESS INDUCTIVE DISTRIBUTOR (BID) SYSTEM	10-45
SPITFIRE/ELECTRONIC ENGINE MANAGEMENT (EMM) SYSTEM	10-49
FORD THICK FILM INTEGRATED IGNITION SYSTEM (TFI-IV)	10-51
INSTRUMENTS AND GAUGES	10-55
SENDING UNITS AND SWITCHES	10-58
WIRING DIAGRAMS	10-59
SPECIFICATIONS	10-89

IGNITION AND ELECTRICAL SYSTEMS

10

COOLING SYSTEM	11-2
MAINTENANCE AND TESTING	11-3
FLOW DIAGRAMS	11-9

COOLING SYSTEM

11

STERN DRIVE UNIT - COBRA, KING COBRA, SP, SX, SX COBRA, DP AND DP DUOPROP MODELS	12-2
UPPER GEAR HOUSING	12-6
LOWER GEAR HOUSING (LOWER UNIT)	12-36
TRANSOM ASSEMBLY	12-62
SPECIFICATIONS	12-71

STERN DRIVE SP/SX/SX COBRA, KING COBRA AND DP/DP DUOPROP

12

SELECT (POWER) TRIM AND TILT - 1986-88 COBRA AND KING COBRA	13-2
POWER TRIM AND TILT - 1989-98 COBRA, KING COBRA, SP(SX) AND DP	13-15
WIRING SCHEMATICS	13-33

TRIM AND TILT

13

MANUAL STEERING SYSTEM	14-2
POWER STEERING SYSTEM	14-4

STEERING SYSTEMS

14

MASTER INDEX	14-13
--------------	-------

MASTER INDEX

BASIC OPERATING PRINCIPLES	1-12
2-STROKE MOTORS	1-12
4-STROKE ENGINES	1-14
COMBUSTION	1-14
BOATING SAFETY	1-4
COURTESY MARINE EXAMINATIONS	1-11
EQUIPMENT NOT REQUIRED	
BUT RECOMMENDED	1-10
REGULATIONS FOR YOUR BOAT	1-4
REQUIRED SAFETY EQUIPMENT	1-5
CHEMICALS	1-15
CLEANERS	1-16
LUBRICANTS & PENETRANTS	1-15
SEALANTS	1-16
COURTESY MARINE EXAMINATIONS	1-11
ELECTRONIC TOOLS	1-21
BATTERY CHARGERS	1-21
BATTERY TESTERS	1-21
GAUGES	1-22
MULTIMETERS (DVOMS)	1-21
EQUIPMENT NOT REQUIRED	
BUT RECOMMENDED	1-10
ANCHORS	1-10
BAILING DEVICES	1-10
FIRST AID KIT	1-10
SECOND MEANS OF PROPULSION	1-10
TOOLS AND SPARE PARTS	1-10
VHF-FM RADIO	1-10
FASTENERS, MEASUREMENTS	
AND CONVERSIONS	1-24
BOLTS, NUTS AND OTHER THREADED	
RETAINERS	1-24
STANDARD AND METRIC	
MEASUREMENTS	1-24
TORQUE	1-24
HAND TOOLS	1-17
BREAKER BARS	1-18
HAMMERS	1-20
PLIERS	1-20
SCREWDRIVERS	1-20
SOCKET SETS	1-17
TORQUE WRENCHES	1-18
WRENCHES	1-19
HOW TO USE THIS MANUAL	1-2
AVOIDING THE MOST	
COMMON	
MISTAKES	1-3
AVOIDING TROUBLE	1-2
CAN YOU DO IT?	1-2
DIRECTIONS AND LOCATIONS	1-2
MAINTENANCE OR REPAIR?	1-2
PROFESSIONAL HELP	1-3

PURCHASING PARTS	1-3
WHERE TO BEGIN	1-2
MEASURING TOOLS	1-22
DIAL INDICATORS	1-23
DEPTH GAUGES	1-23
MICROMETERS & CALIPERS	1-22
TELESCOPING GAUGES	1-23
OTHER COMMON TOOLS	1-20
REGULATIONS FOR YOUR BOAT	1-4
CAPACITY INFORMATION	1-4
CERTIFICATE OF COMPLIANCE	1-5
DOCUMENTING OF VESSELS	1-4
HULL IDENTIFICATION NUMBER	1-4
LENGTH OF BOATS	1-4
NUMBERING OF VESSELS	1-4
REGISTRATION OF BOATS	1-4
SALES AND TRANSFERS	1-4
VENTILATION	1-5
VENTILATION SYSTEMS	1-5
REQUIRED SAFETY EQUIPMENT	1-5
TYPES OF FIRES	1-5
FIRE EXTINGUISHERS	1-6
PERSONAL FLOTATION DEVICES	1-7
SOUND PRODUCING DEVICES	1-8
VISUAL DISTRESS SIGNALS	1-9
WARNING SYSTEM	1-7
SAFETY IN SERVICE	1-11
DO'S	1-11
DON'TS	1-11
SAFETY TOOLS	1-15
EYE AND EAR PROTECTION	1-15
WORK CLOTHES	1-15
WORK GLOVES	1-15
SPECIAL TOOLS	1-21
SPECIFICATIONS	1-25
CONVERSION FACTORS	1-25
METRIC BOLTS, TYPICAL	
TORQUE VALUES	1-26
U.S. STANDARD BOLTS - TYPICAL TORQUE	
VALUES	1-26
TROUBLESHOOTING	1-11
BASIC OPERATING PRINCIPLES	1-12
TOOLS	1-17
ELECTRONIC TOOLS	1-21
HAND TOOLS	1-17
MEASURING TOOLS	1-22
OTHER COMMON TOOLS	1-20
SPECIAL TOOLS	1-21
TOOLS AND EQUIPMENT	1-15
CHEMICALS	1-15
SAFETY TOOLS	1-15

1

GENERAL INFORMATION, SAFETY AND TOOLS

HOW TO USE THIS MANUAL	1-2
BOATING SAFETY	1-4
SAFETY IN SERVICE	1-11
TROUBLESHOOTING	1-11
TOOLS AND EQUIPMENT	1-15
TOOLS	1-17
FASTENERS, MEASUREMENTS	
AND CONVERSIONS	1-24
SPECIFICATIONS	1-25

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 OMC engine and drive system. 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 engine/drive system, 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 OMC.

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 OMC.

You may find that maintaining your engine/drive system 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's boating. If you are 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 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. This hourly rate is often charged from the time they leave their shop to the time that they return home. 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 an engine.

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 wrench 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 engine 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 **bate**, 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 engines), 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 engine, 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.

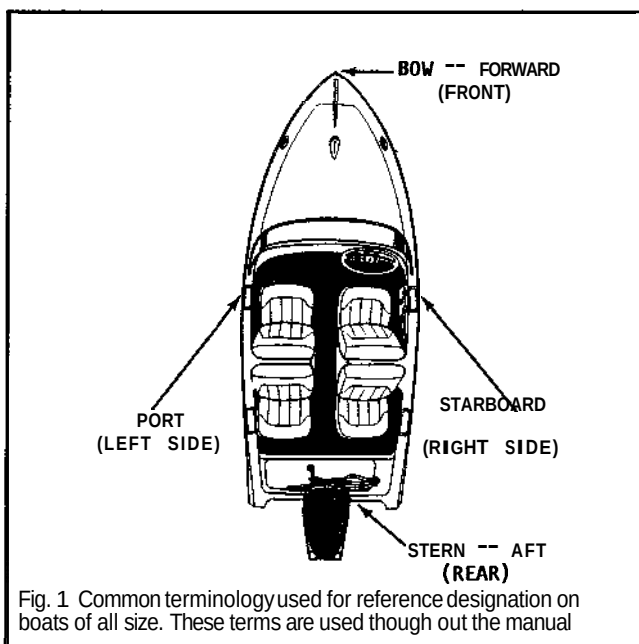


Fig. 1 Common terminology used for reference designation on boats of all size. These terms are used though out the manual

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 engine or drive system 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 in this manual) 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 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

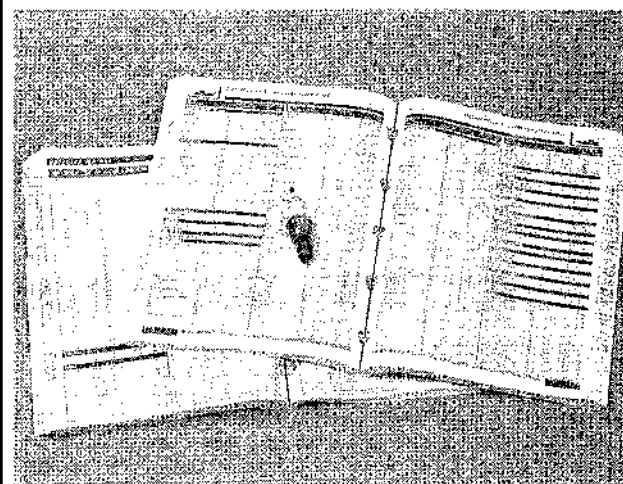


Fig. 3 Parts catalogs, giving application and part number information, are provided by manufacturers for most replacement parts

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. Overtorquing (or undertorquing). While it is more common for overtorquing to cause damage, undertorquing 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.

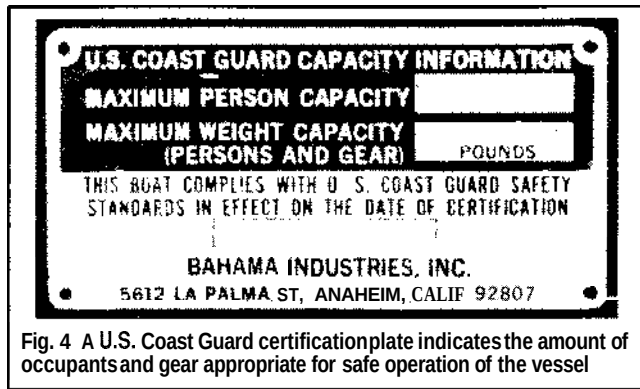


Fig. 4 A U.S. Coast Guard certification plate indicates the amount of occupants and gear appropriate for safe operation of the vessel

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 an 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.

Ventilation for All Other Boats

Powered and natural ventilation are required in an enclosed compartment with a permanently installed gasoline engine that has a starter 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. 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.

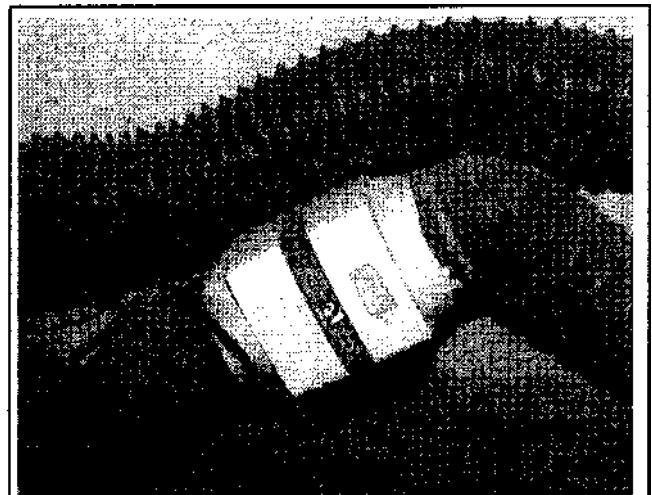


Fig. 5 Typical blower and duct system to vent fumes from the engine compartment

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

1-6 GENERAL INFORMATION, SAFETY AND TOOLS

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 sterndrive 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.



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

Contents of Extinguishers

Fire extinguishers use a variety of materials. Those used on boats usually contain dry chemicals, Halon, or Carbon Dioxide (CO₂). 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 CO₂, 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.

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..., 162.2081," 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 reseal 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 under 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 inch 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.

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.

1-8 GENERAL INFORMATION, SAFETY AND TOOLS

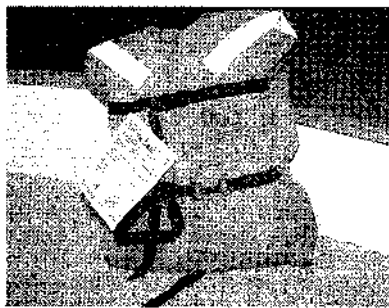


Fig. 7 Type II PFDs are recommended for inshore and inland cruising on calm water (where there is a good chance of fast rescue)



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

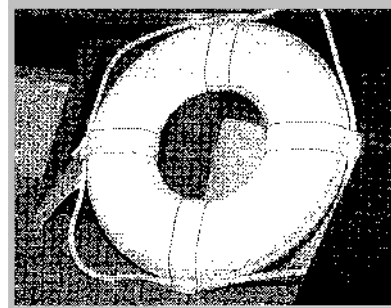


Fig. 9 Type IV throwables, such as this ring life buoy, are not designed for unconscious people, non-swimmers, or children

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 by 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, assures 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.

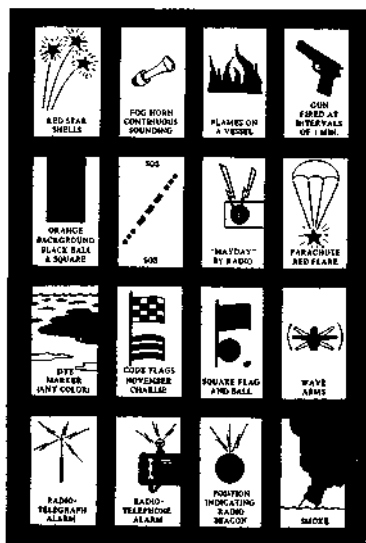


Fig. 10 Internationally accepted distress signals

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.

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.



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

1-10 GENERAL INFORMATION, SAFETY AND TOOLS



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

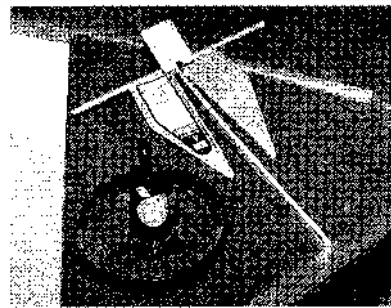


Fig. 13 Choose an anchor of sufficient weight to secure the boat without dragging

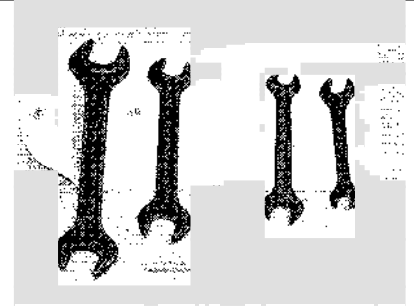


Fig 14 A first aid kit may be a pair of pliers can be very helpful to make emergency repairs

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.

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 inches 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.

Equipment Not Required But Recommended

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

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.

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. You can use it 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.

TOOLS AND SPARE PARTS

◆ See Figures 14 and 15

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

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.

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 it is to the examiner's 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.

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.

- 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. 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.

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 an engine, 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, engine and drive. 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. 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 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 sub-systems (if applicable, for example: the starter circuit) or components (starter solenoid).

1-12 GENERAL INFORMATION, SAFETY AND TOOLS

◆ See Figures 16 and 17

Before attempting to troubleshoot a problem with your engine, 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 and 4-stroke engines (like yours) are given here. A basic understanding of both types of engines is useful not only in understanding and troubleshooting your OMC, but also for dealing with other motors in your life.

All engines 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 engines follow the stages of intake, compression, power

and exhaust. But, the difference between a 2- and 4-stroke engine 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 engines.

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.)

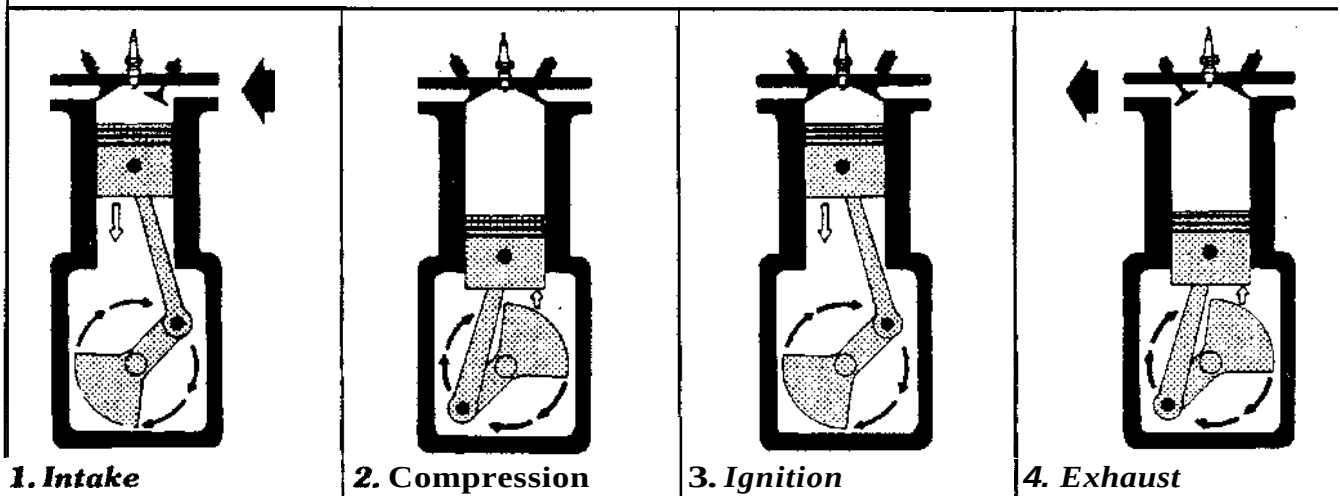
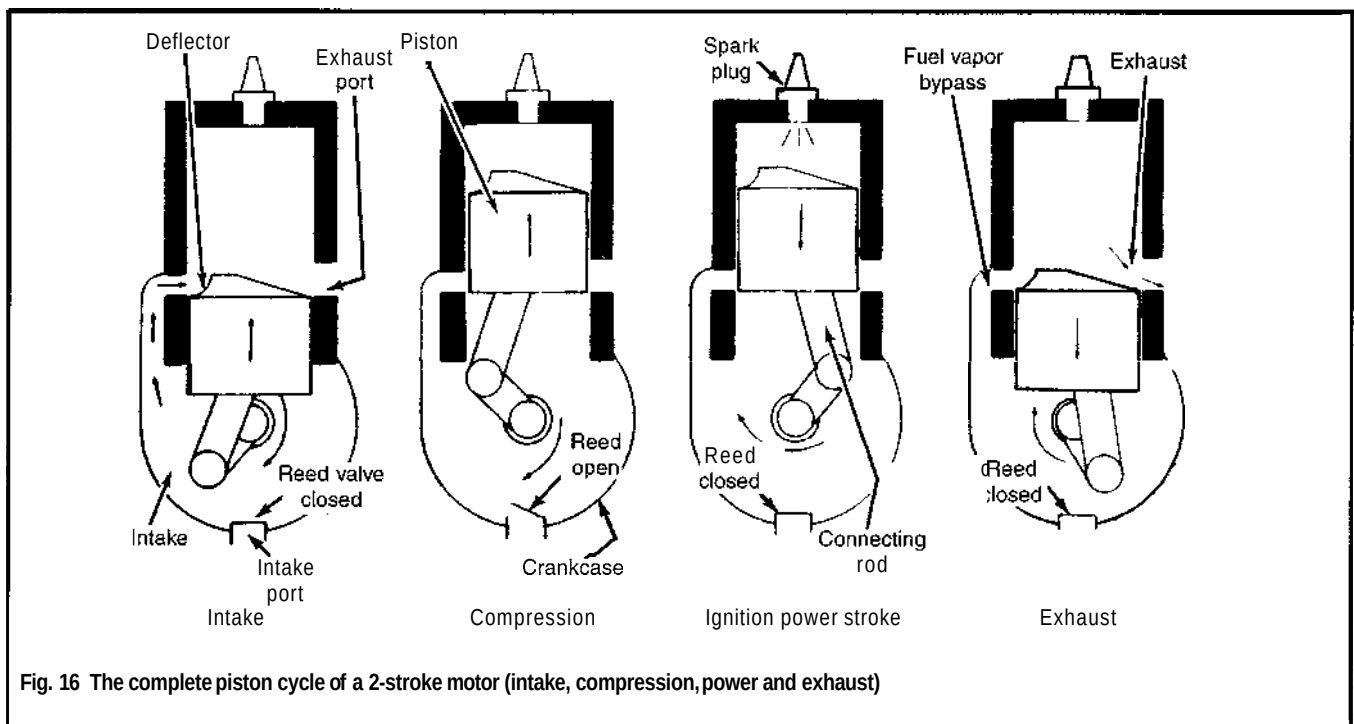


Fig. 17 The complete piston cycle of a 4-stroke engine (intake, compression, power and exhaust)

Intake/Exhaust

- See Figure 18

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, many 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.

These systems of intake and exhaust are in marked contrast to individual valves in the four-stroke engine (and the mechanical act of opening and closing them).

It should be noted that in some stroking systems that utilize a **mechanical valve train**, though it is very different from the valve train employed by most 4-stroke engines. 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 at 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.

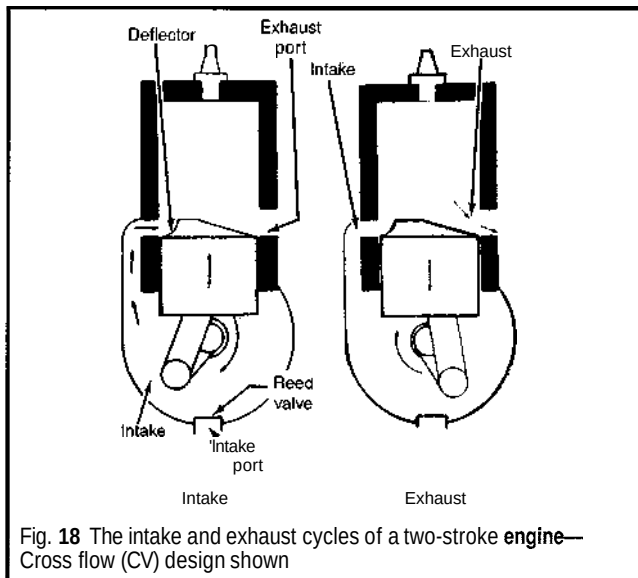
Lubrication

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

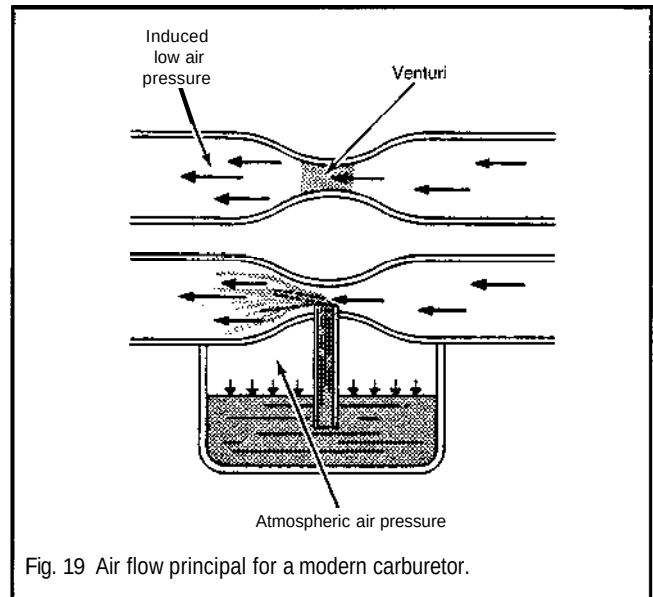
- See Figure 19

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 16

The engine described here is of a carbureted type.

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 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,

1-14 GENERAL INFORMATION, SAFETY AND TOOLS

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 ENGINES

The 4-stroke engine may be easier to understand for some people, either because of its prevalence in automobile and street motorcycle engines 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 (both intake and exhaust valves are closed) combustion chamber 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 engines).

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 engine will cause the engine 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 engines, 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 engine. But it is better to get the lawn tractor stuck on stale gasoline than it would be to have your boat engine quit in the middle of the bay or lake.

For hard-starting engines, is the primer system operating properly. Remember that the primer 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 engine for a hot start may flood the engine, preventing it from starting properly. One method to clear a flood is to crank the engine while at wide-open throttle (allowing the maximum amount of air into the engine 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.

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 engine 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 engine to run properly. It is much more likely that an improperly stored engine (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.

The electronics of the fuel injection system used on some models will monitor the condition of the circuitry. Don't suspect a fuel injection problem unless the CHECK ENGINE indicator of gauge remains illuminated during engine operation. If so, refer to the information on the Fuel Injection system regarding Trouble Codes and fuel injection diagnostics.

TOOLS AND EQUIPMENT**Safety Tools****WORK GLOVES**

◆ See Figure 20

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 it has been reported 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 21 and 22

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.

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!

LUBRICANTS & PENETRANTS

◆ See Figure 23

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 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 it 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!



Fig. 20 Three different types of work gloves. The box contains latex gloves

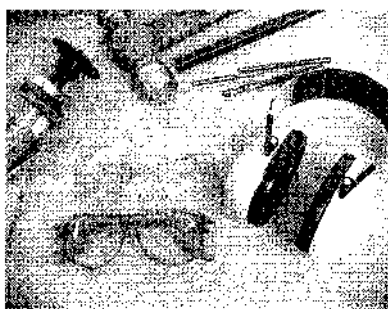


Fig. 21 Don't begin major repairs without a pair of goggles for your eyes and earmuffs to protect your hearing

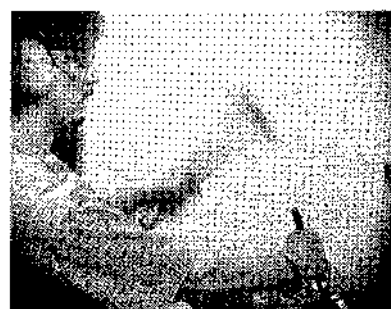


Fig. 22 Things have a habit of, splashing, spraying, splintering and flying around during repairs

1-16 GENERAL INFORMATION, SAFETY AND TOOLS



Fig. 23 Anti-seize, penetrating oil, lithium grease, electronic cleaner and silicone spray should be a part of your chemical collection



Fig. 24 Sealants are essential for preventing leaks

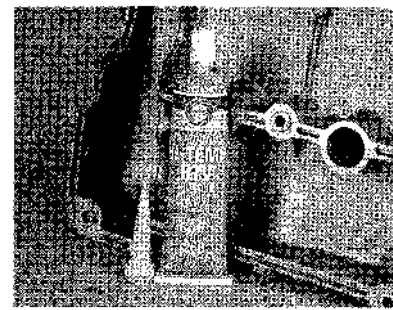


Fig. 25 On some engines, RTV is used instead of gasket material to seal components

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 24 and 25

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 26 and 27

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—please resist that urge to use parts cleaner on your hands when they are really bad!!

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.



Fig. 26 Citrus hand cleaners not only work well, but they smell pretty good too. Choose one with pumice for added cleaning power



Fig. 27 The use of hand lotion seals your hands and keeps dirt and grease from sticking to your skin

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.

TOOLS

◆ See Figure 28

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, many 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.

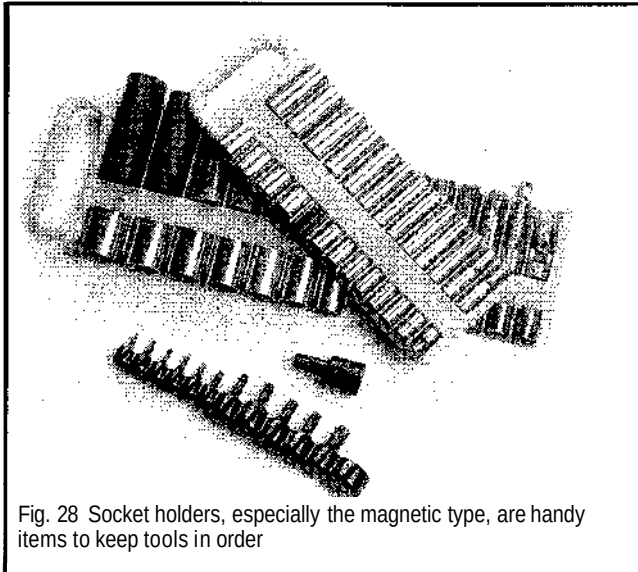


Fig. 28 Socket holders, especially the magnetic type, are handy items to keep tools in order

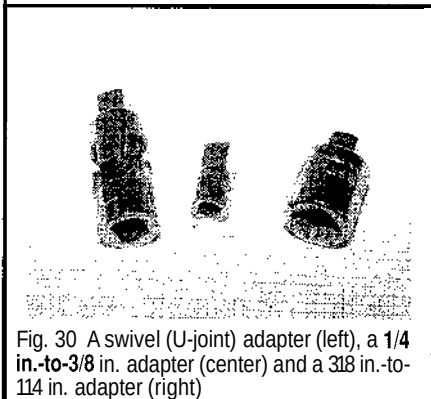


Fig. 30 A swivel (U-joint) adapter (left), a 1/4 in.-to-3/8 in. adapter (center) and a 3/8 in.-to-1 1/4 in. adapter (right)

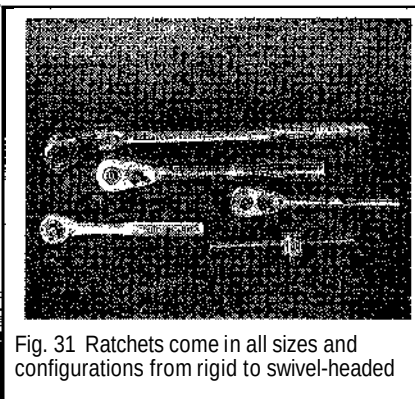


Fig. 31 Ratchets come in all sizes and configurations from rigid to swivel-headed

Hand Tools

SOCKET SETS

◆ See Figures 29, 30, 31, 32, 33, 34 and 35

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 in., 3/8 in. and 1/2 in. Drive size refers to the size of the drive lug on the ratchet, breaker bar or speed handle.

A 1/2 in. 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 in. through 1 in. for standard fasteners, and a 6mm through 19mm for metric fasteners.

You'll need a good 1/2 in. 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 in. drive.

Plus, 1/4 in. 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.

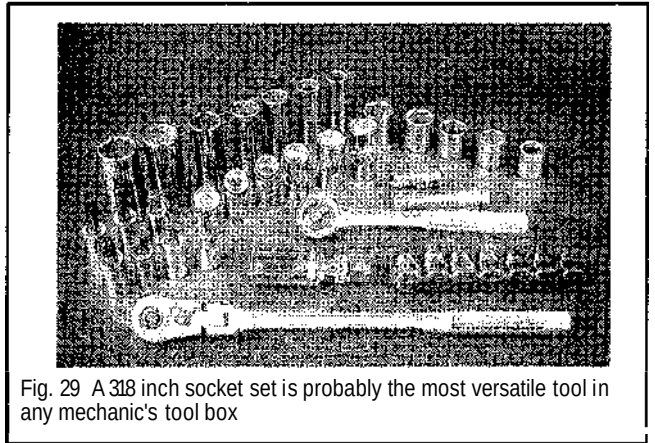


Fig. 29 A 1/2 inch socket set is probably the most versatile tool in any mechanic's tool box

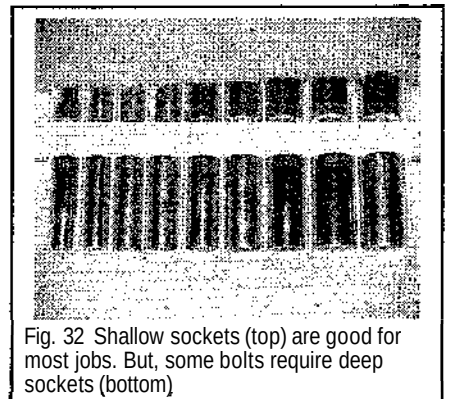
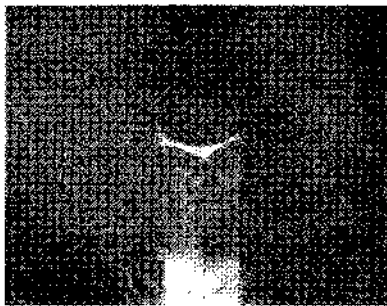
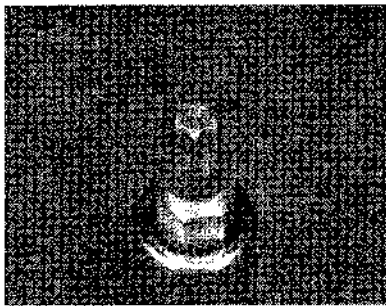


Fig. 32 Shallow sockets (top) are good for most jobs. But, some bolts require deep sockets (bottom)

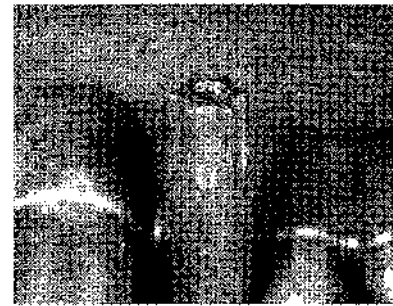
1-18 GENERAL INFORMATION, SAFETY AND TOOLS



See Fig. 33 Hex-head fasteners require a socket with a hex shaped driver



See Fig. 34 Torx® drivers . . .



See Fig. 35 . . . and tamper resistant drivers are required to remove special fasteners

Most marine manufacturers use recessed hex-head fasteners to retain many of the engine parts. These fasteners require 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 TorxB head fasteners, which were once known as tamper resistant fasteners (because many people did not have tools with the necessary odd driver shape). Since TorxB fasteners have become commonplace in many DIYer tool boxes, manufacturers designed newer tamper resistant fasteners that are essentially TorxB 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

4 See Figure 36

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

4 See Figures 37 and 38

The beam type torque wrench is one of the most popular styles in use. If used properly, it can be the most accurate also.

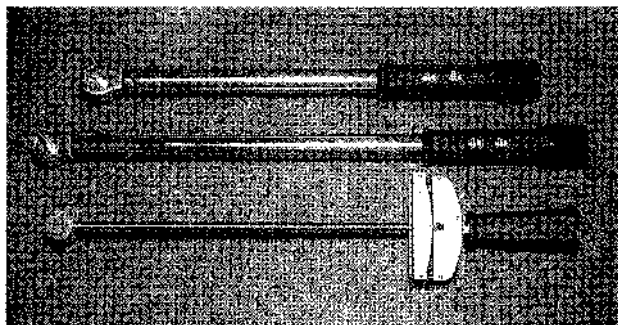


Fig. 36 Three types of torque wrenches. Top to bottom: a 318 in. drive beam-type that reads in inch lbs., a 112 in. drive clicker-type and a 112 in. drive beam-type

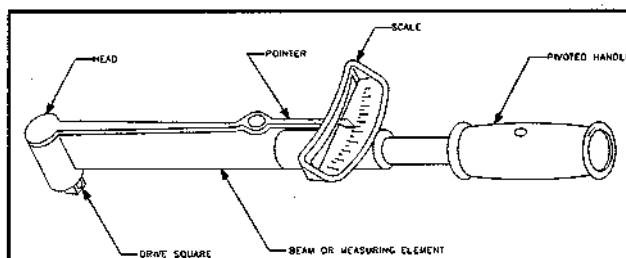


Fig. 37 Parts of a beam-type torque wrench

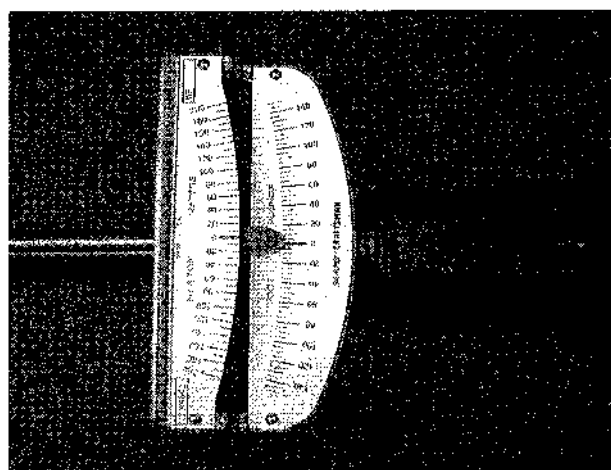


Fig. 38 A beam-type torque wrench consists of a pointer attached to the head that runs the length of the flexible beam (shaft) to a scale located near the handle

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

4 See Figures 39 and 40

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.

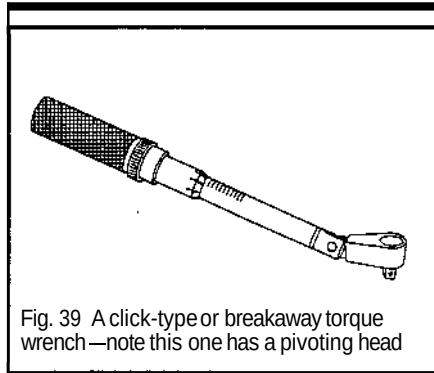


Fig. 39 A click-type or breakaway torque wrench—note this one has a pivoting head

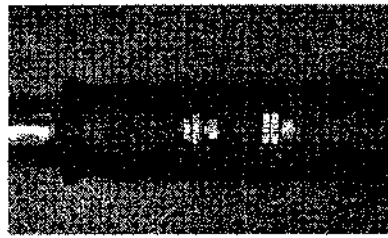


Fig. 40 Setting the torque on a click-type wrench involves turning the handle until the specification appears on the dial



Fig. 41 Breaker bars are great for loosening large or stuck fasteners

Breaker Bars

- ◆ See Figure 41

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 42, 43, 44, 45 and 46

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.

INCHES		WRENCH	DECIMAL	MILLIMETERS	
1/8"	.125		.118	3mm	
3/16"	.187		.157	4mm	
1/4"	.250		.236	6mm	
5/16"	.312		.354	9mm	
3/8"	.375		.394	10mm	
7/16"	.437		.472	12mm	
1/2"	.500		.512	13mm	
9/16"	.562		.590	15mm	
5/8"	.625		.630	16mm	
11/16"	.687		.709	18mm	
3/4"	.750		.748	19mm	
13/16"	.812		.787	20mm	
7/8"	.875		.866	22mm	
15/16"	.937		.945	24mm	
1"	1.00		.984	25mm	

Fig. 42 Comparison of U.S. measure and metric wrench sizes



Fig. 43 Always use a back-up wrench to prevent rounding flare nut fittings

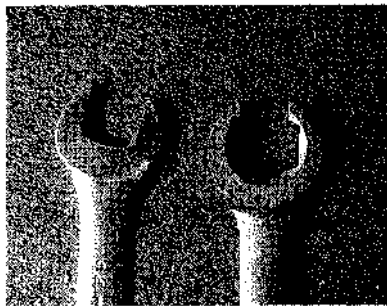


Fig. 44 Note how the flare wrench sides are extended to grip the fitting tighter and prevent rounding

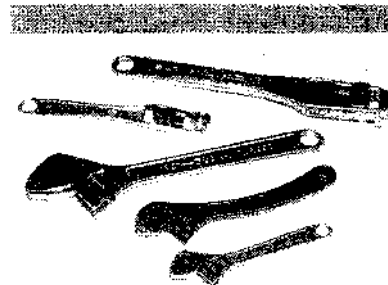


Fig. 45 Several types and sizes of adjustable wrenches

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 47

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.

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 48

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 DIYer will eventually need (though not all for basic maintenance). They include:

- Funnel
- 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.

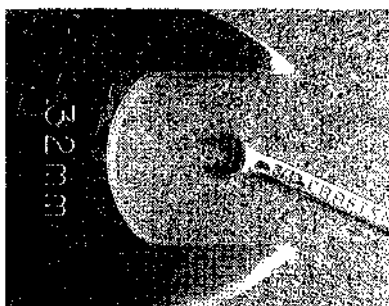


Fig. 46 You may find a nut that requires a particularly large or small wrench (it is usually available at your local tool store)

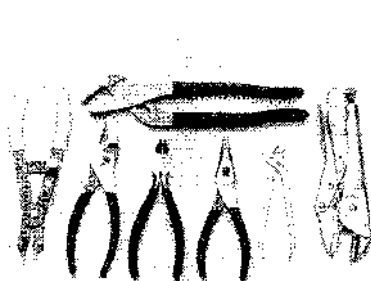


Fig. 47 Pliers and cutters come in many shapes and sizes. You should have an assortment on hand

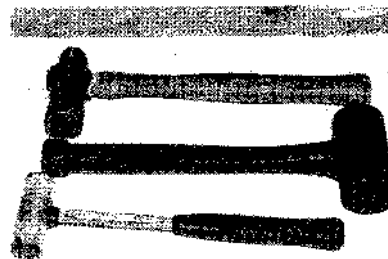


Fig. 48 Three types of hammers. Top to bottom: ball peen, rubber dead-blow, and plastic

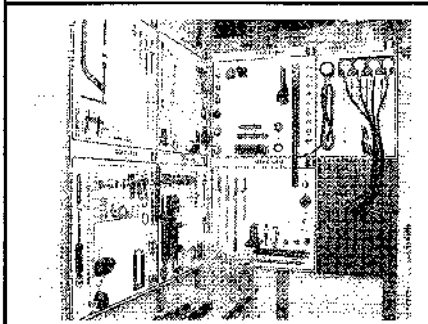


Fig. 49 Almost every marine engine around today requires at least one special tool to perform a certain task

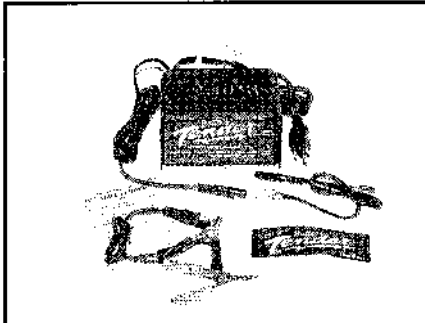


Fig. 50 The Battery Tender® is more than just a battery charger; when left connected it keeps **your** battery fully charged

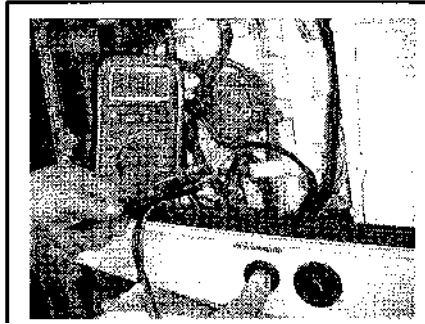


Fig. 51 Multimeters, such as this one from **VEI**, are an extremely useful tool for troubleshooting electrical problems

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.

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 driving a putty knife at various points between the two parts will break the seal without damage to the parts.

A small — 8–10 inches (20–25 centimeters) 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 broke off flush with the surface of the part.

Special Tools

◆ See Figure 49

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.

BATTERY CHARGERS

◆ See Figure 50

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 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.

MULTIMETERS (DVOMS)

● See Figure 51

Multimeters or Digital Volt Ohmmeter (DVOMS) are an extremely useful tool for troubleshooting electrical problems. They can be purchased in analog or digital form and have a price range to suit any budget. A multimeter 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 megaohms or more). A brief description of the multimeter 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.

1-22 GENERAL INFORMATION, SAFETY AND TOOLS

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 engines to run slowly, lights to dim and other components to not operate properly.

GAUGES

Compression Gauge

◆ See Figure 52

An important element in checking the overall condition of your engine is to check compression. This becomes increasingly more important on engines 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.



Fig. 52 Cylinder compression test results are extremely valuable indicators of internal engine condition

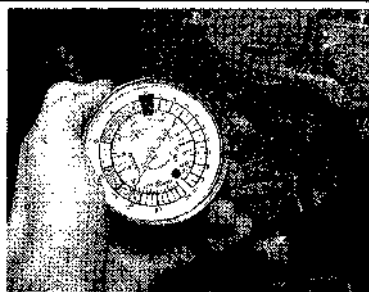


Fig. 53 Vacuum gauges are useful for troubleshooting including testing some fuel pumps

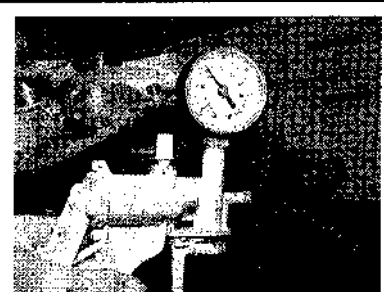


Fig. 54 You can also use the vacuum gauge on a hand-operated vacuum pump for tests

Vacuum Gauge

◆ See Figures 53 and 54

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 55

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 as 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.

Inside micrometers are used to measure the distance between two parallel surfaces. For example, in engine 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.

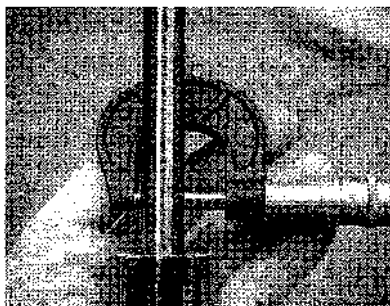


Fig. 55 Outside micrometers measure the thickness of parts like shims or the diameter of a shaft

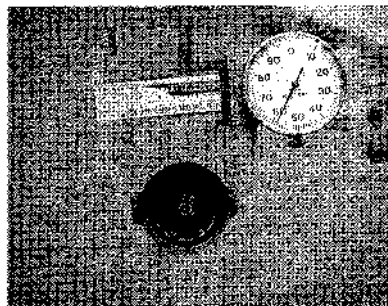


Fig. 56 Calipers are the fast and easy way to make precise measurements

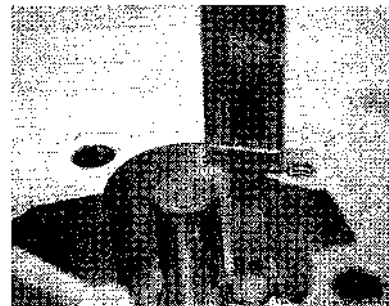


Fig. 57 Calipers can also be used to measure depth . . .

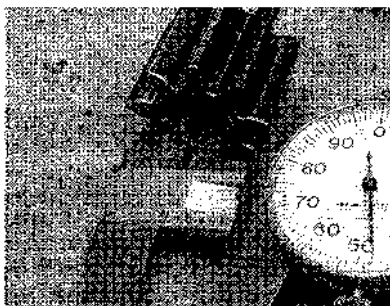


Fig. 58 . . . and inside diameter measurements, usually to 0.001 inch accuracy

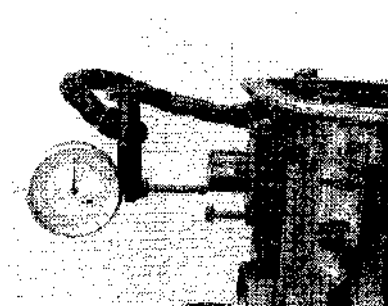


Fig. 59 This dial indicator is measuring the end-play of a crankshaft during an engine rebuild



Fig. 60 Telescoping gauges are used during engine rebuilding procedures to measure the inside diameter of bores

Calipers

- ◆ See Figures 56, 57 and 58

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 59

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.

TELESCOPING GAUGES

- ◆ See Figure 60

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 61

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.

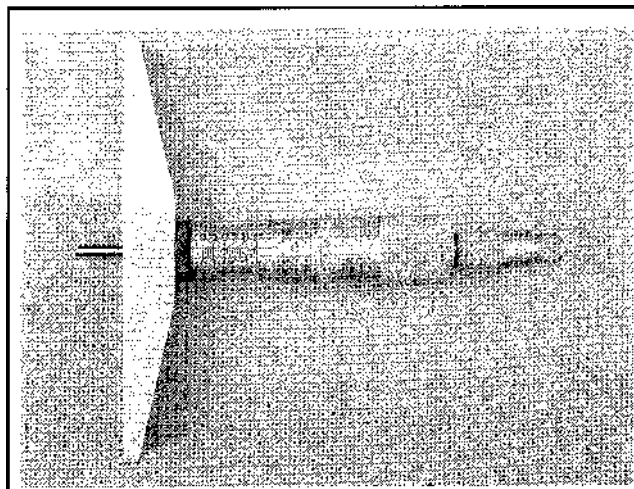


Fig. 61 Depth gauges are used to measure the depth of bore or other small holes

FASTENERS, MEASUREMENTS AND CONVERSIONS

Bolts, Nuts and Other Threaded Retainers

◆ See Figures 62 and 63

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.

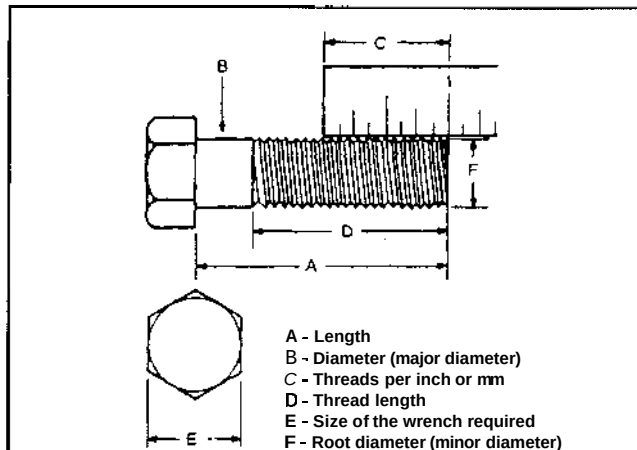


Fig. 62 Threaded retainer sizes are determined using these measurements

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).

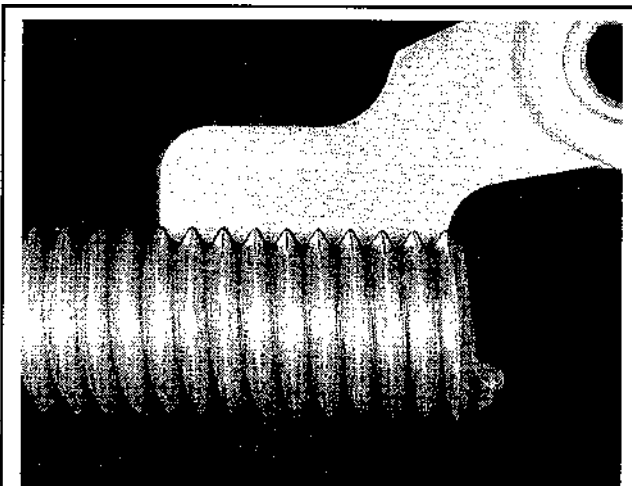


Fig. 63 Thread gauges measure the threads-per-inch and the pitch of a bolt or stud's threads

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 engine afterwards.

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.

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 accompanying conversion factors 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.

CONVERSION FACTORS

LENGTH-DISTANCE

Inches (in.)	x 25.4	= Millimeters (mm)	x .0394	= Inches
Feet (ft.)	x .305	= Meters (m)	x 3.281	= Feet
Miles	x 1.609	= Kilometers (km)	x .621	= Miles

VOLUME

Cubic Inches (in ³)	x 16.387	= Cubic Centimeters	x .061	= in ³
IMP Pints (IMP pt.)	x .568	= Liters (L)	x 1.76	= IMP pt.
IMP Quarts (IMP qt.)	x 1.137	= Liters (L)	x .88	= IMP qt.
IMP Gallons (IMP gal.)	x 4.546	= Liters (L)	x .22	= IMP gal.
IMP Quarts (IMP qt.)	x 1.201	= US Quarts (US qt.)	x .833	= IMP qt.
IMP Gallons (IMP gal.)	x 1.201	= US Gallons (US gal.)	x .833	= IMP gal.
Fl. Ounces	x 29.573	= Milliliters	x .034	= Ounces
US Pints (US pt.)	x .473	= Liters (L)	x 2.113	= Pints
US Quarts (US qt.)	x .946	= Liters (L)	x 1.057	= Quarts
US Gallons (US gal.)	x 3.785	= Liters (L)	x .264	= Gallons

MASS-WEIGHT

Ounces (oz.)	x 28.35	= Grams (g)	x .035	= Ounces
Pounds (lb.)	x .454	= Kilograms (kg)	x 2.205	= Pounds

PRESSURE

Pounds Per Sq. In. (psi)	x 6.895	= Kilopascals (kPa)	x .145	= psi
Inches of Mercury (Hg)	x .4912	= psi	x 2.036	= Hg
Inches of Mercury (Hg)	x 3.377	= Kilopascals (kPa)	x .2961	= Hg
Inches of Water (H ₂ O)	x .07355	= Inches of Mercury	x 13.783	= H ₂ O
Inches of Water (H ₂ O)	x .03613	= psi	x 27.684	= H ₂ O
Inches of Water (H ₂ O)	x .248	= Kilopascals (kPa)	x 4.026	= H ₂ O

TORQUE

Pounds-Force Inches (in-lb)	x .113	= Newton Meters (N·m)	x 8.85	= in-lb
Pounds-Force Feet (ft-lb)	x 1.356	= Newton Meters (N·m)	x .738	= ft-lb

VELOCITY

Miles Per Hour (MPH)	x 1.609	= Kilometers Per Hour (KPH)	x .621	= MPH
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POWER

Horsepower (Hp)	x .745	= Kilowatts	x 1.34	= Horsepower
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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

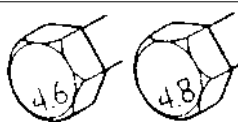
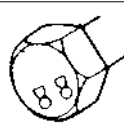
*It is common to convert from miles per gallon (mpg) to liters/100 kilometers (l/100 km), where mpg (IMP) x 1/100 km = 282 and mpg (US) x 1/100 km = 235.

TEMPERATURE

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

1-26 GENERAL INFORMATION, SAFETY AND TOOLS

Metric Bolts

Relative Strength Marking	4.6, 4.8			8.8		
Bolt Markings						
Usage	Frequent			Infrequent		
Bolt Size	Maximum Torque			Maximum Torque		
Thread Size x Pitch (mm)	Ft-Lb	Kgm	Nm	Ft-Lb	Kgm	Nm
6 x 1.0	2-3	.2-.4	3-4	3-6	.4-.8	5-8
8 x 1.25	6-8	.8-1	8-12	9-14	1.2-1.9	13-19
10 x 1.25	12-17	1.5-2.3	16-23	20-29	2.7-4.0	27-39
12 x 1.25	21-32	2.9-4.4	29-43	35-53	4.8-7.3	47-72
14 x 1.5	35-52	4.8-7.1	48-70	57-85	7.8-11.7	77-110
16 x 1.5	51-77	7.0-10.6	67-100	90-120	12.4-16.5	130-160
18 x 1.5	74-110	10.2-15.1	100-150	130-170	17.9-23.4	180-230
20 x 1.5	110-140	15.1-19.3	150-190	190-240	26.2-46.9	160-320
22 x 1.5	150-190	22.0-26.2	200-260	250-320	34.5-44.1	340-430
24 x 1.5	190-240	26.2-46.9	260-320	310-410	42.7-56.5	420-550

SAE Bolts

SAE Grade Number	1 or 2			5			6 or 7		
Bolt Markings									
Usage	Frequent			Frequent			Infrequent		
Bolt Size (inches)—(Thread)	Maximum Torque			Maximum Torque			Maximum Torque		
	Ft-Lb	kgm	Nm	Ft-Lb	kgm	Nm	Ft-Lb	kgm	Nm
1/4—20	5	0.7	6.8	8	1.1	10.8	10	1.4	13.5
—28	6	0.8	8.1	10	1.4	13.6			
5/16—18	11	1.5	14.9	17	2.3	23.0	19	2.6	25.8
—24	13	1.8	17.6	19	2.6	25.7			
3/8—16	18	2.5	24.4	31	4.3	42.0	34	4.7	46.0
—24	20	2.75	27.1	35	4.8	47.5			
7/16—14	28	3.8	37.0	49	6.8	66.4	55	7.6	74.5
—20	30	4.2	40.7	55	7.6	74.5			
1/2—13	39	5.4	52.8	75	10.4	101.7	85	11.75	115.2
—20	41	5.7	55.6	85	11.7	115.2			
9/16—12	51	7.0	69.2	110	15.2	149.1	120	16.6	162.7
—18	55	7.6	74.5	120	16.6	162.7			
5/8—11	83	11.5	112.5	150	20.7	203.3	167	23.0	226.5
—18	95	13.1	128.8	170	23.5	230.5			
3/4—10	105	14.5	142.3	270	37.3	366.0	280	38.7	379.6
—16	115	15.9	155.9	295	40.8	400.0			
7/8—9	160	22.1	216.9	395	54.6	535.5	440	60.9	596.5
—14	175	24.2	237.2	435	60.1	589.7			
1—8	236	32.5	318.6	590	81.6	799.9	660	91.3	894.8
—14	250	34.6	338.9	660	91.3	849.8			

ANODES (ZINCS)	2-48	POWER STEERING	2-34
INSPECTION	2-48	POWER TRIM/TILT PUMP	2-45
SERVICING	2-48	STERN DRIVE UNIT	2-41
BATTERIES	2-48	FUEL AND OIL RECOMMENDATIONS	2-29
CHARGERS	2-51	FUEL FILTER	2-6
CHECKING SPECIFIC GRAVITY	2-49	REMOVAL & INSTALLATION	2-7
CLEANING	2-49	IDLE SPEED AND MIXTURE	2-27
PRECAUTIONS	2-50	ADJUSTMENT	2-27
REPLACING CABLES	2-51	IGNITION TIMING	2-22
STORAGE	2-51	ADJUSTMENT	2-22
TERMINALS	2-50	LUBRICATION POINTS	2-45
BELTS	2-8	GIMBAL BEARING AND U-JOINTS	2-46
ADJUSTMENT	2-11	PROPELLER SHAFT	2-45
INSPECTION	2-8	SHIFT CABLE AND TRANSMISSION	
REMOVAL & INSTALLATION	2-12	LINKAGE PIVOT POINTS	2-45
ROUTING DIAGRAMS	2-10	STEERING SYSTEM	2-46
BOAT MAINTENANCE	2-47	THROTTLE CABLE	2-45
ANODES (ZINCS)	2-48	OIL	2-30
BATTERIES	2-48	LEVEL CHECK	2-30
INSIDE THE BOAT	2-47	OIL & FILTER CHANGE	2-32
THE BOAT'S EXTERIOR	2-47	PCV VALVE	2-29
BREAKER POINTS AND CONDENSER	2-25	INSPECTION	2-29
ADJUSTMENT - DWELL METER	2-26	REMOVAL & INSTALLATION	2-29
ADJUSTMENT - FEELER GAUGE	2-26	POWER STEERING	2-34
REMOVAL & INSTALLATION	2-25	BLEEDING	2-34
COOLING SYSTEM	2-35	FLUID LEVEL	2-34
DRAINING & FILLING	2-37	POWER TRIM/TILT PUMP	2-45
FLUSHING THE SYSTEM	2-35	FLUID LEVEL	2-45
LEVEL CHECK	2-35	SERIAL NUMBER IDENTIFICATION	2-2
PRESSURE CAP	2-37	ENGINE	2-2
PRESSURE TEST	2-37	STERN DRIVE	2-3
CYLINDER COMPRESSION	2-16	TRANSOM ASSEMBLY	2-3
CHECKING	2-16	SPARK PLUGS	2-17
DISTRIBUTOR AIR GAP	2-27	HEAT RANGE	2-17
ADJUSTMENT	2-27	INSPECTION & GAPPING	2-20
ENGINE AND DRIVE MAINTENANCE	2-2	READING	2-19
BELTS	2-8	REMOVAL & INSTALLATION	2-18
BREAKER POINTS AND CONDENSER	2-25	SERVICE	2-18
CYLINDER COMPRESSION	2-16	SPARK PLUG WIRES	2-22
DISTRIBUTOR AIR GAP	2-27	REMOVAL & INSTALLATION	2-22
FLAME ARRESTOR	2-3	TESTING	2-22
FUEL FILTER	2-6	SPECIFICATIONS	2-55
IDLE SPEED AND MIXTURE	2-27	CAPACITIES	2-63
IGNITION TIMING	2-22	ENGINE MODEL APPLICATIONS	2-55
OVERVIEW	2-2	MAINTENANCE INTERVALS	2-64
PCV VALVE	2-29	TROUBLESHOOTING	2-66
SERIAL NUMBER IDENTIFICATION	2-2	TUNE-UP	2-57
SPARK PLUG WIRES	2-22	SPRING COMMISSIONING	2-52
SPARK PLUGS	2-17	SPRING COMMISSIONING CHECKLIST	2-52
THERMOSTAT	2-13	STERN DRIVE	2-41
VALVE ADJUSTMENT	2-29	CHECKING FOR WATER	2-41
FIRING ORDERS	2-52	DRAIN AND REFILL	2-42
FLAME ARRESTOR	2-3	FLUID LEVEL	2-41
REMOVAL & INSTALLATION	2-4	THERMOSTAT	2-13
FLUIDS AND LUBRICANTS	2-29	REMOVAL & INSTALLATION	2-13
COOLING SYSTEM	2-35	TESTING	2-15
ENGINE	2-30	VALVE ADJUSTMENT	2-29
FLUID DISPOSAL	2-29	WINTER STORAGE	2-51
FLUSHING THE SYSTEM		WINTER STORAGE CHECKLIST	2-51
FUEL AND OIL RECOMMENDATIONS	2-29		

2

ENGINE AND DRIVE MAINTENANCE

ENGINE AND DRIVE MAINTENANCE	2-2
FLUIDS AND LUBRICANTS	2-29
LUBRICATION POINTS	2-45
BOAT MAINTENANCE	2-47
WINTER STORAGE	2-51
FIRING ORDERS	2-52
SPRING COMMISSIONING	2-52
SPECIFICATIONS	2-55

2-2 ENGINE AND DRIVE MAINTENANCE

ENGINE AND DRIVE MAINTENANCE

Overview

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 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 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 engine 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 engine 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 engine 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.

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.

Serial Number Identification

An engine specifications decal can generally be found on top of the flame arrestor, on the side of the thermostat housing, or on the top/side of the rocker arm cover, usually near the breather/PCV line (most models); all pertinent serial number information can be found here—engine and drive designations, serial numbers and model numbers. Unfortunately this decal is not always legible on older engines and it can be quite difficult to find, so please refer to the following procedures for each individual unit's serial number location.

Serial numbers tags are frequently difficult to see when the engine is installed in the boat; a mirror can be a handy way to read all the numbers.

ENGINE

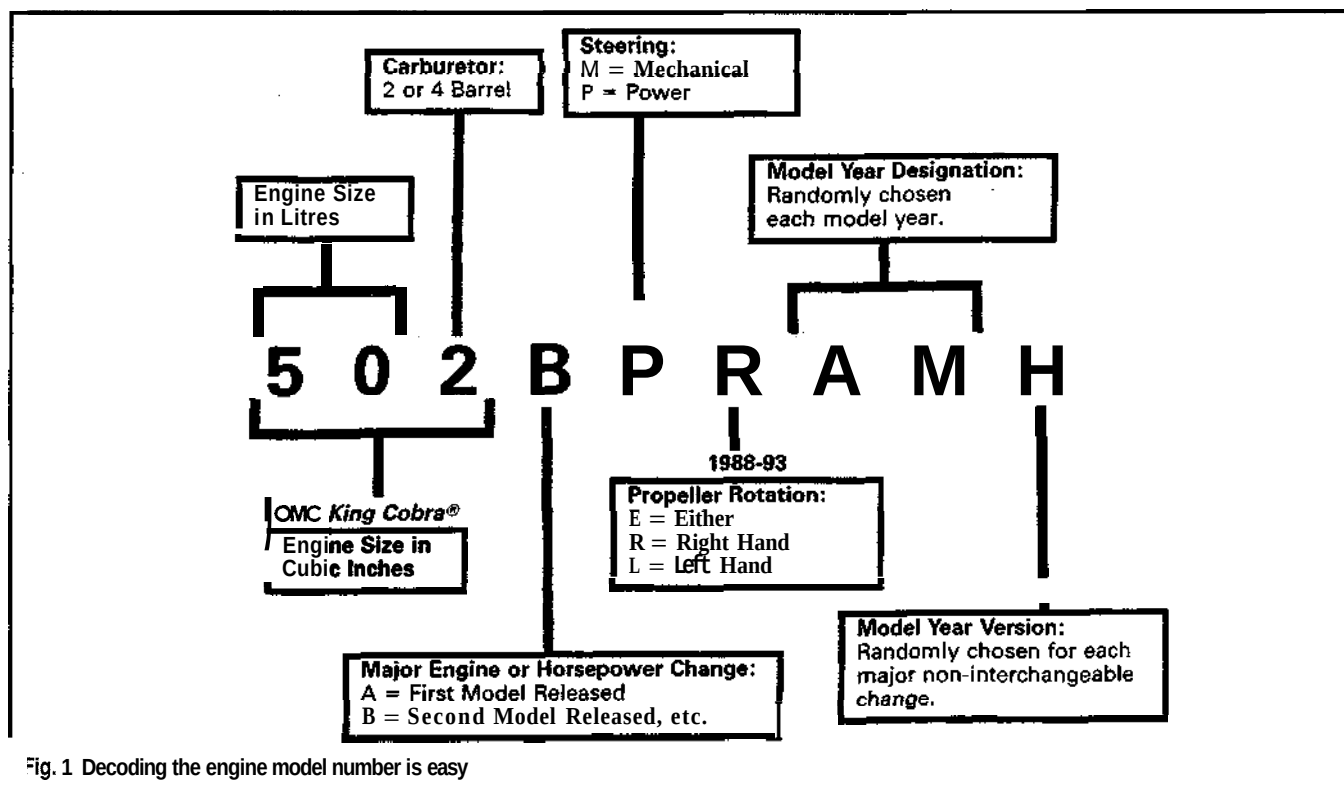
♦ See Figures, 1, 2, 3, 4, 5, 6 and 7

The engine serial numbers are the manufacturer's key to engine changes. These alpha-numeric codes identify the year of manufacture, the horsepower rating and various model option differences. If any correspondence or parts are required, the engine serial number must be used for proper identification.

Remember that the serial number establishes the year in which the engine was produced, which is often not the year of first installation.

The engine specifications decal contains information such as the model number or code, the serial number (a unique sequential identifier given ONLY to that one engine) as well as other useful information.

An engine specifications decal can generally be found on top of the flame arrestor, on the side of the thermostat housing (early V6/V8 engines), or on the inner side of the rocker arm cover, usually near the breather/PCV line (port side on most models) - all pertinent serial number information can be found here—engine and drive designations, serial numbers and model



numbers. Unfortunately this decal is not always legible on older boats and it's also quite difficult to find, so please refer to the following procedures for each individual's unit's serial number location.

Serial numbers tags are frequently difficult to see when the engine is installed in the boat; a mirror can be a handy way to read all the numbers.

The engine serial/model number is sometimes also stamped on the port rear side of the engine where it attaches to the bell housing; although on most later models it may instead be a metal plate attached in the same location. If your engine has a stamped number it will simply be the serial number; if you have a plate (and you should), it will always show a Model number and then the actual Serial number. Additionally, most models will also have this plate or sticker on the transom bracket.

- The first two characters identify the engine size in liters (L); 30 represents the 3.0L, 43 represents the 4.3L, 50 represents the 5.0L and so forth. Please note though, that there were a few King Cobra engines that listed the engine size in cubic inches; the 1989 460 for example used the first three characters and showed 460 rather than the 75 that it would normally show.

- The third character identifies the fuel delivery system; 2 designates a 2 bbl carburetor, 4 is a 4 bbl carburetor, and F is a fuel injected engine. Remember those King Cobras we just discussed? If the engine designation is in cubic inches rather than liters, the third character will not be used to designate the type of fuel delivery.

- The fourth character designates a major engine or horsepower change—it doesn't let you know what the change was, just that there was some sort of change. A means it is the first model released, B would be the second, and so forth

- The fifth character designates what type of steering system was used; M would be manual steering and P would be power steering.

- Now here's where it gets interesting; on 1986-87 engines and 1994-98 engines, the sixth, seventh and eighth characters designate the model year. The sixth and seventh actually show the model year, while the eighth is a random model year version code. KWB and WXS represent 1986; and ARJ, ARF, FTC, SRC or SRY show 1987. MDA is 1994, HUB is 1995, NCA is 1996, LKD is 1997 and BYC is 1998.

- On 1988-93 engines, the sixth character designates the direction of propeller rotation. R is right hand, L is left hand and E is either.

- Also on 1988-93 engines, the seventh, eighth and ninth characters designate the model year. The seventh and eighth actually show the model year, while the ninth is a random model year version code. GDE or GDP is 1988, MED or MEF is 1989, PWC, PWR or PWS is 1990, RGD or RGF is 1991, AMH or AMK is 1992 and JVB or JVN is 1993.

Any remaining characters are proprietary. So in example, a Model number on the ID plate that reads **574AMFTC** would designate a 1987 5.7L engine with a 4 bbl carburetor and manual steering, first model released. A number reading **58FAPRJVB** would designate a 1993 5.8L engine with fuel injection, power steering and a right hand propeller, first release; get the picture?

STERN DRIVE

◆ See Figures 8 and 9

The stern drive serial/model number plate can be found on the center port side of the unit, just under and beneath the trim/tilt cylinder. Both the serial number and the gear ratio should be on the tag. Make sure you don't confuse the two! You may also find the model number included on the transom assembly tag.

TRANSOM ASSEMBLY

◆ See Figure 9

The transom assembly serial number decal/plate can be found on the upper starboard end of the unit.

Flame Arrestor

In a marine engine compartment, the minimal amount of dust and dirt in the air mean that a marine air filter requires less maintenance than its counterpart in the automotive world. However, the maintenance of a marine air filter is equally important.

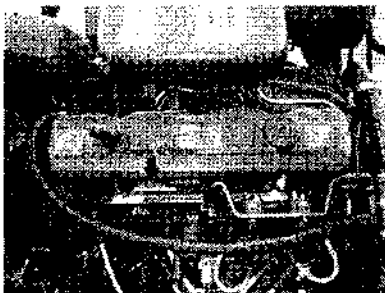


Fig. 2 Engine serial number **sticker**—3.0L engines (2.3L and 2.5L engine similar)

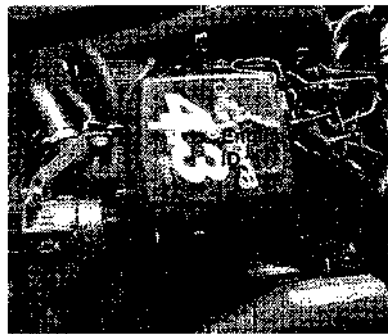


Fig. 3 Engine serial number **sticker**—4.3L engines

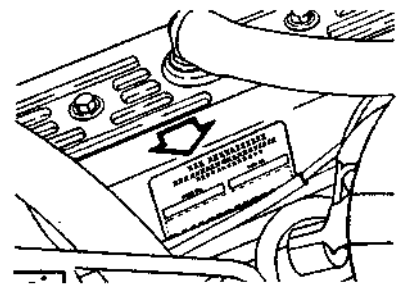


Fig. 4 Engine serial number sticker—V6 and V8 engines

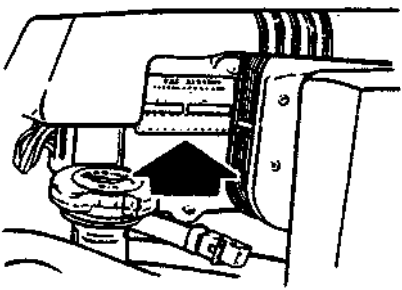


Fig. 5 The engine serial number sticker on injected Ford motors can be found on the Thick Film module bracket engines



Fig. 6 On many early engines, the sticker is found on the thermostat housing



Fig. 7 You should also be able to find a plate on the transom bracket

2-4 ENGINE AND DRIVE MAINTENANCE

The marine filter prevents dirt from entering the engine. This lessens oil/fuel consumption and extends the engine's life. The air filter on some engines is also used as an intake silencer to quiet the intake air sound as it rushes into the cylinder head from the intake ports.

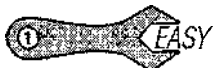
Over time, the air filter element will become clogged with dirt and oil, decreasing the amount of air entering the engine and lowering engine output. If an excessive amount of oil is clogging the filter, this could be an indication of worn cylinders or piston ring failure causing high pressure in the crankcase.

The maintenance interval for flame arrestor cleaning is at the end of the first boating season, and then every 100 hours of engine operation or once a year, whichever comes first on 1986-90 engines. On 1991-98 engines, the interval is decreased to every 50 hours of engine operation or once a season, whichever comes first.

REMOVAL & INSTALLATION

All Models W/Carburetor Or TBI

◆ See Figures 10, 11, 12, 13 and 14



1. Remove or open the engine compartment cover.
2. Many models utilize a plastic cover over the flame arrestor—if so equipped, remove the retaining nut and lift off the cover.
3. Tag and disconnect the crankcase ventilation hose and bracket from the arrestor and the rocker arm cover. TBI models and later carbureted models will have two hoses and brackets.
2. Remove the nut and washer securing the flame arrestor cover to the carburetor.
3. Lift off the flame arrestor. Unscrew the stud if necessary.

Early 2.5L and 3.0L engine utilize a gasket between the arrestor and the carburetor—remove this gasket and discard it.

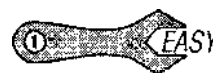
4. On TBI models, lift the injector baffle off of the stud.

To install:

5. Clean the arrestor in solvent and dry with compressed air if possible; otherwise make sure that it dries completely by air. Clean the hose(s) and then inspect them for cracks or deterioration. Replace if necessary.
6. Install the injector baffle if removed.
7. If you remove the stud, thread it into the carburetor (or throttle body) and tighten it to 65-80 inch lbs. (7.3-9 Nm).
8. Install a new gasket onto the carburetor on 2.5L/3.0L engines if equipped.
9. Position the arrestor over the stud and reconnect the ventilation hose(s) and bracket(s).
10. Install the washer and nut, tightening it to 30-40 inch lbs. (3.4-4.5 Nm) on carbureted models; or 25-35 inch lbs. (2.8-4 Nm) on TBI models.
11. Install the flame arrestor cover (if equipped) and tighten the nut 30-35 inch lbs. (3.4-4 Nm) on carbureted models; or 25-35 inch lbs. (2.8-4 Nm) on TBI models.
12. Close the engine compartment.

Ford Engines With MFI

+ See Figures 15, 16 and 17



1. Remove or open the engine compartment cover.
2. Remove the four screws securing the plastic flame arrestor cover to the engine and lift off the cover. Set it aside where you won't step on it—they break easy and they're expensive!
3. Remove the two bolts (1) and washers securing the flame arrestor to the throttle body.

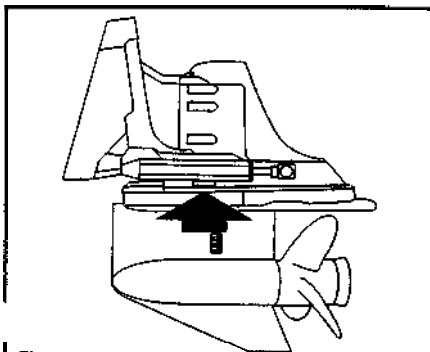


Fig. 8 Stern drive unit serial number location

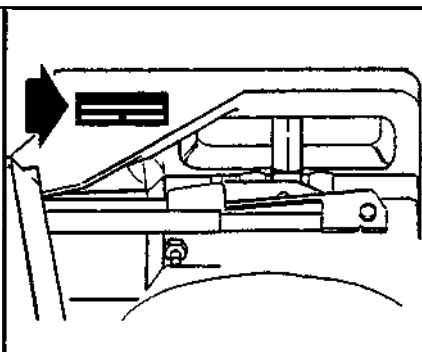


Fig. 9 Transom assembly serial number tag

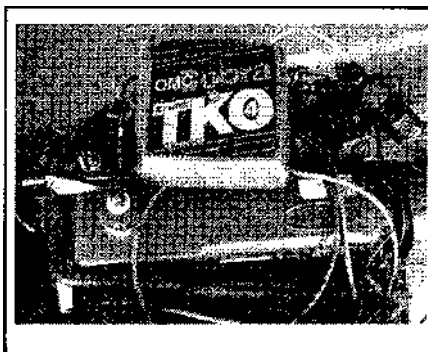


Fig. 10-Many models will have a decorative cover over the arrestor cover...



Fig. 11 ...make sure to remove the nut(s) before lifting it off

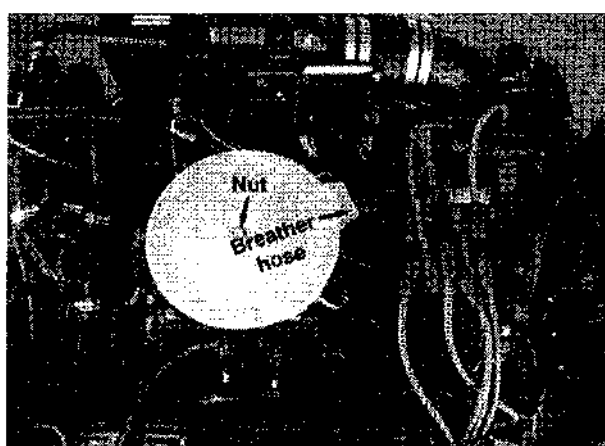


Fig. 12 Once the plastic cover is removed, loosen the arrestor retaining nut and remove the breather hose(s). Notice that not all models have a bracket for the hose—this late model 5.7L has the connection built-in...



Fig. 13 ...and then lift off the arrestor

□ Make sure you secure the lower bracket while removing the bolts as it will fall free when the bolts are removed.

4. Cut the plastic tie strap securing the breather hose to the oil filler fitting and wiggle the hose off the nipple.
5. Lift off the flame arrestor.
- To install:
6. Clean the arrestor in solvent and dry with compressed air if possible; otherwise make sure that it dries completely by air.
7. Check the rubber gasket around the throttle body throat for any cracks, tears or other obvious signs of deterioration. Replace if necessary and make sure that it seats properly. The little nipple must be facing downward. We would replace it whether it needs it or not—cheap insurance; but you make the call.
8. Position the arrestor over the throttle body throat and move the lower bracket into position so the nipple in the gasket (1) fits into the hole on the bracket. Install the bolts finger-tight.

*** WARNING

When tightening the flame arrestor, you must have pressure on it while tightening the mounting bolts in order to ensure against any air leaks.

9. Have an assistant press the arrestor in, and against, the throttle body while you tighten the two mounting bolts to 24-48 inch lbs. (2.75-4.8 Nm).
10. Wiggle the breather hose back into position on the filler nipple and secure it with a new plastic tie.
11. Install the plastic cover and tighten the four screws securely. Make sure you don't tighten them too much or you'll crack the cover.
12. Close the engine compartment.

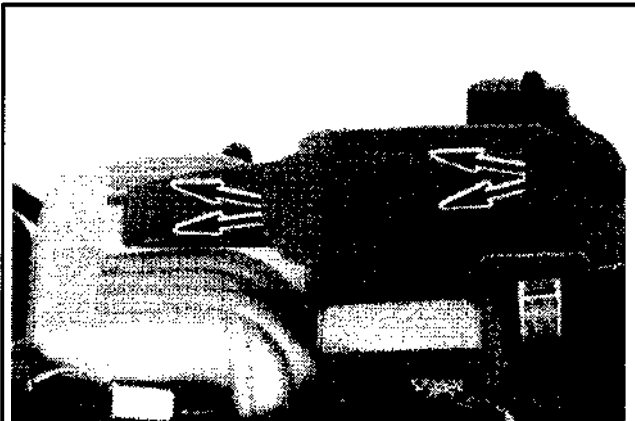


Fig. 15 Remove the 4 screws and lift off the plastic cover

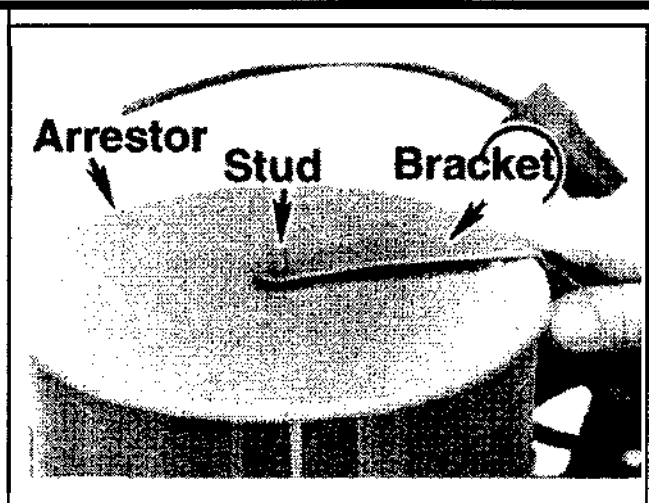
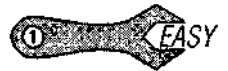


Fig. 14 Here's a good shot of the breather hose

GM Engines With MFI Except 1998 7.4Gi Engines



◆ See Figures 18, 19 and 20

1. Remove or open the engine compartment cover.
2. Carefully wiggle the crankcase ventilation hoses off of their necks on the sides of the arrestor.
3. Remove the nut securing the flame arrestor to the throttle body.
4. Lift off the flame arrestor.

Take note of the positioning of the arrestor prior to removal. Many models use a baffle to ensure correct air distribution and must be installed in the same position that they were in when removed.

5. Remove the rubber gasket from the lip on the arrestor.
- To install:
6. Clean the arrestor in solvent and dry with compressed air if possible; otherwise make sure that it dries completely by air.
7. Check the rubber gasket for any cracks, tears or other obvious signs of deterioration. Replace if necessary and make sure that it seats properly. We would replace it whether it needs it or not—its cheap insurance; but you make the call.
8. Position the arrestor, install the retaining nut and washer and tighten securely but not so tightly as to dimple the cover.
9. Check the breather hose ends for cracks or deterioration and then slide them back into position.
10. Close the engine compartment.

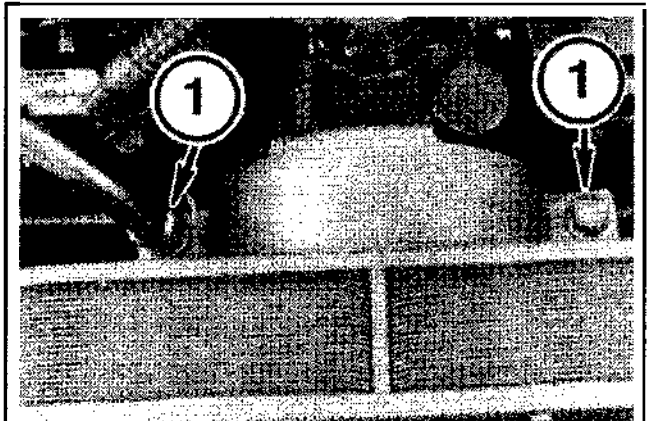


Fig. 16 Remove the 2 bolts and lift off the flame arrestor

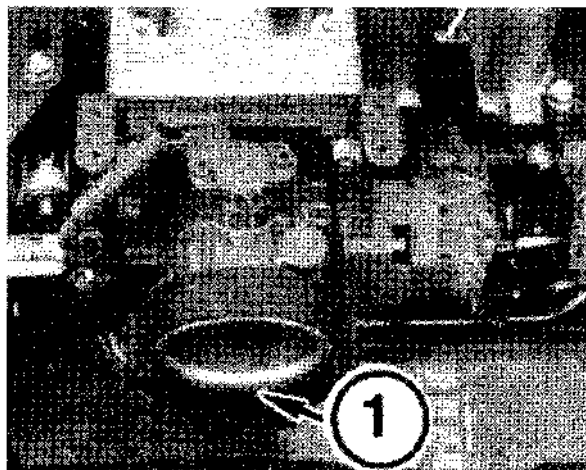


Fig. 17 Make sure the nipple on the gasket is positioned correctly

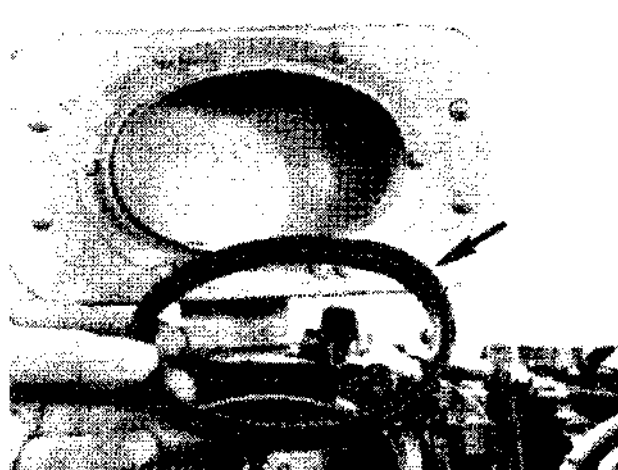


Fig. 18 Remove the gasket before cleaning the arrestor..

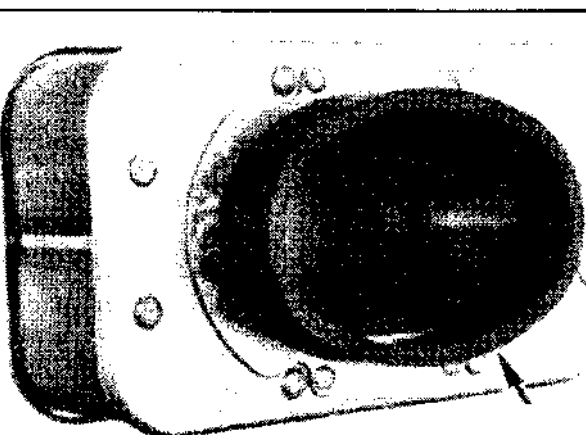


Fig. 19 ..and then make sure it is positioned correctly before reinstalling

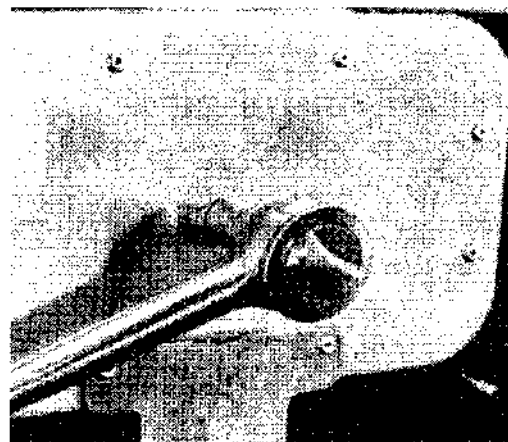
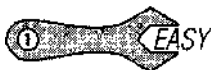


Fig. 20 Tighten the mounting bolt before installing the hoses

1998 7.4Gi Engines With MFI

◆ See Figures 21 and 22



1. Remove or open the engine compartment cover.
2. Remove the retaining nuts (one or two, depending on application) from the plastic cover and lift off the cover. Set it aside where you won't step on it—they break easy and they're expensive!
3. Tag and disconnect the MAP sensor harness connector on the 8.1L and move it aside. Press inward on the grey plastic lip while carefully pulling down on the lower half of the connector.
4. Back off the adjusting screw on the arrestor clamp until the clamp is loose.
5. Lift off the flame arrestor.

☐ Take note of the positioning of the arrestor prior to removal. Many models use a baffle to ensure correct air distribution and must be installed in the same position that they were in when removed.

To install:

6. Clean the arrestor in solvent and dry with compressed air if possible; otherwise make sure that it dries completely by air.
7. Position the arrestor, install the retaining clamp and tighten the adjusting screw securely.
8. Reconnect the MAP sensor on the 8.1L.
9. Install the plastic cover and tighten the nut(s) securely
10. Close the engine compartment.

Fuel Filter

A fuel filter is designed to keep particles of dirt and debris from entering the carburetors or the fuel injection system and clogging the tiny internal passages of either. 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/oil 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. Although a clogged fuel passage in a fuel injected engine could also cause lean symptoms and idle problems, dirt can also prevent a fuel injector from closing properly. A fuel injector that is stuck partially open by debris would likely cause the engine to run rich due to the unregulated fuel constantly spraying from the pressurized injector.

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 pretty inexpensive (at least when compared to a tow) and replacement is a simple task. Service your fuel filter on a regular basis to avoid fuel delivery problems. All filters should be replaced no less than once a season or every 50 hours of operation, although halving this interval is cheap insurance!

The type of fuel filter used on your engine will vary with the year and model. 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 engine, trace the fuel line from the tank to the fuel pump and then from the pump to the carburetors or throttle body. As a general rule of thumb, the majority of engines covered here utilize a canister-type in-line water separating filter. Most 2.5L and 3.0L engines have the filter incorporated into the fuel pump; but may also have an in-line water separating filter. Additionally, most carbureted engines will further utilize a small filter/screen in the carburetor.

As mentioned previously, most new engines have a factory-installed water separating fuel filter. This type filter is also available as an accessory for all other engines and should be installed at the earliest possible convenience. Such a kit is not expensive, and contains instructions for correct installation.

A water separating filter, as its name suggests, removes water and other fuel system contaminants before they reach the carburetor and helps minimize potential problems. The presence of water in the fuel will alter the proportion of air/fuel mixture to the "lean" side, resulting in a higher operating temperature and possible damage to pistons, if not corrected.

The filter consists of a mounting plate and disposable canister filter (much like an oil filter). The filter is installed between the fuel tank and the fuel pump

REMOVAL & INSTALLATION

** 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 **of fire or explosion.**

Fuel Pump Filter—2.5L And 3.0L Engines Only

- ◆ See Figures 23 and 24



■ All 2.5L engines and MOST 3.0L engines are equipped with this style filter, but not all—1986-90 engines should have the filter canister in the top half of the fuel pump, 1991-94 engines should have no filter in the fuel pump and use a standard in-line canister filter, while 1995-98 engines should have the filter in the lower half of the fuel pump. Further, any of these engine may also use a standard in-line canister filter, and they all should have a small in-line filter at the carburetor.

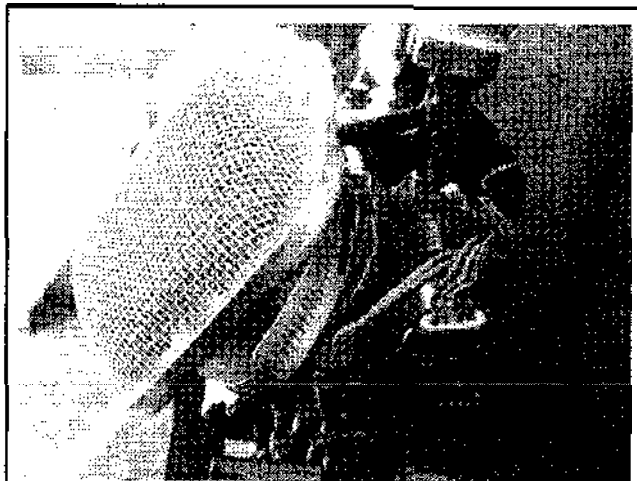


Fig. 21 A good shot of the arrestor retaining clamp

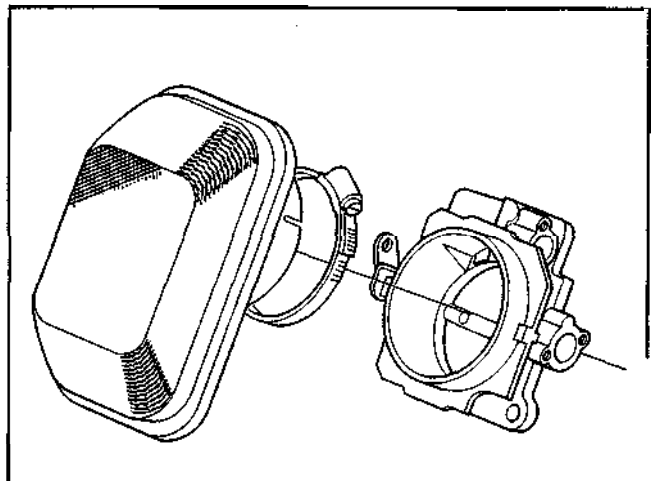


Fig. 22 Removing the flame arrestor—7.4Gi Engines w/MFI

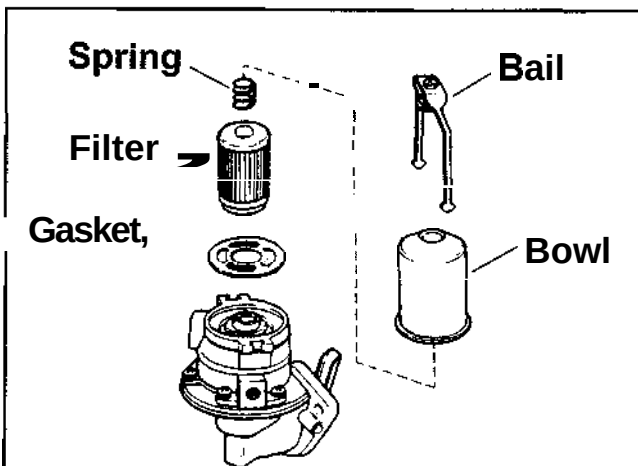


Fig. 23 Some engines have the filter in the top half of the fuel pump...

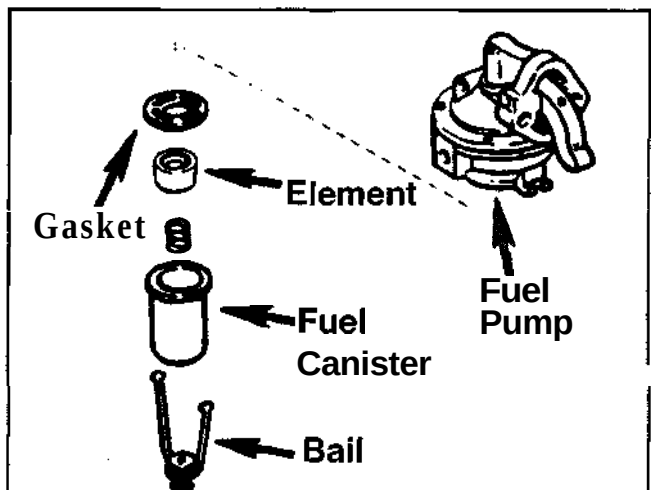


Fig. 24 ...while others have it in the lower half of the pump

2-8 ENGINE AND DRIVE MAINTENANCE

✖✖ 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.

1. Remove or open the engine compartment hatch.
2. Disconnect the negative battery cable and then remove the flame arrestor.
3. Remove the safety wire from the screw at the bottom (or top) of the pump.
4. Loosen the screw and release the filter bowl bail from the housing. It's not necessary to remove the bail completely, you can usually swing the bail to the side far enough to allow removal of the bowl/canister.

✖✖ CAUTION

There will be fuel in the bowl, so have plenty of rags available.

5. Carefully pry the bowl from the pump housing and remove the spring, filter element and gasket.
To install:
6. Clean all parts carefully and check for any cracks, deterioration or other damage.
7. Position the spring, new filter and gasket into the bowl. Make sure that the open end faces the pump.
8. Hold the bowl in position on the pump and snap the retaining bail into place.
9. Tighten the screw securely, but not too tight, and then install the safety wire (if equipped).
10. Reconnect the battery cable, install the flame arrestor and start the engine. Check that there are no fuel leaks and then install or close the engine compartment hatch.

Carburetor Fuel Inlet Filter

◆ See Figures 25 and 26



✖✖ 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.

1. Remove or open the engine compartment cover.
2. Disconnect the negative battery cable.
3. Remove the flame arrestor as detailed in this section.
4. Position an flare wrench on the fuel inlet filter nut at the carburetor. Position another wrench on the fuel line nut. Loosen the fuel line nut while holding the inlet nut with the other wrench and pull out the fuel line. Make sure you plug the line to prevent any fuel from spilling and carefully position it out of the way.
5. Loosen and then carefully remove the inlet nut from the carburetor body. Pull out the gasket(s) (one or two), the filter element and the spring.

■ On models with a non-replaceable filter, the inlet nut will simply have a filter screen attached to its inner end. There will be no small washer, filter element or spring.

To install:

6. Although most elements can be cleaned and reused, we recommend replacement with a new one whenever possible.

Certain models do not utilize a replaceable filter, instead they will have a filter screen attached to the inner end of the inlet nut which can only be cleaned and reused.

7. On models with a replaceable filter:
 - a. Insert the spring into the carburetor and then slide in the filter element. Be sure that the open end of the filter faces out (toward the inlet nut).
 - b. Position the large gasket over the inlet nut threads and the small one inside the nut. Screw the nut into the carburetor and tighten it securely; but not too tight.
8. On models with a non-replaceable filter:
 - a. Slide the washer over the inlet nut threads.
 - b. Screw the nut into the carburetor and tighten it securely; but not too tight.
9. Clean the threads and position the fuel line nut into the inlet, seat it a few turns with your fingers and then tighten it to 11-13 ft. lbs. (14.9-17.6 Nm).
10. Install the flame arrestor and connect the battery cable. Start the engine and check for fuel leaks.
11. Install or close the engine compartment.

Water Separating Canister Filter

◆ See Figures 27 and 28



✖✖ 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.

1. Remove or open the engine compartment hatch.
2. Disconnect the negative battery cables.
3. Remove the canister filter from the mounting plate by rotating the canister counterclockwise—as viewed from the bottom end of the filter canister. An oil filter strap wrench may be necessary to break the filter free. Keep the filter upright to avoid spilling fuel. Properly dispose of the fuel and fuel saturated canister. Make sure you have plenty of rags handy just in case!

✖✖ WARNING

The old canister filter cannot be cleaned and used a second time. Never attempt to reuse the filter!

To install:

4. Coat the sealing ring(s) of a NEW canister filter with clean engine oil (there may be two rings so make sure that the old one comes out and the new one goes in!).
5. Install the filter onto the mounting plate and tighten it securely by hand—approximately 112 of a turn after the gasket makes initial contact with the flange.

✖✖ WARNING

Never use an oil filter wrench to tighten the canister.

6. Reconnect the battery cables and start the engine. Check that there are no fuel leaks and then close the engine hatch.

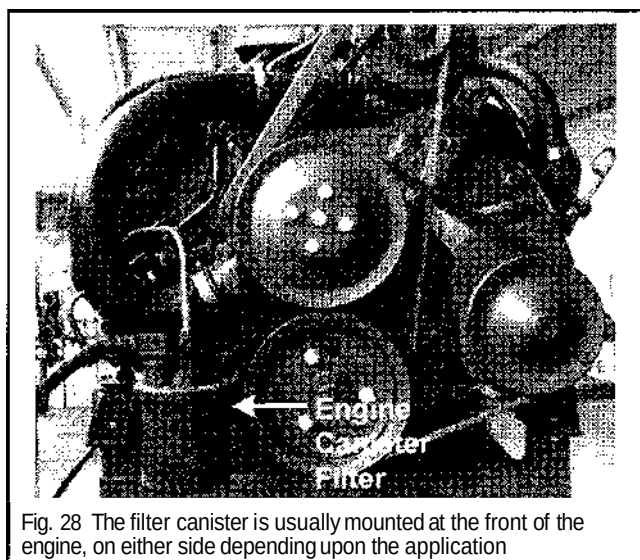
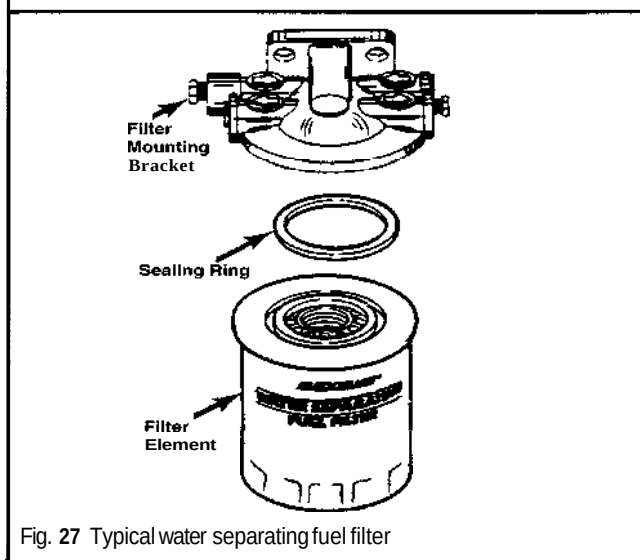
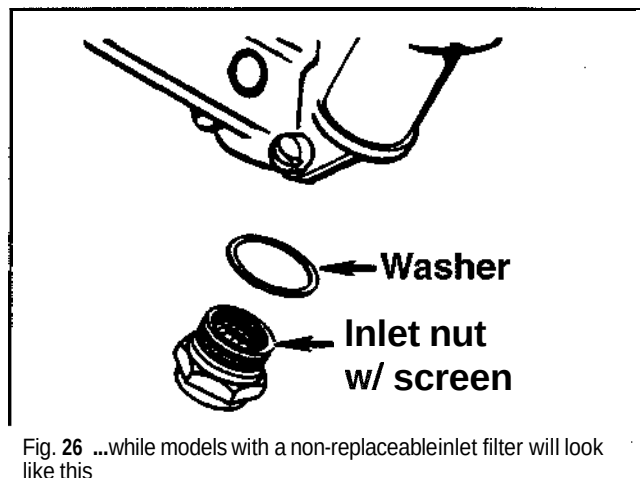
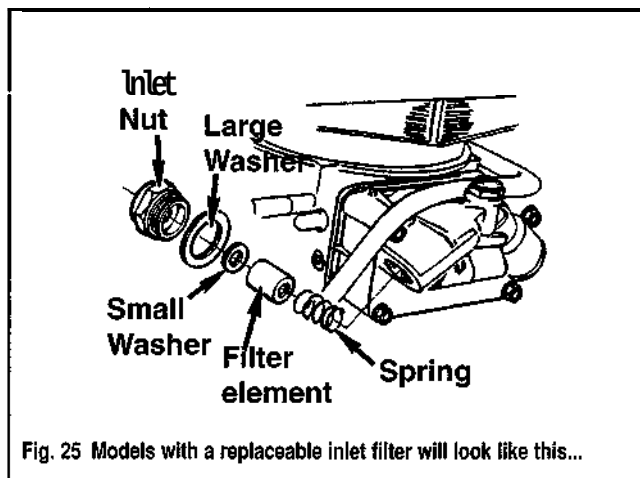
Belts

INSPECTION



◆ See Figures 29, 30, 31, 32 and 33

V-belts should be inspected on a regular basis for signs of glazing or cracking. A glazed belt will be perfectly smooth from slippage, while a good belt will have a slight texture of fabric visible. Cracks will usually start at the inner edge of the belt and run outward. All worn or damaged drive belts



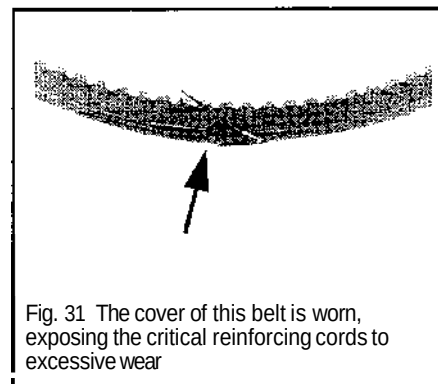
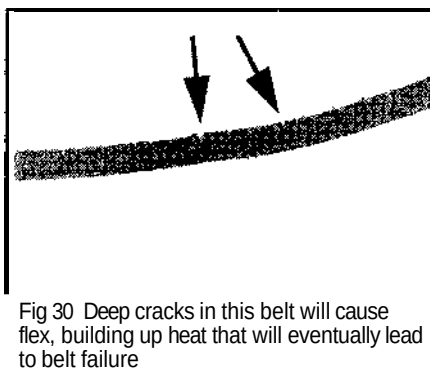
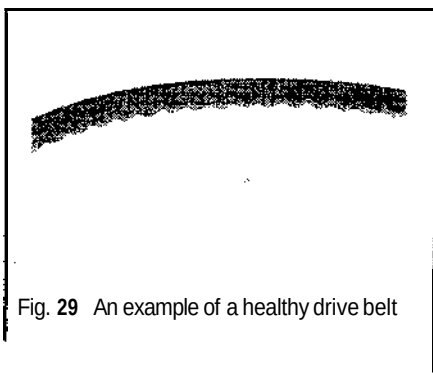
should be replaced immediately. It is best to replace all drive belts at one time, as a preventive maintenance measure, during this service operation.

Inspect the alternator, power steering, sea-water supply pump and water pump V-belts every 50 hours or twice a season (whichever comes first) for evidence of wear such as cracking, fraying, and incorrect tension. New belts should be checked after the first 10 hours of operation.

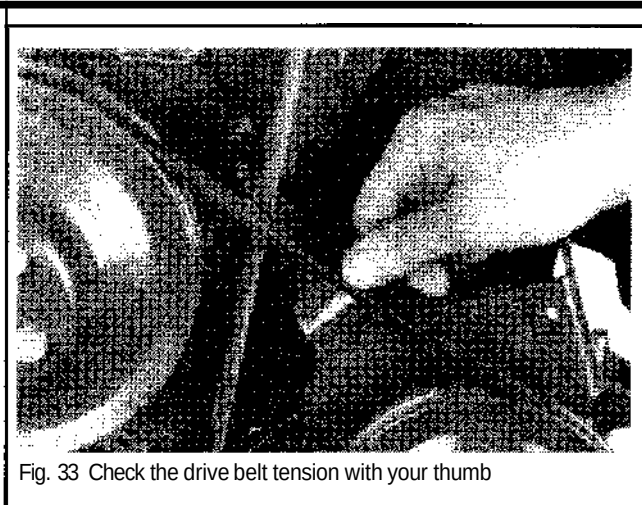
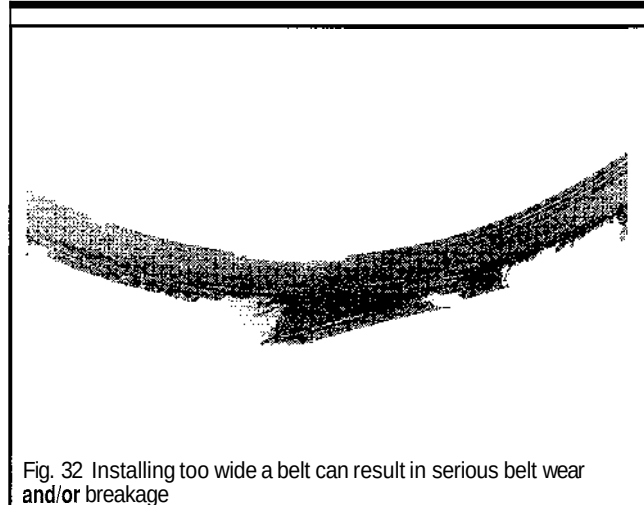
Determine the V-belt tension at a point halfway between the pulleys by pressing on the belt with moderate thumb pressure. The belt should deflect 1/4-1/2 in. (6-13mm) on all engines. If the deflection is found to be too much or too little, make adjustments as necessary. Always test the tension between the component pulley and the engine circulating pump (water pump) pulley

An alternate method (and actually much more accurate) is to use an OMC tension gauge (#1159660-8) or an equivalent tension gauge and check that the tension is 44-55 lbs. (20-25 kg).

When replacing belts, we recommend cleaning the inside of the belt pulleys to extend the service life of the belts. Never use automotive belts, marine belts used on your engine are heavy duty and not interchangeable.

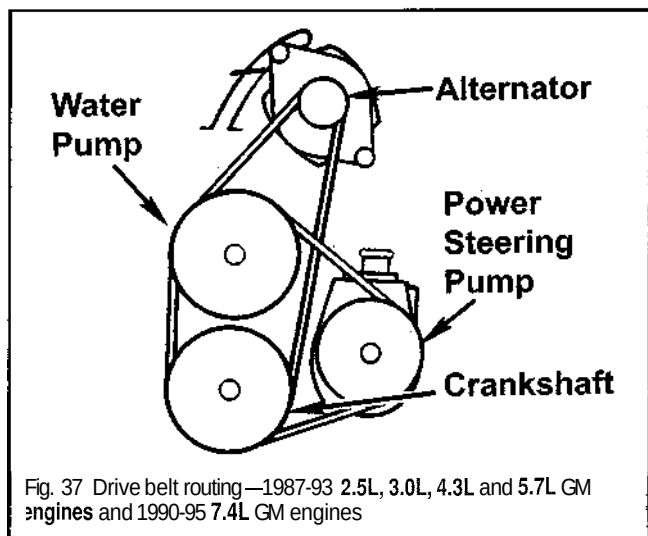
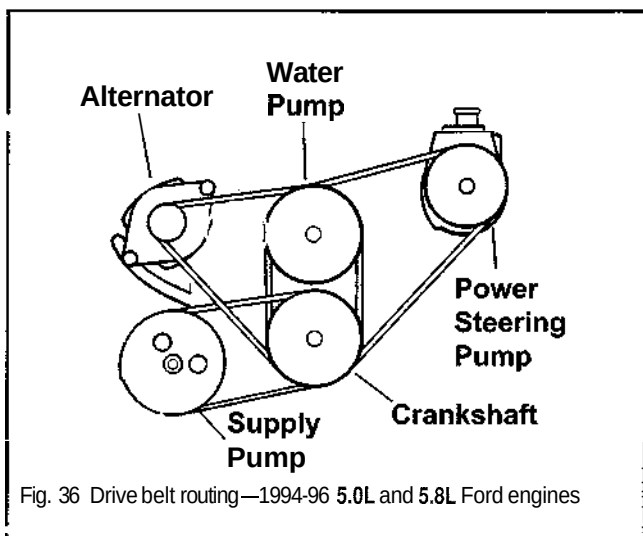
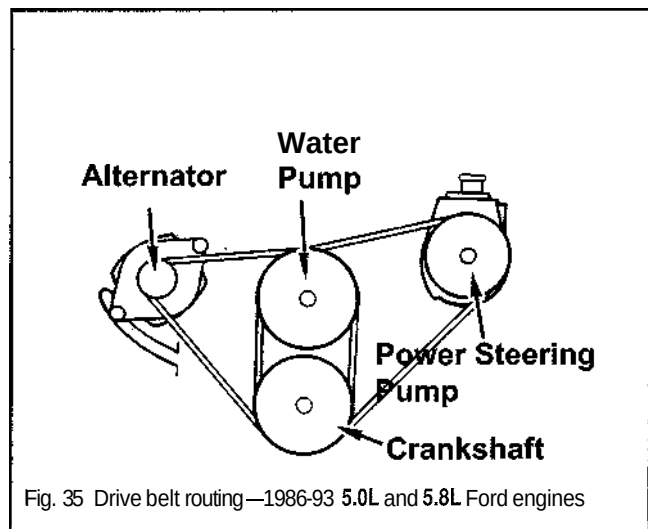
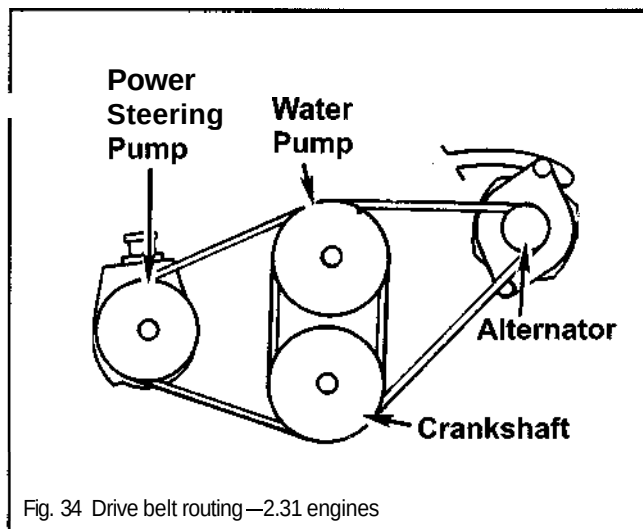


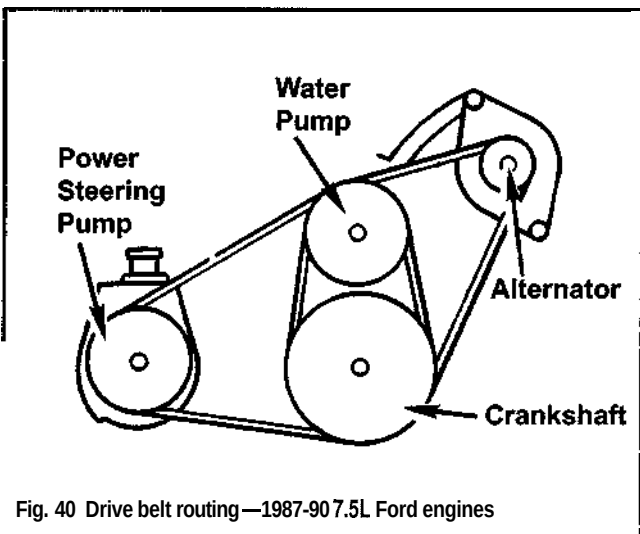
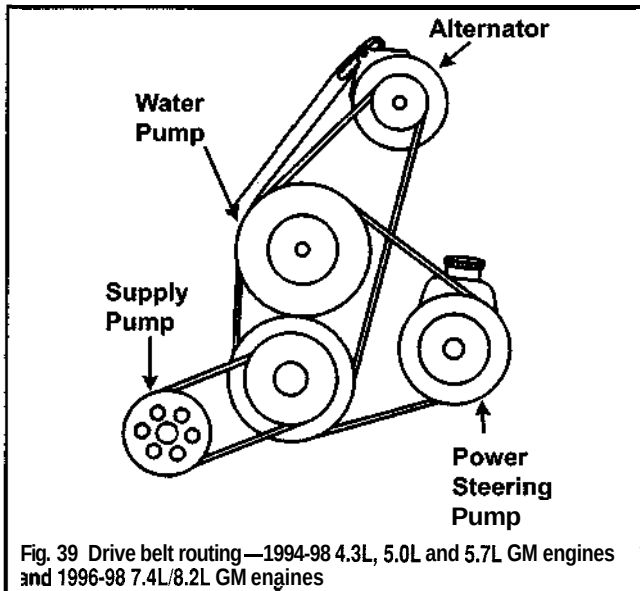
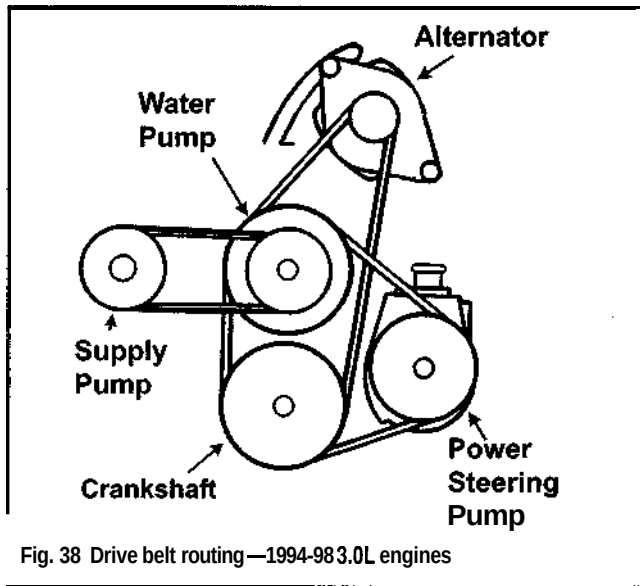
2-10 ENGINE AND DRIVE MAINTENANCE



ROUTING DIAGRAMS

◆ See Figures 34 thru 40





ADJUSTMENT

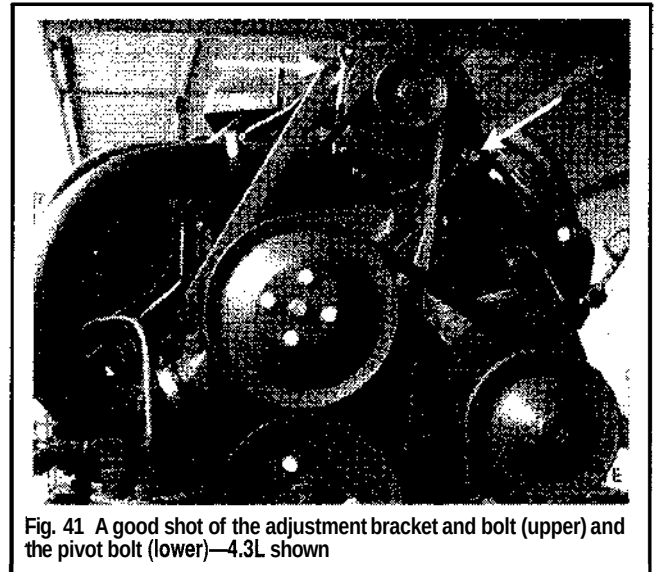
Alternator

◆ See Figure 41



Although most alternators can be found on the upper port side of the engine, certain Ford engines will have it located on the lower port side.

1. Remove or open the engine hatch and disconnect the battery cables.
2. Loosen the nut on the lower pivot bolt at the bottom of the alternator.
3. Loosen the bolt on the adjustment bracket behind the assembly.
4. Carefully insert a 1/2 in. breaker bar into the space between the alternator and a sturdy spot on the engine block, and then pivot the alternator away from the engine.
5. Check that the tension is now within specifications and tighten the bolt and nut while keeping steady pressure on the breaker bar.
6. Recheck the belt tension and connect the battery cable.
7. Close the engine compartment.



Power Steering Pump

All Engines Except 7.4L/7.5L/8.2L

◆ See Figures 42 and 43



Although on most engines the power steering pump can be found on the lower port side of the engine; 2.3L engines have it located on the lower starboard side, while 5.0L/5.8L Ford engines will have it on the upper port side.

1. Remove or open the engine hatch and disconnect the battery cables.
2. Loosen the power steering pump mounting bolts and/or nuts—usually two, but the 2.3L engine use four (3 in the front and 1 in the back).
3. Insert a 1/2 in. breaker bar into the square hole on the mounting bracket and then pivot the pump assembly away from the engine.

×× CAUTION

Never pry against the reservoir or filler neck.

4. Check that the tension is now within specifications and tighten the mounting bolts or nuts while keeping steady pressure on the breaker bar.
5. Recheck the belt tension and connect the battery cable.
6. Close the engine compartment.

2-12 ENGINE AND DRIVE MAINTENANCE

7.4L, 7.5L And 8.2L Engines

† See Figure 44

Although on the two GM engines the power steering pump can be found on the lower port side of the engine; 7.5L engines will have it located on the lower starboard side.

7. Remove or open the engine hatch and disconnect the battery cables.
8. Loosen the pump mounting bracket bolts or nuts.
9. Insert a long screw driver-like breaker bar into the space between the pump and the engine and then pry against the corner of the timing chain cover and the tab on the pump mounting bracket.

❖❖ CAUTION

Never pry against the reservoir or filler neck.

10. Check that the tension is now within specifications and tighten the bolt closest to the tab. Tighten the remaining bolts while keeping steady pressure on the breaker bar.

11. Recheck the belt tension and connect the battery cable.
12. Close the engine compartment.

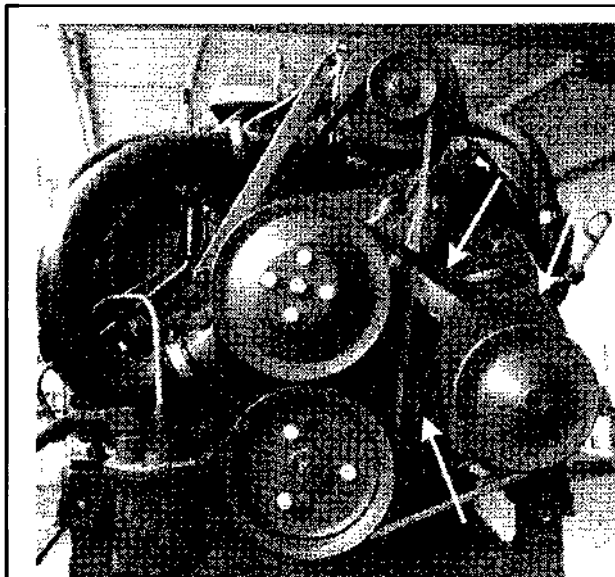


Fig. 42 Use the square hole in the bracket to adjust the power steering pump—most GM engine similar

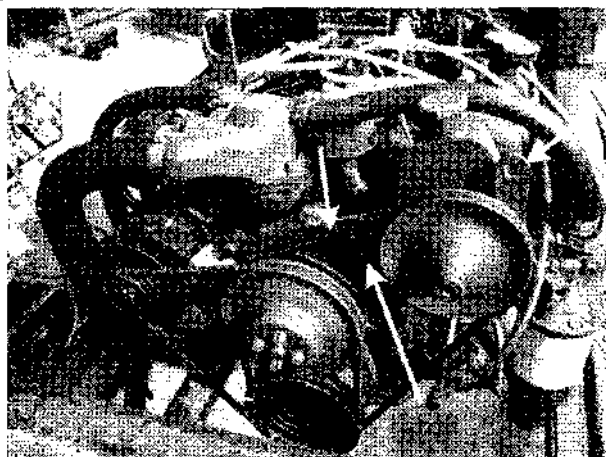


Fig. 43 Use the square hole in the bracket to adjust the power steering pump—5.0L/5.8L Ford engines

Raw Water Supply Pump

◆ See Figure 45



The supply pump is always located on the starboard side of the engine on all applications.

1. Remove or open the engine hatch and disconnect the battery cables.
2. Loosen the mounting bracket bolts.
3. Insert a 112 in. breaker bar (we actually prefer a wooden broom handle) between the pump housing and a sturdy point on the engine and then pivot the pump assembly away from the engine.
4. Check that the tension is now within specifications and tighten the bolts while keeping steady pressure on the breaker bar.
5. Recheck the belt tension and connect the battery cable.
6. Close the engine compartment.

REMOVAL & INSTALLATION



The replacement of the inner belt on multi-belted engines may require the removal of the outer belts.

To replace a drive belt, loosen the pivot and mounting bolts of the component which the belt is driving, then, using a wooden lever or equivalent, pry the component inward to relieve the tension on the drive belt; always be careful where you locate the prybar, or damage to components may result. Slip the belt off the component pulley, and match the new belt with the old belt for length and width.

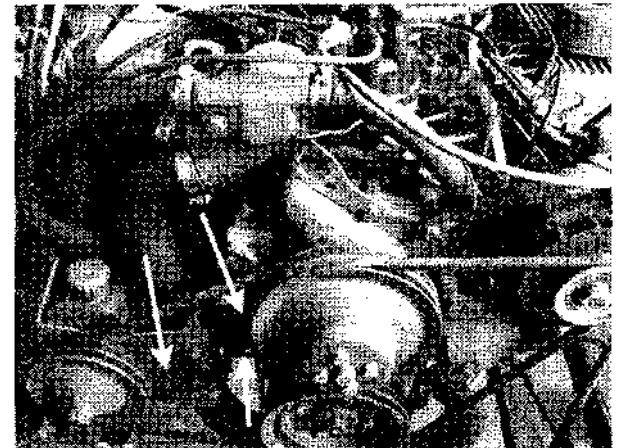


Fig. 44 Use the square hole in the bracket to adjust the power steering pump—7.5L Ford engines

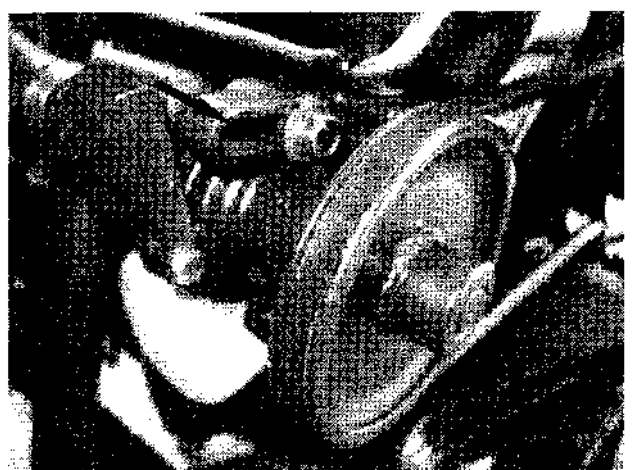


Fig. 45 A good shot of the adjustment bracket and bolt