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Quick Reference Data

RECOMMENDED SPARK PLUGS

Model	NGK spark plug number (RFI)*	Gap in. (mm)
75, 90 hp and 65 Jet	BUHW-2 (BUZHW-2)	NA
100, 115, 125 hp and 80 Jet	BP8H-N-10 (BPZ8H-N-10)	.040 (1.02)
135-200 hp, 105 and 140 Jet	BU8H (BUZ8H)	NA
200 DFI (direct fuel injected)	Champion RC10ECC	.040 (1.02)
225 hp (carbureted 1994-1996)	Use resistor (BPZ8H-N-10)	.040 (1.02)
225 hp (carbureted 1997)	Champion QL77CC	.035 (0.89)
225-250 hp EFI (electronic fuel injection)	Champion QL77CC	.035 (0.89)
275 hp	BU8H (BUZ8H)	NA

*Use resistor or suppression spark plugs if radio frequency interference (RFI) suppression is required.

GEARCASE GEAR RATIO AND APPROXIMATE LUBRICANT CAPACITY

Model	Gear ratio	Tooth count	Lubricant capacity
75 and 90 hp	2.3:1	13:30	22.5 oz. (665 ml)
100, 115 and 125 hp	2.07:1	14:29	22.5 oz. (665 ml)
135 and 150 hp	2.00:1	14:28	22.5 oz. (665 ml)
XR6 and Magnum III (small gearcase)	1.78:1	14:25	21.0 oz. (621 ml)
XR6 and Magnum III (large gearcase)	1.87:1	15:28	22.5 oz. (665 ml)
150-200 XRI, 175-200 hp	1.87:1	15:28	22.5 oz. (665 ml)
200 DFI (direct fuel injection)	1.75:1	12:21	28.0 oz. (828 ml)
225-250 hp (1994)	1.64:1	17:28	28.0 oz. (828 ml)
225-250 hp (1995-1997)	1.75:1	12:21	28.0 oz. (828 ml)
275 hp	1.64:1	17:28	29.0 oz. (858 ml)

RECOMMENDED LUBRICANTS, SEALANTS AND ADHESIVES

	Part No.
Lubricants	
Quicksilver 2-Cycle TC-W3 outboard oil	(dealer stock item)
Quicksilver Special Lubricant 101	92-13872A-1
Quicksilver 2-4-C Multi-Lube	(dealer stock item)
Quicksilver Anti-Corrosion Grease	92-78376A-6
Quicksilver Needle Bearing Grease	92-825265A-1
Quicksilver Power Trim and Steering Fluid	92-90100A12
Quicksilver Premium Blend Gear Lube	(dealer stock item)
Quicksilver High Performance Gear Lube	(dealer stock item)

(continued)

RECOMMENDED LUBRICANTS, SEALANTS AND ADHESIVES *(continued)*

	Part No.
Sealants	
Quicksilver Perfect Seal	92-34227-1
Loctite 5900 Ultra black RTV sealant	92-809826
Sealer (crankcase halves)	92-90113-2
Loctite Master Gasket Sealer	92-12564-2
Quicksilver Liquid Neoprene	92-25711-2
Loctite 567 PST pipe sealant	92-809822
Quicksilver Bellows Adhesive	92-86166-1
Quicksilver Ignition Coil Insulation Compound	92-41669-1
Adhesives	
Locquic Primer	92-809824
Loctite 271 threadlocking sealant (high strength)	92-809819
Loctite 242 threadlocking sealant (medium strength)	92-809821
Loctite RC680 high strength retaining compound	92-809833
Miscellaneous	
Quicksilver Power Tune Engine Cleaner	92-15104A12
Quicksilver Corrosion Guard	92-815869A12
Quicksilver Storage Seal Rust Inhibitor	92-86145A12
Quicksilver Dielectric silicone grease	92-823506-1

STARTING SERIAL NUMBER LISTING

	1994	1995	1996	1997
Mercury outboard models				
75 hp	0D283222	0G077367	0G301751	0G438000
90 hp	0D283222	0G077369	0G301751	0G438000
100 hp	0D283222	0G090125	0G301751	0G438000
115 hp	0D283222	0G127522	0G301751	0G438000
125 hp	0D283222	0G090127	0G301751	0G438000
135 hp	0D284788	0G127861	0G303046	0G438000
150 hp	0D284788	0G129272	0G303046	0G438000
175 hp	0D284788	0G129337	0G303046	0G438000
200 hp	0D284788	0G077376	0G303046	0G438000
200 DFI	–	–	0G386496	0G438000
225 hp	0D280813	0G077384	0G303046	0G438000
250 EFI	–	–	0G303046	0G438000
275 hp	0D280900	–	–	–
Mercury Jet models				
Jet 65 hp	0G052651	0G077369	0G301804	0G438000
Jet 80 hp	0G052652	0G127529	0G302040	0G438000
Jet 105 hp	0G052656	0G129884	0G304512	0G438000
Jet 140 hp	0G052657	0G129601	0G304134	0G438000
Mariner outboard models				
75 hp	0D283222	0G127540	0G301751	0G438000
90 hp	0D283222	0G127561	0G301751	0G438000
100 hp	0D283222	0G127812	0G302262	0G438000
115 hp	0D283222	0G127500	0G301751	0G438000

(continued)

STARTING SERIAL NUMBER LISTING (continued)

	1994	1995	1996	1997
Mariner outboard models (continued)				
125 hp	0D283222	0G127766	0G301751	0G438000
135 hp	0D284788	0G129222	0G303046	0G438000
150 hp	0D284788	0G129477	0G303046	0G438000
175 hp	0D284788	0G129394	0G303046	0G438000
200 hp	0D284788	0G129303	0G303046	0G438000
200 DFI	–	–	0G386496	0G438000
225 hp	0D280813	0G106786	0G303046	0G438000
250 EFI	–	–	0G303046	0G438000
275 hp	0D280900	–	–	–
Mariner Jet models				
Jet 65 HP	0G052651	0G127642	0G302037	0G438000
Jet 80 HP	0G052652	0G127629	0G301751	0G438000
Jet 105 HP	0G052656	0G129872	0G325593	0G438000
Jet 140 HP	0G052657	0G129675	0G303046	0G438000

Chapter One

General Information

This detailed, comprehensive manual contains complete information covering maintenance, repair and overhaul. Hundreds of photos and drawings guide you throughout every procedure.

Troubleshooting, tune-up, maintenance and repair are not difficult if you know what tools and equipment to use and what to do. Anyone not afraid to get their hands dirty, of average intelligence and with some mechanical ability can perform most of the procedures in this manual. See Chapter Two for more information on tools and techniques.

A shop manual is a reference. You want to be able to find information quickly. Clymer books are designed with you in mind. All chapters are thumb tabbed and important items are indexed at the end of the manual. All procedures, tables, photos and instructions in this manual assume the reader may be working on the machine or using the manual for the first time.

Keep the manual in a handy place in your toolbox or boat. It will help you to better understand how your boat runs, lower repair and maintenance costs and generally increase your enjoyment of your boat.

MANUAL ORGANIZATION

This chapter provides general information useful to boat owners and marine mechanics.

Chapter Two discusses the tools and techniques for preventative maintenance, troubleshooting and repair.

Chapter Three provides troubleshooting and testing procedures for all systems and individual components.

Following chapters describe specific systems, providing disassembly, inspection, assembly and adjustment procedures in simple step-by-step form. Specifications concerning a specific system are included at the end of the appropriate chapter.

NOTES, CAUTIONS AND WARNINGS

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

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

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

TORQUE SPECIFICATIONS

Torque specifications throughout this manual are given in foot-pounds (ft.-lb.), inch-pounds (in.-lb.) and newton meters (N•m.). Newton meters are being adopted in place of meter-kilograms (mkg) in accordance with the International Modernized Metric System. Existing torque wrenches calibrated in meter-kilograms can be used by performing a simple conversion: move the decimal point one place to the right. For example, 4.7 mkg = 47 N•m. This conversion is accurate enough for most mechanical operations even though the exact mathematical conversion is 3.5 mkg = 34.3 N•m.

ENGINE OPERATION

All marine engines, whether two or four-stroke, gasoline or diesel, operate on the Otto cycle of intake, compression, power and exhaust phases.

Two-Stroke Cycle

A two-stroke engine requires one crankshaft revolution (two strokes of the piston) to complete the Otto cycle. All engines covered in this manual are a two-stroke design. **Figure 1** shows gasoline two-stroke engine operation.

Four-Stroke Cycle

A four-stroke engine requires two crankshaft revolutions (four strokes of the piston) to complete the Otto cycle. **Figure 2** shows gasoline four-stroke engine operation.

FASTENERS

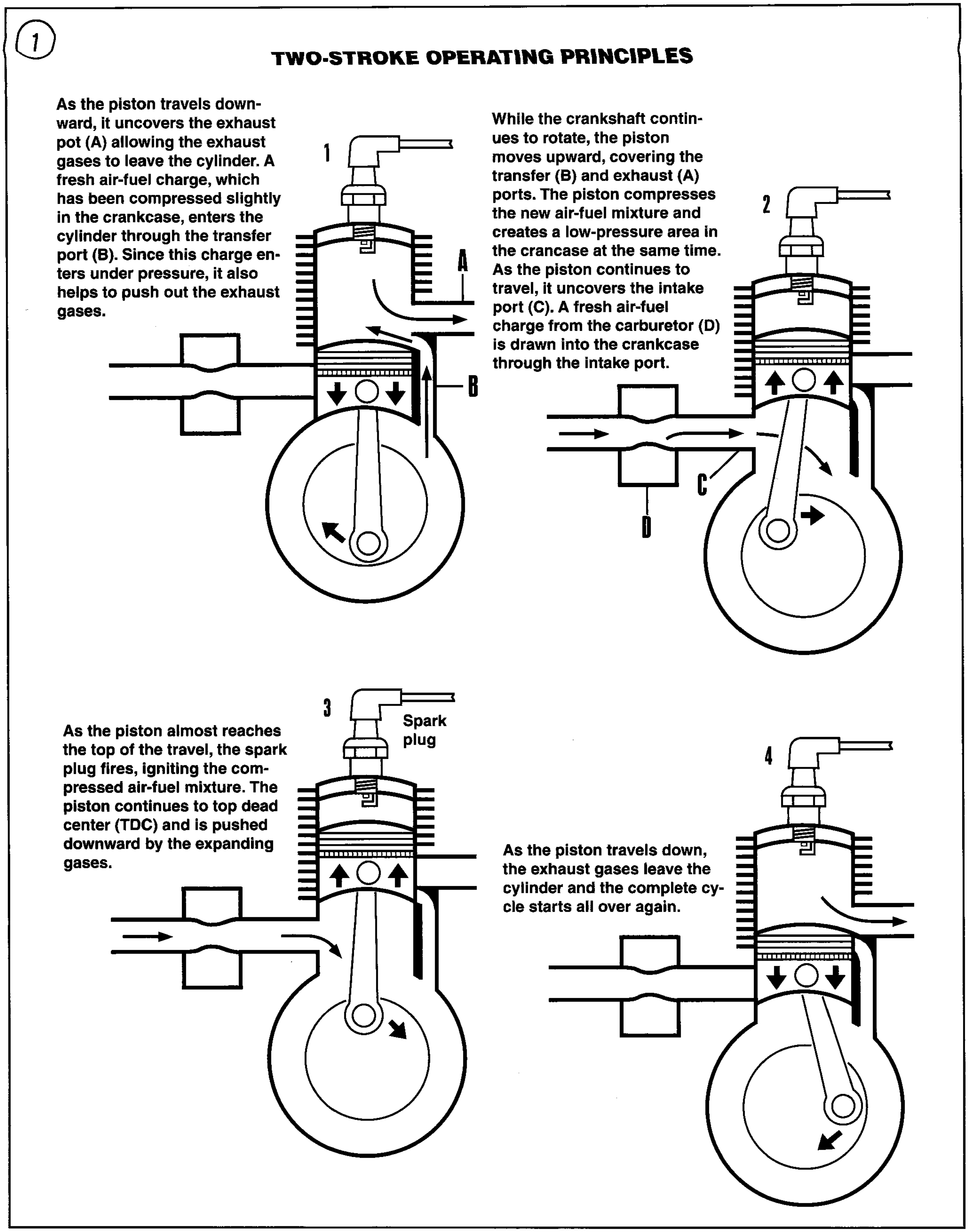
The material and design of the various fasteners used on marine equipment are carefully thought out and designed. Fastener design determines the type of tool required to work with the fastener. Fastener material is carefully selected to decrease the possibility of physical failure or corrosion. See *Galvanic Corrosion* in this chapter for information on marine materials.

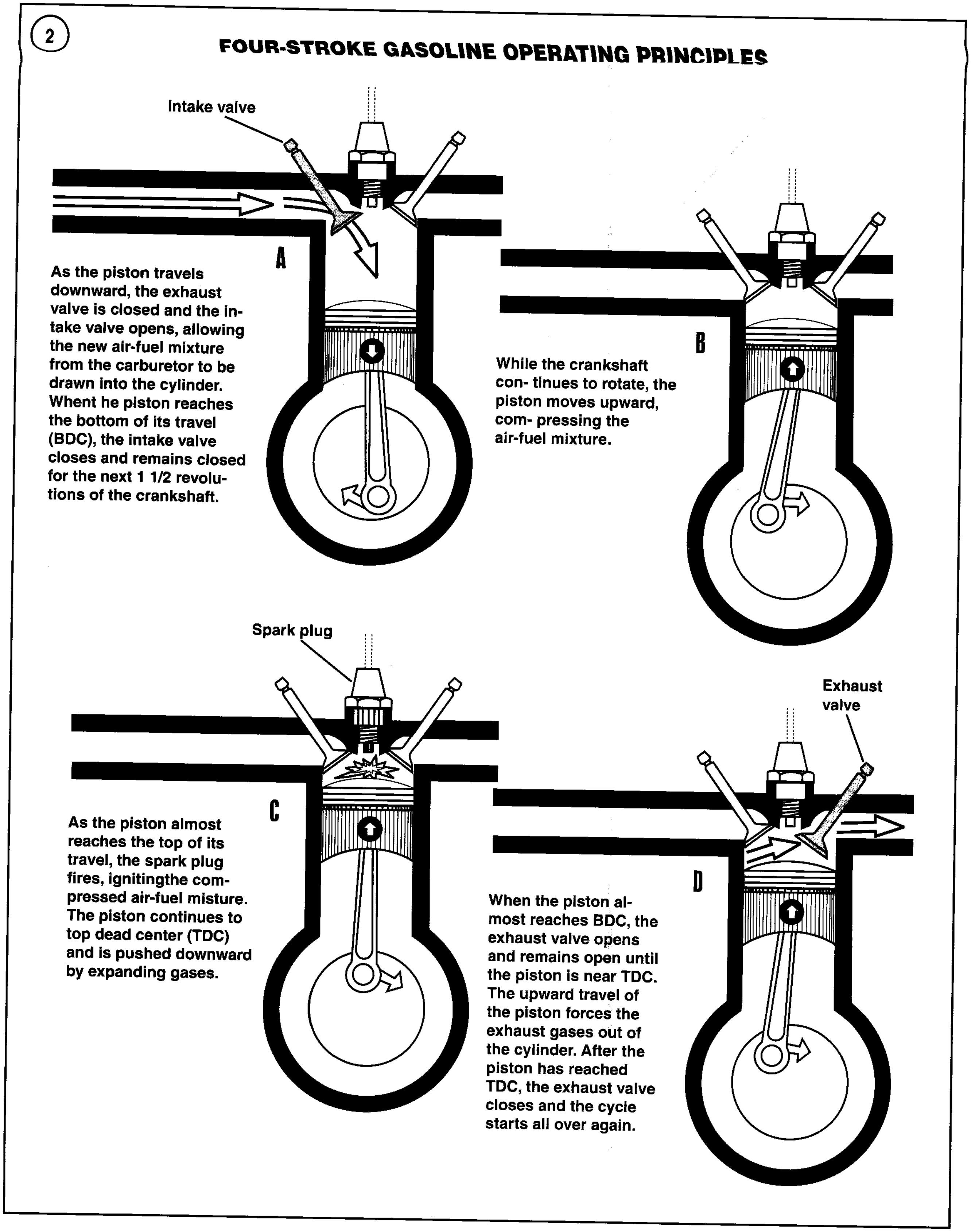
Nuts, bolts and screws are manufactured in a wide range of thread patterns. To join a nut and bolt, the diameter of the bolt and the diameter of the hole in the nut must be the same. It is just as important that the threads are compatible.

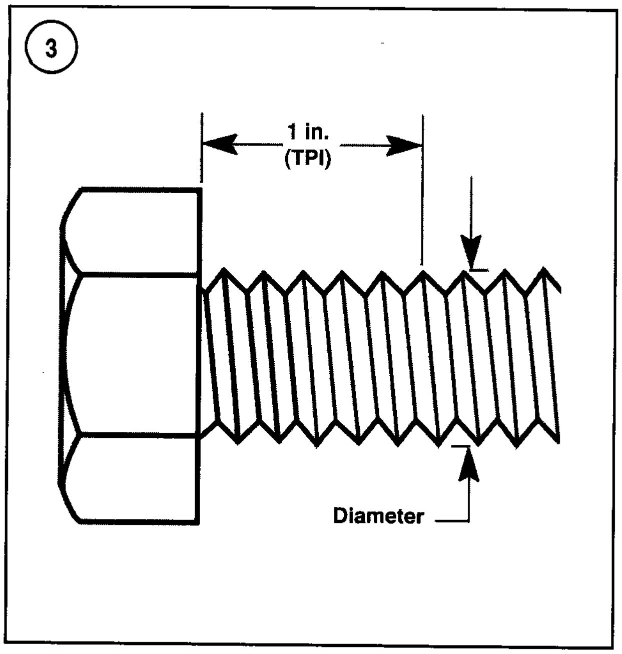
The easiest way to determine if fastener threads are compatible is to turn the nut on the bolt, or bolt into its threaded opening, using fingers only. Be sure both pieces are clean. If much force is required, check the thread condition on each fastener. If the thread condition is good but the fasteners jam, the threads are not compatible.

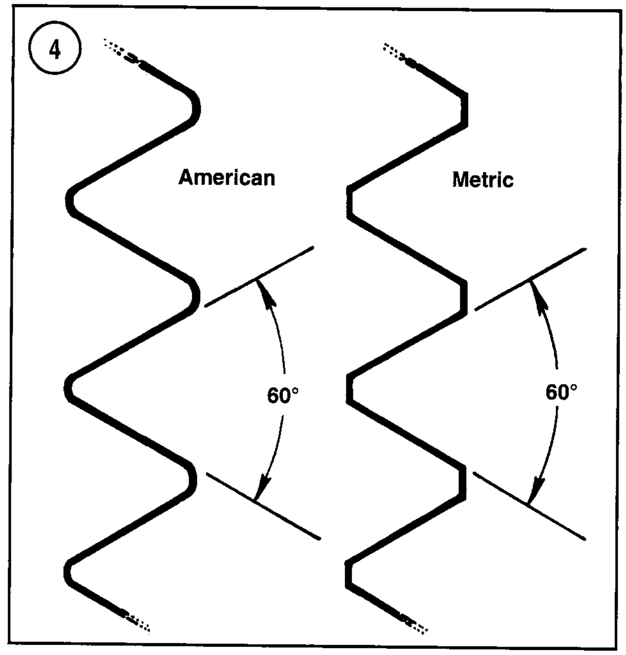
Four important specifications describe the thread:

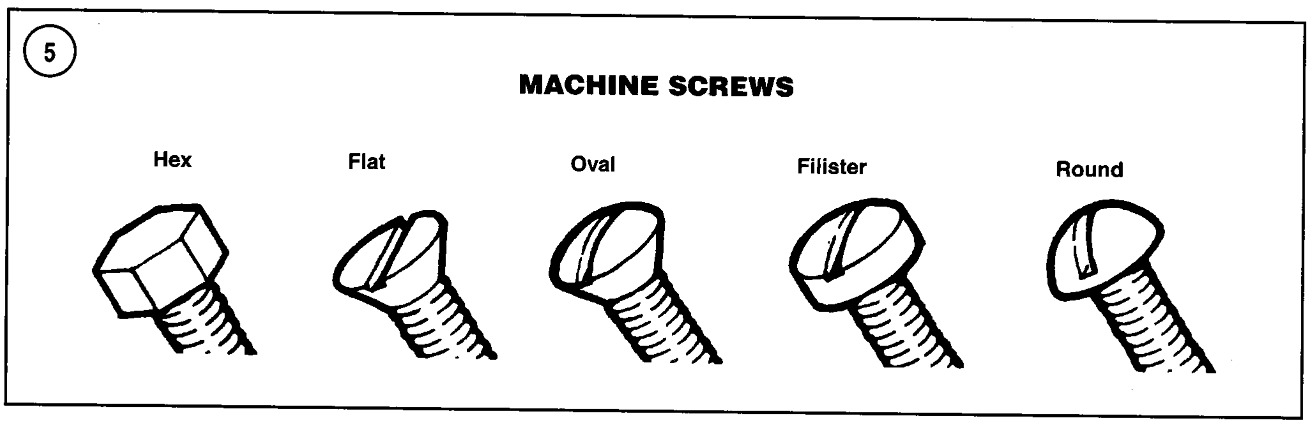
1. Diameter.
2. Threads per inch.
3. Thread pattern.


1
TWO-STROKE OPERATING PRINCIPLES
As the piston travels downward, it uncovers the exhaust pot (A) allowing the exhaust gases to leave the cylinder. A fresh air-fuel charge, which has been compressed slightly in the crankcase, enters the cylinder through the transfer port (B). Since this charge enters under pressure, it also helps to push out the exhaust gases.
1
A
B
While the crankshaft continues to rotate, the piston moves upward, covering the transfer (B) and exhaust (A) ports. The piston compresses the new air-fuel mixture and creates a low-pressure area in the crancase at the same time. As the piston continues to travel, it uncovers the intake port (C). A fresh air-fuel charge from the carburetor (D) is drawn into the crankcase through the intake port.
2
C
D
As the piston almost reaches the top of the travel, the spark plug fires, igniting the compressed air-fuel mixture. The piston continues to top dead center (TDC) and is pushed downward by the expanding gases.
3
Spark plug
As the piston travels down, the exhaust gases leave the cylinder and the complete cycle starts all over again.
4


2
FOUR-STROKE GASOLINE OPERATING PRINCIPLES
Intake valve
A
As the piston travels downward, the exhaust valve is closed and the in- take valve opens, allowing the new air-fuel mixture from the carburetor to be drawn into the cylinder. Whent he piston reaches the bottom of its travel (BDC), the intake valve closes and remains closed for the next 1 1/2 revolu- tions of the crankshaft.
B
While the crankshaft con- tinues to rotate, the piston moves upward, com- pressing the air-fuel mixture.
Spark plug
C
As the piston almost reaches the top of its travel, the spark plug fires, ignitingthe com- pressed air-fuel misture. The piston continues to top dead center (TDC) and is pushed downward by expanding gases.
Exhaust valve
D
When the piston al- most reaches BDC, the exhaust valve opens and remains open until the piston is near TDC. The upward travel of the piston forces the exhaust gases out of the cylinder. After the piston has reached TDC, the exhaust valve closes and the cycle starts all over again.







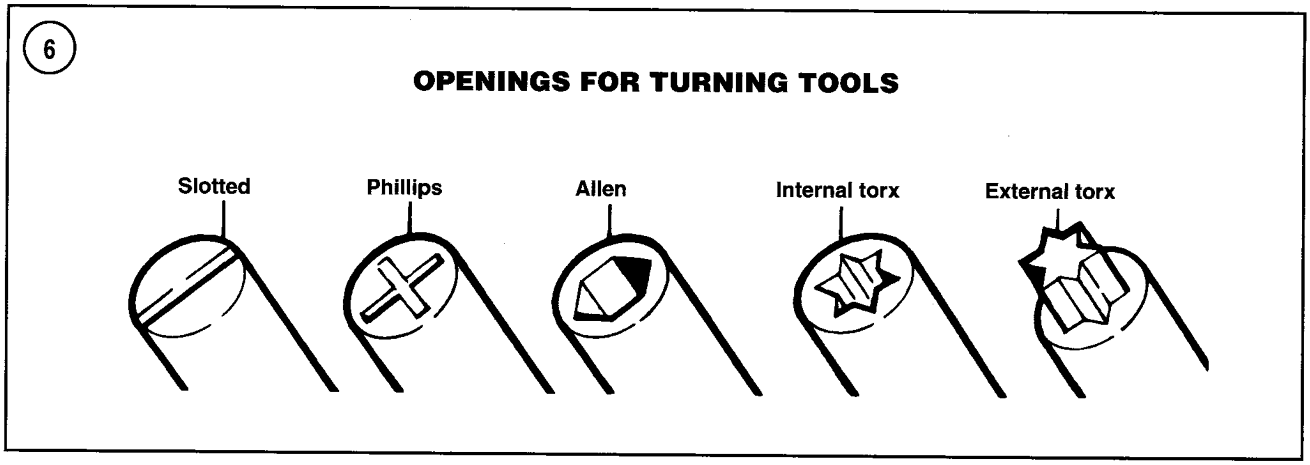
4. Thread direction

Figure 3 shows the first two specifications. Thread pattern is more subtle. Italian and British standards exist, but the most commonly used by marine equipment manufactures are American standard and metric standard. The root and top of the thread are cut differently as shown in **Figure 4**.

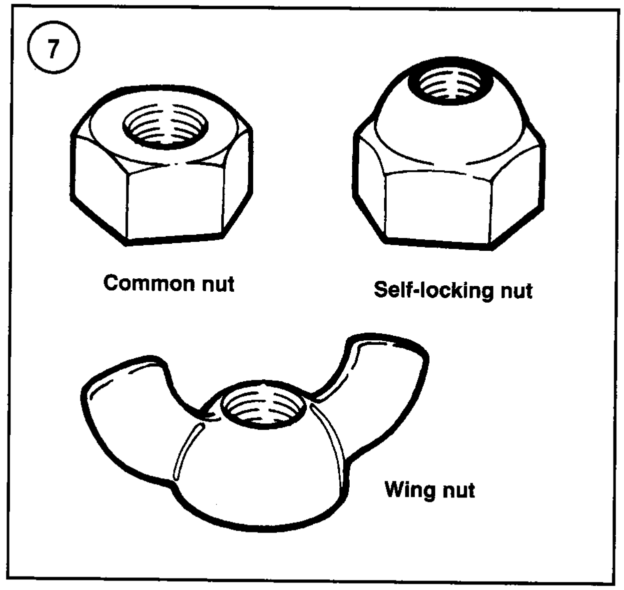
Most threads are cut so the fastener must be turned clockwise to tighten it. These are called right-hand threads. Some fasteners have left-hand threads; they must be turned counterclockwise to tighten. Left-hand threads are used in locations where normal rotation of the equipment would tend to loosen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

Machine Screws

There are many different types of machine screws (**Figure 5**). Most are designed to protrude above the secured surface (rounded head) or be slightly recessed below the surface (flat head). In some applications the screw head is recessed well below the fastened sur-



face. **Figure 6** shows a number of screw heads requiring different types of turning tools.



Bolts

Commonly called bolts, the technical name for this fastener is cap screw. They are normally described by diameter, threads per inch and length. For example, 1/4-20 × 1 indicates a bolt 1/4 in. in diameter with 20 threads per inch, 1 in. long. The measurement across two flats of the bolt head indicates the proper wrench size required to turn the bolt.

Nuts

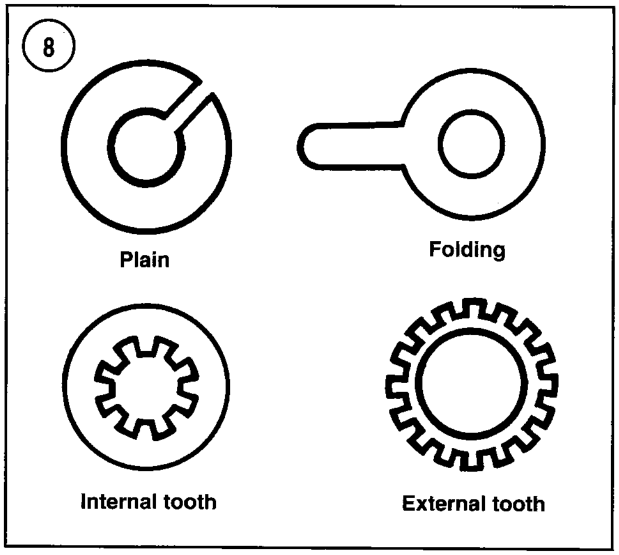
Nuts are manufactured in a variety of types and sizes. Most are hexagonal (six-sides) and fit on bolts, screws and studs with the same diameter and threads per inch.

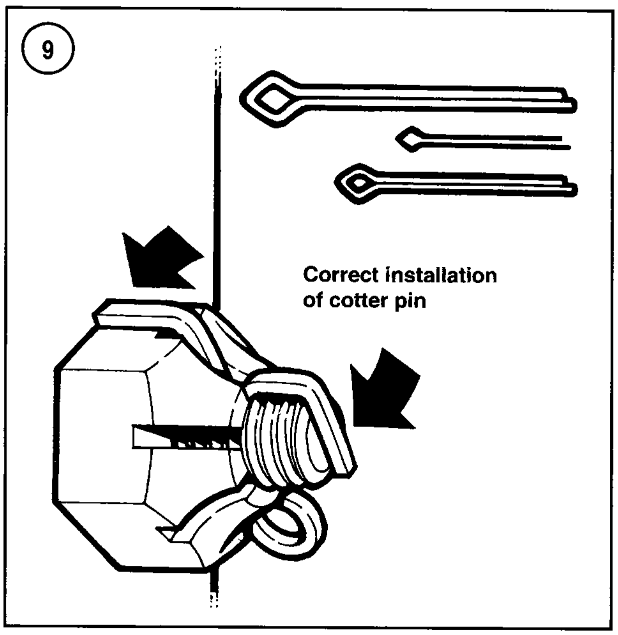
Figure 7 shows several types of nuts. The common nut is usually used with some type of lockwasher. Self-locking nuts have a nylon insert that helps prevent the nut from loosening; no lockwasher is required. Wing nuts are designed for fast removal by hand. Wing nuts are used for convenience in non-critical locations.

To indicate the size of a nut, manufactures specify the diameter of the opening and the threads per inch. This is similar to a bolt specification, but without the length dimension. The measurement across two flats of the nut indicates the wrench size required to turn the nut.

Washers

There are two basic types of washers: flat washers and lockwashers. A flat washer is a simple disc with a hole that fits the screw or bolt. Lockwashers are designed to prevent a fastener from working loose due to vibration, expansion and contraction. **Figure 8** shows several types of lockwashers. Note that flat washers are often

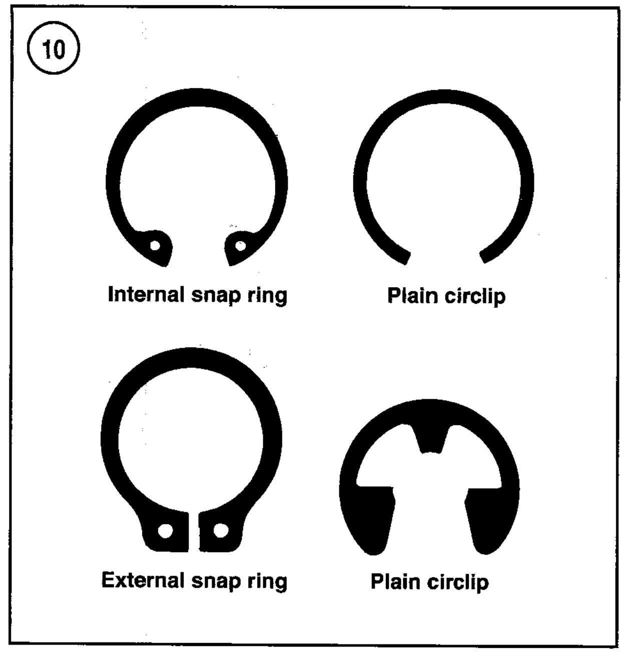




used between a lockwasher and a fastener to provide a smooth bearing surface. This allows the fastener to be turned easily with a tool.

Cotter Pins

In certain applications, a fastener must be secured so it cannot possibly loosen. The propeller nut on some marine drive systems is one such application. For this purpose, a cotter pin (**Figure 9**) and slotted or castellated nut is often used. To use a cotter pin, first make sure the pin fits snugly, but not too tight. Then, align a slot in the fastener with the hole in the bolt or axle. Insert the cotter pin through the nut and bolt or propeller shaft and bend the ends over to secure the cotter pin tightly. If the holes do not align, tighten the nut just enough to obtain the proper alignment. Unless specifically instructed to do so, never loosen the fastener to align the slot and hole. Because the cotter pin is weakened after installation and removal, never reuse a cotter pin. Cotter pins are available in several styles, lengths and diameters. Measure cotter pin length from the bottom of its head to the tip of its shortest prong.



Snap Rings

Snap rings (**Figure 10**) can be an internal or external design. They are used to retain components on shafts (external type) or inside openings (internal type). Snap rings can be reused if they are not distorted during removal. In some applications, snap rings of varying thickness (selective fit) can be selected to position or control end play of parts assemblies.

LUBRICANTS

Periodic lubrication helps ensure long service life for any type of equipment. It is especially important with marine equipment because it is exposed to salt, brackish or polluted water and other harsh environments. The type of lubricant used is just as important as the lubrication service itself, although in an emergency, the wrong type of lubricant is better than none at all. The following paragraphs describe the types of lubricants most often used on marine equipment. Be sure to follow the equipment manufacture's recommendations for the lubricant types.

Generally, all liquid lubricants are called *oil*. They may be mineral-based (including petroleum bases), natural-based (vegetable and animal bases), synthetic-based or emulsions (mixtures). *Grease* is lubricating oil that has a thickening compound added. The resulting material then usually enhanced with anticorrosion, antioxidant and extreme pressure (EP) additives. Grease is often classified by the type of thickener added; lithium and calcium soap are the most commonly used.

Two-stroke Engine Oil

Lubrication for a two-stroke engine is provided by oil mixed with the incoming air/fuel mixture. Some of the oil mist settles out in the crankcase, lubricating the crankshaft, bearings and lower end of the connecting rod. The rest of the oil enters the combustion chamber to lubricate the piston, rings and the cylinder wall. This oil is then burned along with the air/fuel mixture during the combustion process.

Engine oil must have several special qualities to work well in a two-stroke engine. It must mix easily and stay in suspension in gasoline. When burned, it cannot leave behind excessive deposits. It must also withstand the high operating temperature associated with two-stroke engines.

The National Marine Manufacturer's Association (NMMA) has set standards for oil used in two-stroke, water-cooled engines. This is the NMMA TC-W (two-cycle, water-cooled) grade. It indicates the oil's performance in the following areas:

1. Lubrication (preventing wear and scuffing).
2. Spark plug fouling.
3. Piston ring sticking.
4. Preignition.
5. Piston varnish.
6. General engine condition (including deposits).
7. Exhaust port blockage.
8. Rust prevention.
9. Mixing ability with gasoline.

In addition to oil grade, manufactures specify the ratio of gasoline and oil required during break-in and normal engine operation.

Gearcase Oil

Gearcase lubricants are assigned SAE viscosity numbers under the same system as four-stroke engine oil. Gearcase lubricant falls into the SAE 72-250 range. Some gearcase lubricants are multigrade. For example, SAE 80-90 is a common multigrade gear lubricant.

Three types of marine gearcase lubricants are generally available; SAE 90 hypoid gearcase lubricant is designed for older manual-shift units; type C gearcase lubricant contains additives designed for the electric shift mechanisms; high-viscosity gearcase lubricant is a heavier oil designed to withstand the shock loads of high performance engines or units subjected to severe duty use. Always use the gearcase lubricant specified by the manufacturer.

Grease

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

GASKET SEALANT

Gasket sealant is used instead of preformed gaskets on some applications, or as a gasket dressing on others. Three types of gasket sealant are commonly used: gasket sealing compound, room temperature vulcanizing (RTV) and anaerobic. Because these materials have different sealing properties, they cannot be used interchangeably.

Gasket Sealing Compound

This nonhardening liquid is used primarily as a gasket dressing. Gasket sealing compound is available in tubes or brush top containers. When exposed to air or heat it forms a rubber-like coating. The coating fills in small imperfections in gasket and sealing surfaces. Do not use gasket sealing compound that is old, has began to solidify or has darkened in color.

Applying Gasket Sealing Compound

Carefully scrape residual gasket material, corrosion deposits or paint from the mating surfaces. Use a blunt scraper and work carefully to avoid damaging the mating surfaces. Use quick drying solvent and a clean shop towel and wipe oil or other contaminants from the surfaces. Wipe or blow loose material or contaminants from the gasket. Brush a light coating on the mating surfaces and both sides of the gasket. Do not apply more compound than needed. Excess compound will be squeezed out as the surfaces mate and may contaminate other components. Do not allow compound into bolt or alignment pin holes

A hydraulic lock can occur as the bolt or pin compresses the compound, resulting in incorrect bolt torque.

RTV Sealant

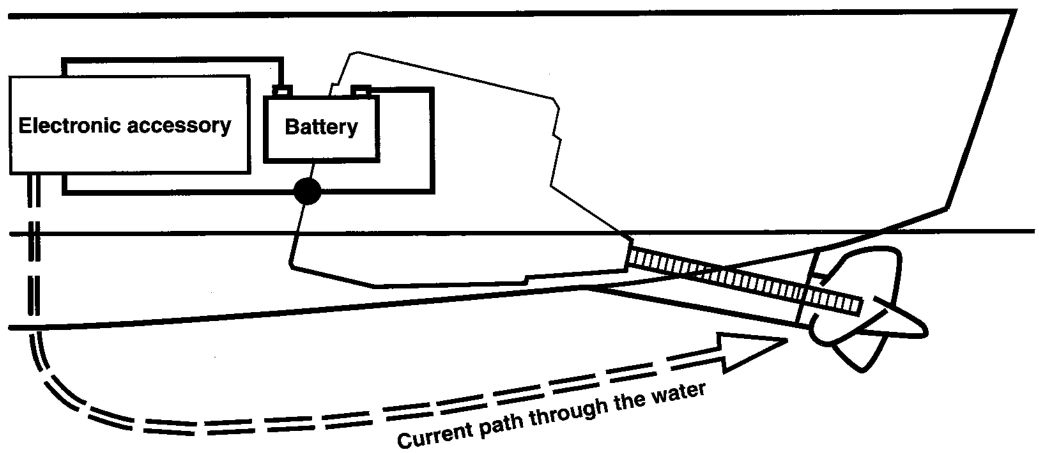
This is a silicone gel supplied in tubes. Moisture in the air causes RTV to cure. Always place the cap on the tube as soon as possible if using RTV. RTV has a shelf life of approximately one year and will not cure properly after the shelf life expires. Check the expiration date on the tube and keep partially used tubes tightly sealed. RTV can generally fill gaps up to 1/4 in. (6.3 mm) and works well on slightly flexible surfaces.

Applying RTV Sealant

Carefully scrape all residual sealant and paint from the mating surfaces. Use a blunt scraper and work carefully to avoid damaging the mating surfaces. The mating surfaces must be absolutely free of gasket material, sealant, dirt, oil grease or other contamination. Lacquer thinner, acetone, isopropyl alcohol or similar solvents work well to clean the surfaces. Avoid using solvents with on oil, wax or petroleum base as they are not compatible with RTV compounds. Remove all sealant from bolt or alignment pin holes.

Apply RTV sealant in a continuous bead 0.08-0.12 in. (2-3 mm) thick. Circle all mounting bolt or alignment pin holes unless otherwise specified. Do not allow RTV sealant into bolt holes or other openings. A hydraulic lock can

11



occur as the bolt or pin compresses the sealant, resulting in incorrect bolt torque. Tighten the mounting fasteners within 10 minutes after application.

Anaerobic Sealant

This is a gel supplied in tubes. It cures only in the absence of air, as when squeezed tightly between two machined mating surfaces. For this reason, it will not spoil if the cap is left off the tube. Do not use anaerobic sealant if one of the surfaces is flexible. Anaerobic sealant is able to fill gaps up to 0.030 in. (0.8 mm) and generally works best on rigid, machined flanges or surfaces.

Applying Anaerobic Sealant

Carefully scrape all residual sealant from the mating surfaces. Use a blunt scraper and work carefully to avoid damaging the mating surfaces. The mating surfaces must be absolutely free of gasket material, sealant, dirt, oil grease or other contamination. Lacquer thinner, acetone, isopropyl alcohol or similar solvents work well to clean the surfaces. Avoid using solvents with on oil, wax or petroleum base as they are not compatible with anaerobic compounds. Clean a sealant from the bolt or alignment pin holes. Apply anaerobic sealant in a 0.04 in. (1 mm) thick continuous bead onto one of the surfaces. Circle all bolt and alignment pin opening. Do not apply sealant into bolt holes or other openings. A hydraulic lock can occur as the bolt or pin compresses the sealant, resulting in incorrect bolt torque. Tighten the mounting fasteners within 10 minutes after application.

GALVANIC CORROSION

A chemical reaction occurs whenever two different types of metal are joined by an electrical conductor and immersed in an electrolytic solution such as water. Electrons transfer from one metal to the other through the electrolyte and return through the conductor.

The hardware on a boat is made of many different types of metal. The boat hull acts as a conductor between the metals. Even if the hull is wooden or fiberglass, the slightest film of water (electrolyte) on the hull provides conductivity. This combination creates a good environment for electron flow (**Figure 11**). Unfortunately, this electron flow results in galvanic corrosion of the metal involved, causing one of the metals to be corroded or eroded away. The amount of electron flow, and therefore the amount of corrosion, depends on several factors:

1. The types of metal involved.
2. The efficiency of the conductor.
3. The strength of the electrolyte.

Metals

The chemical composition of the metal used in marine equipment has a significant effect on the amount and speed of galvanic corrosion. Certain metals are more resistant to corrosion than others. These electrically negative metals are commonly called *noble*; they act as the cathode in any reaction. Metals that are more subject to corrosion are electrically positive; they act as the anode in a reaction. The more *noble* metals include titanium, 18-8 stainless steel and nickel. Less *noble* metals include zinc, aluminum and magnesium. Galvanic corrosion becomes more severe as the difference in electrical potential between the two metals increases.

In some cases, galvanic corrosion can occur within a single piece of metal. For example, brass is a mixture of zinc and copper, and, when immersed in an electrolyte, the zinc portion of the mixture will corrode away as a galvanic reaction occurs between the zinc and copper particles.

Conductors

The hull of the boat often acts as the conductor between different types of metal. Marine equipment, such as the drive unit can act as the conductor. Large masses of metal, firmly connected together, are more efficient conductors than water. Rubber mountings and vinyl-based paint can act as insulators between pieces of metal.

Electrolyte

The water in which a boat operates acts as the electrolyte for the corrosion process. The more efficient a conductor is, the more severe and rapid the corrosion will be.

Cold, clean freshwater is the poorest electrolyte. Pollutants increase conductivity; therefore, brackish or saltwater is an efficient electrolyte. This is one of the reasons that most manufacturers recommend a freshwater flush after operating in polluted, brackish or saltwater.

Protection From Galvanic Corrosion

Because of the environment in which marine equipment must operate, it is practically impossible to totally prevent galvanic corrosion. However, there are several ways in which the process can be slowed. After taking these precautions, the next step is to *fool* the process into occurring only where you want it to occur. This is the role of sacrificial anodes and impressed current systems.

Slowing Corrosion

Some simple precautions can help reduce the amount of corrosion taking place outside the hull. These precautions are not substitutes for the corrosion protection methods discussed under *Sacrificial Anodes* and *Impressed Current Systems* in this chapter, but they can help these methods reduce corrosion.

Use fasteners made of metal more noble than the parts they secure. If corrosion occurs, the parts they secure may suffer but the fasteners are protected. The larger secured parts are more able to withstand the loss of material. Also major problems could arise if the fasteners corrode to the point of failure.

Keep all painted surfaces in good condition. If paint is scraped off and bare metal exposed, corrosion rapidly increases. Use a vinyl- or plastic-based paint, which acts as an electrical insulator.

Be careful when applying metal-based antifouling paint to the boat. Do not apply antifouling paint to metal parts of the boat or the drive unit. If applied to metal surfaces, this type of paint reacts with the metal and results in corrosion between the metal and the layer of paint. Maintain a minimum 1 in. (25 mm) border between the painted surface and any metal parts. Organic-based paints are available for use on metal surfaces.

Where a corrosion protection device is used, remember that it must be immersed in the electrolyte along with the boat to provide any protection. If you raise the gearcase out of the water with the boat docked, any anodes on the gearcase may be removed from the corrosion process rendering them ineffective. Never paint or apply any coating to anodes or other protection devices. Paint or other coatings insulate them from the corrosion process.

Any change in the boat's equipment, such as the installation of a new stainless steel propeller, changes the electrical potential and may cause increased corrosion. Always consider this when adding equipment or changing exposed materials. Install additional anodes or other protection equipment as required ensuring the corrosion protection system is up to the task. The expense to repair corrosion damage usually far exceeds that of additional corrosion protection.

Sacrificial Anodes

Sacrificial anodes are specially designed to do nothing but corrode. Properly fastening such pieces to the boat causes them to act as the anode in any galvanic reaction that occurs; any other metal in the reaction acts as the cathode and is not damaged.

Anodes are usually made or zinc, a far from a noble material. Some anodes are manufactured of an aluminum and indium alloy. This alloy is less noble than the aluminum alloy in drive system components, providing the desired sacrificial properties. The aluminum and indium alloy is more resistant to oxide coating than zinc anodes. Oxide coating occurs as the anode material reacts with oxygen in the water. An oxide coating will insulate the anode, dramatically reducing corrosion protection.

Anodes must be used properly to be effective. Simply fastening anodes to the boat in random locations will not do the job.

First determine how much anode surface is required to adequately protect the equipment's surface area. A good starting point is provided by the Military Specification MIL-A-818001, which states that one square inch of new anode protects either:

1. 800 square inches of freshly painted steel.
2. 250 square inches of bare steel or bare aluminum alloy.
3. 100 square inches of copper or copper alloy.

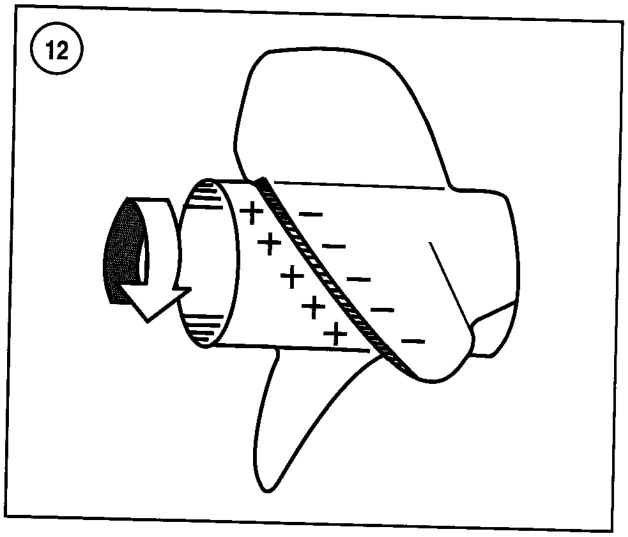
This rule is valid for a boat at rest. If underway, additional anode area is required to protect the same surface area.

The anode must be in good electrical contact with the metal that it protects. If possible, attach an anode to all metal surfaces requiring protection.

Good quality anodes have inserts around the fastener holes that are made of a more noble material. Otherwise, the anode could erode away around the fastener hole, allowing the anode to loosen or possibly fall off, thereby loosing needed protection.

Impressed Current System

An impressed current system can be added to any boat. The system generally consists of the anode, controller and reference electrode. The anode in this system is coated with a very noble



metal, such as platinum, so that it is almost corrosion-free and can last almost indefinitely. The reference electrode, under the boat's waterline, allows the control module to monitor the potential for corrosion. If the module senses that corrosion is occurring, it applies positive battery voltage to the anode. Current then flows from the anode to all other metal component, regardless of how noble or non-noble these components may be. Essentially, the electrical current from the battery counteracts the galvanic reaction to dramatically reduce corrosion damage.

Only a small amount of current is needed to counteract corrosion. Using input from the sensor, the control module provides only the amount of current needed to suppress galvanic corrosion. Most systems consume a maximum of 0.2 Ah at full demand. Under normal conditions, these systems can provide protection for 8-12 weeks without recharging the battery. Remember that this system must have constant connection to the battery. Often the battery supply to the system is connected to a battery switching device causing the operator to inadvertently shut off the system while docked.

An impressed current system is more expensive to install than sacrificial anodes but, considering it low maintenance requirements and the superior protection it provides, the long term cost may be lower.

PROPELLERS

The propeller is the final link between the boat's drive system and the water. A perfectly maintained engine and hull are useless if the propeller is the wrong type, is damaged or is deteriorated. Although propeller selection for a specific application is beyond the scope of this manual, the following provides the basic information needed to make an informed decision. The professional at a reputable marine dealership is the best source for a propeller recommendation.

How a Propeller Works

As the curved blades of a propeller rotate through the water, a high-pressure area forms on one side of the blade and a low-pressure area forms on the other side of the blade (**Figure 12**). The propeller moves toward the low-pressure area, carrying the boat with it.

Propeller Parts

Although a propeller is usually a one-piece unit, it is made of several different parts (**Figure 13**). Variations in the design of these parts make different propellers suitable for different applications.

The blade tip is the point of the blade furthest from the center of the propeller hub or propeller shaft bore. The blade tip separates the leading edge from the trailing edge.

The leading edge is the edge of the blade nearest the boat. During forward operation, this is the area of the blade that first cuts through the water.

The trailing edge is the surface of the blade furthest from the boat. During reverse operation,

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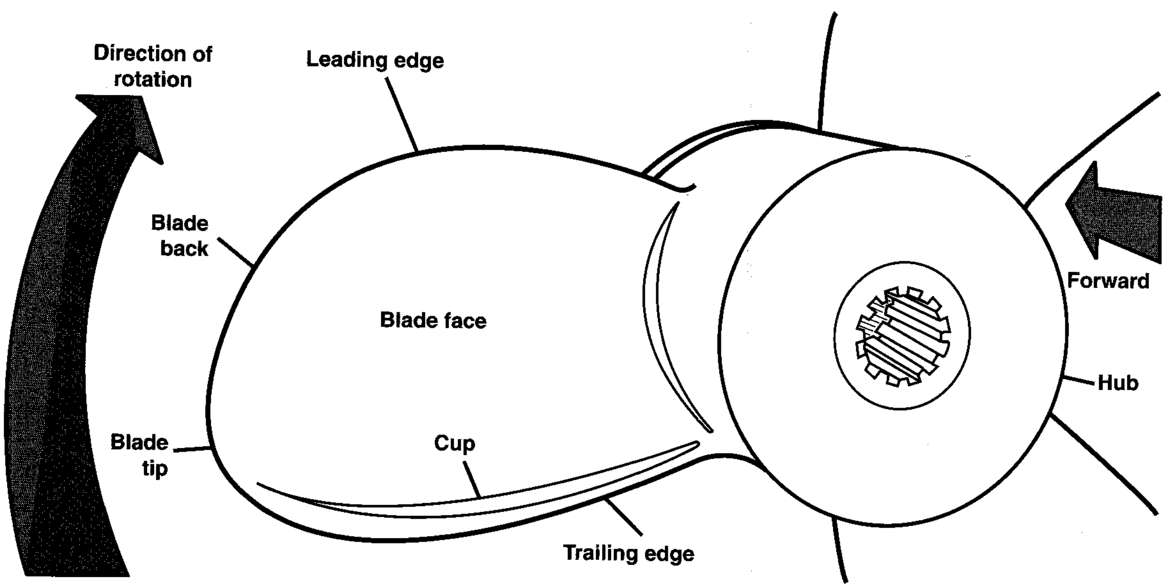

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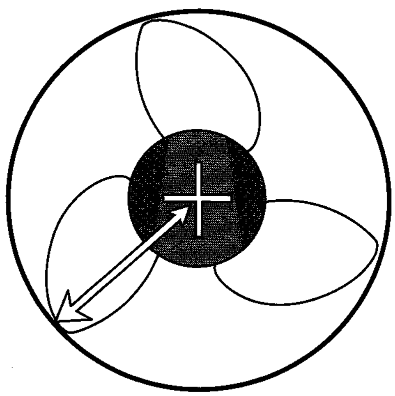

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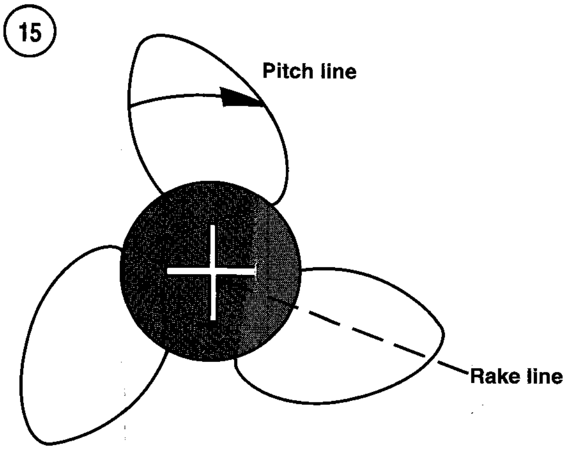

this is the area of the blade that first cuts through the water.

The blade face is the surface of the blade that faces away from the boat. During forward operation, high-pressure forms on this side of the blade.

The blade back is the surface of the blade that faces toward the boat. During forward gear operation, low-pressure forms on this side of the blade.

The cup is a small curve or lip on the trailing edge of the blade. Cupped propeller blades generally perform better than non-cupped propeller blades.

The hub is the center portion of the propeller. It connects the blades to the propeller shaft. On most drive systems, engine exhaust is routed through the hub; in this case, the hub is made up of an outer and inner portion, connected by ribs.

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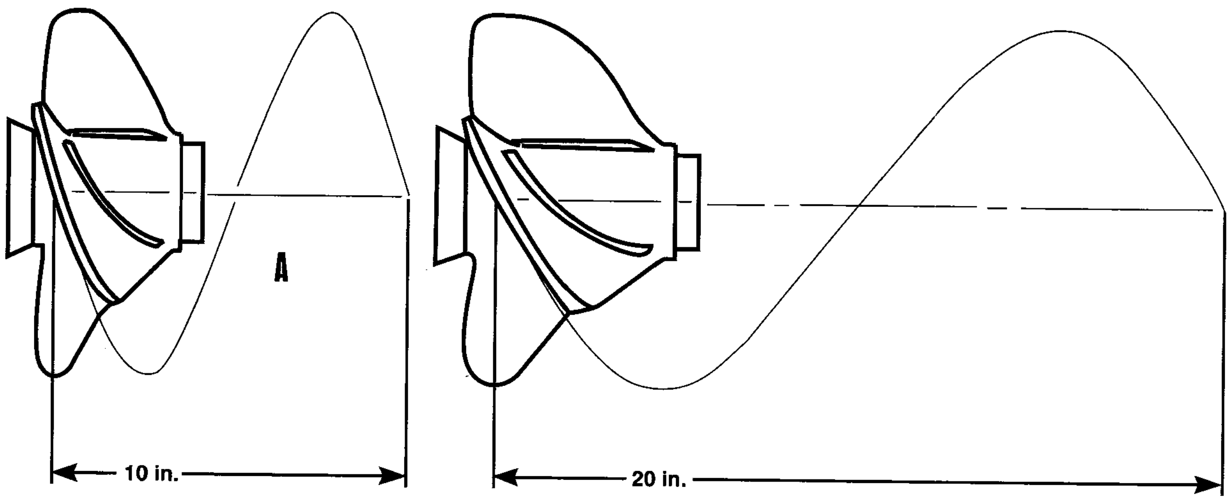


The diffuser ring is used on though- hub exhaust models to prevent exhaust gasses from entering the blade area.

Propeller Design

Changes in length, angle, thickness and material of propeller parts make different propellers suitable for different applications.

Diameter

Propeller diameter is the distance from the center of the hub to the blade tip, multiplied by two. Essentially it is the diameter of the circle formed by the blade tips during propeller rotation (**Figure 14**).

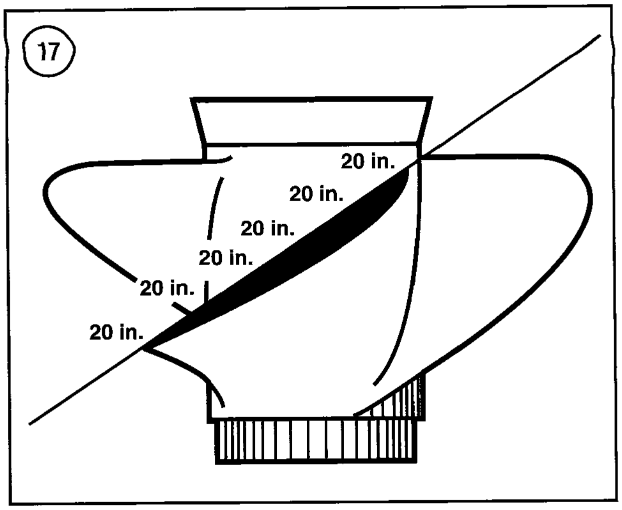
Pitch and rake

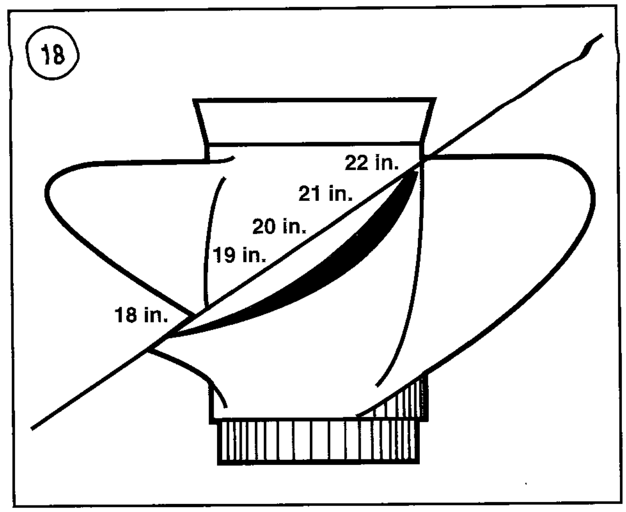
Propeller pitch and rake describe the placement of the blades in relation to the hub (**Figure 15**).

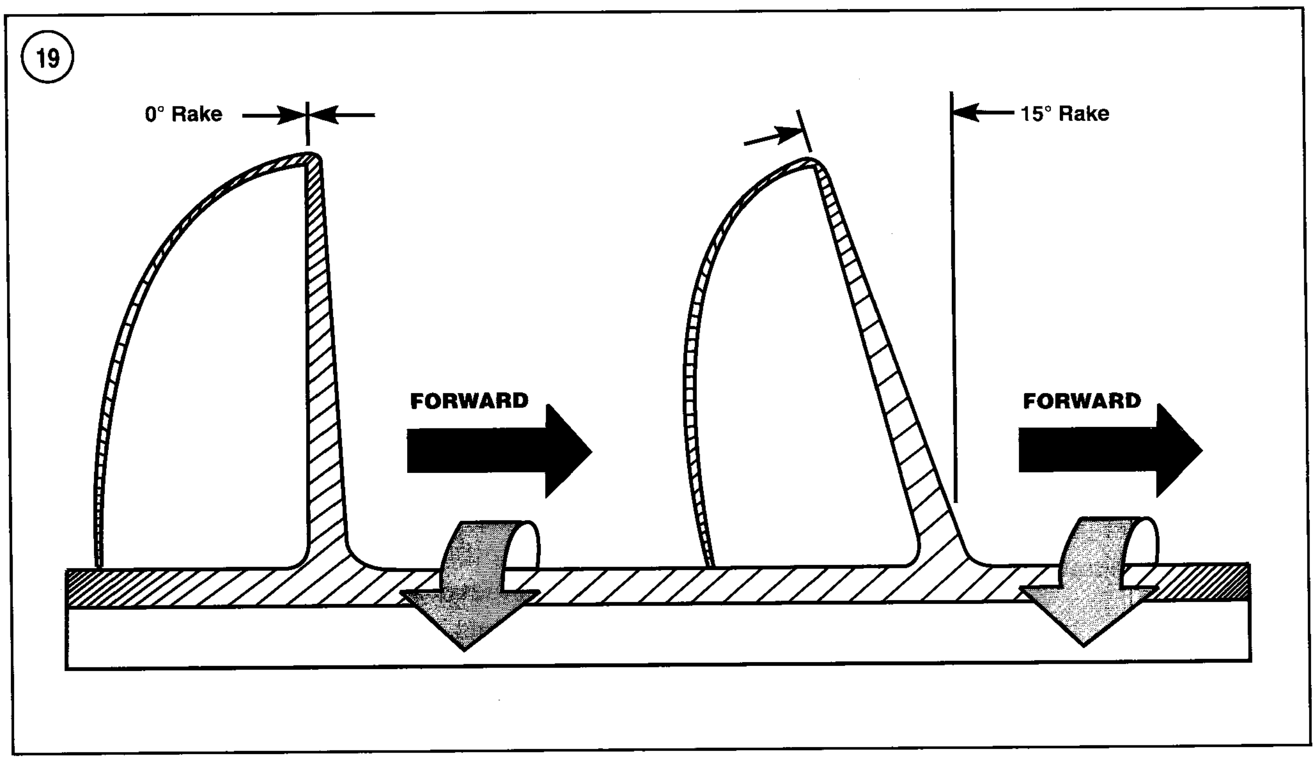
Pitch describes the theoretical distance the propeller would travel in one revolution. In A, **Figure 16**, the propeller would travel 10 inches in one revolution. In B, **Figure 16**, the propeller would travel 20 inches in one revolution. This distance is only theoretical; during operation, the propeller achieves only 75-85% of its pitch. Slip rate describes the difference in actual travel relative to the pitch. Lighter, faster boats typically achieve a lower slip rate than heavier, slower boats.

Propeller blades can be constructed with constant pitch (**Figure 17**) or progressive pitch (**Figure 18**). On a progressive propeller, the pitch starts low at the leading edge and increases toward the trailing edge. The propeller pitch specification is the average of the pitch across the entire blade. Propellers with progressive pitch usually provide better overall performance than constant pitch propellers.

Blade rake is specified in degrees and is measured along a line from the center of the hub to the blade tip. A blade that is perpendicular to the







hub (**Figure 19**) has 0° rake. A blade that is angled from perpendicular (**Figure 19**) has a rake expressed by its difference from perpendicular. Most propellers have rakes ranging from 0-20°. Lighter faster boats generally perform better with propeller with a greater amount of rake. Heavier, slower boats generally perform better using a propeller with less rake.

Blade thickness

Blade thickness in not uniform at all points along the blade. For efficiency, blades are as thin a possible at all points while retaining enough strength to move the boat. Blades are thicker where they meet the hub and thinner at the blade tips (**Figure 20**). This is necessary to support the

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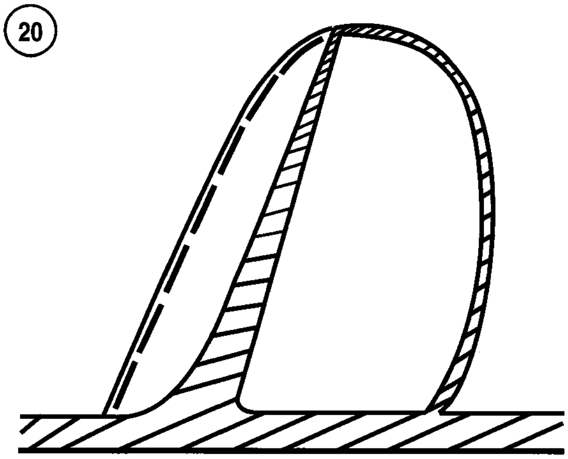

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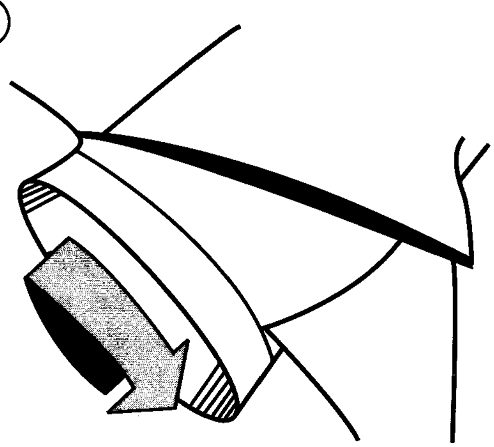

heavier loads at the hub section of the blade. Overall blade thickness is dependent on the strength of the material used.

When cut along a line from the leading edge to the trailing edge in the central portion of the blade (**Figure 21**), the propeller blade resembles and airplane wing. The blade face, where high-pressure exists during forward rotation, is almost flat. The blade back, where low-pressure exists during forward rotation, is curved, with the thinnest portions at the edges and the thickest portion at the center.

Propellers that run only partially submerged, as in racing applications, may have a wedge

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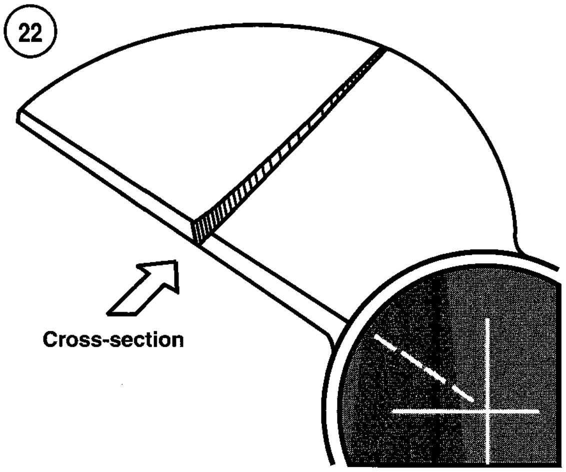

shaped cross-section (**Figure 22**). The leading edge is very thin and the blade thickness increases toward the trailing edge, where it is thickest. If a propeller such as this is run totally submerged, it is very inefficient.

Number of blades

The number of blades used on a propeller is a compromise between efficiency and vibration. A one-bladed propeller would the most efficient, but it would create an unacceptable amount of vibration. As blades are added, efficiency decreases, but so does vibration. Most propellers have three or four blades, representing the most practical trade-off between efficiency and vibration.

Material

Propeller materials are chosen for strength, corrosion resistance and economy. Stainless steel, aluminum, plastic and bronze are the most commonly used materials. Bronze is quite strong but rather expensive. Stainless steel is more common than bronze because of its combination of strength and lower cost. Aluminum alloy and plastic materials are the least expensive


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