GENERAL INFORMATION

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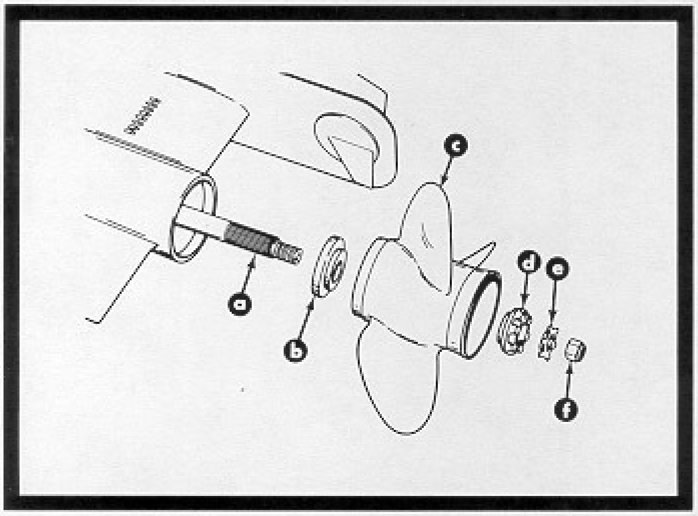


PROPELLERS

MerCruiser
STERN DRIVES & INBOARDS

INDEX

Function and Engineering

What Do They Do?

A marine propeller is the primary connection between your motor and the water. Powered by the engine, it moves a boat forward or backward. Without the propeller, nothing happens.

The propeller has blades that are designed (when rotated) to move the boat forward by creating a negative or pulling pressure on one side and a positive or pushing pressure on the other side of the blades. These pressures cause water to be drawn into the propeller from in front and accelerated out the back (Figure 1). But just any propeller won't do the best job.

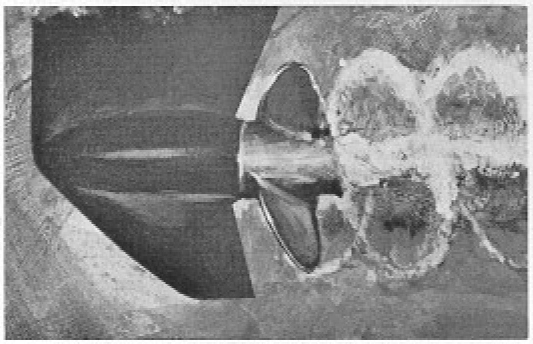


Figure 1

Choosing the correct propeller isn't that difficult; however, it must be selected for the particular job that the boat is to perform. Fishing. Skiing. Cruising. Racing. Or, if the customer uses his boat for several activities and the load varies from very light to very heavy, two different propellers might be recommended.

The waters in which the boat is operated may well determine the best material to use in the propeller. Will boating be in fresh, salt or brackish water, deep or shallow, rocky waters?

How Do They Work?

(Figure 2) Household fan with arrows showing air movement: An ordinary electric fan pulls air in from behind it and blows it out toward you. The marine propeller acts in much the same way, except that it acts on water rather than on air.

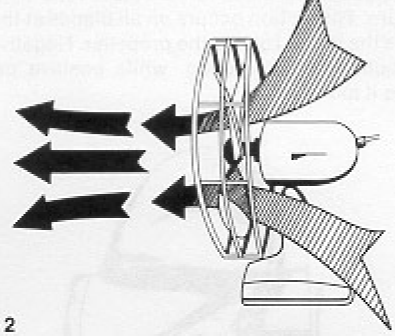


Figure 2

(Figure 3) Propeller with arrows showing water movement to it, through it, from it. The marine propeller draws or pulls water in from its front end through an imaginary cylinder a little larger than the propeller diameter. The front end is the end that faces the boat. As the propeller spins, water accelerates through it, creating a slightly smaller jet stream of higher-pressure water behind the propeller. This exiting water jet is smaller in diameter than the actual diameter of the propeller. This water jet action of pulling water in and pushing it out results in what is called "thrust". It is the pulling and pushing force that moves a boat forward.

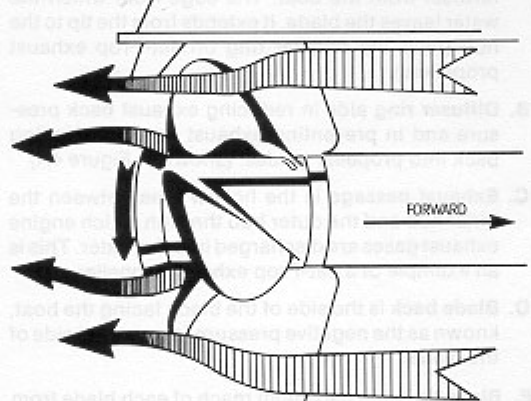


Figure 3

What Makes The Rotation Propeller Move Through The Water?

Look at the blade facing directly at you in this side view (Figure 4A). As it rotates downward, water is pushed down and back naturaly, just as it is done by your hand when swimming. This results in positive pressure. At the same time, water is being drawn in on the top side of the blade as the blade turns. This results in negative pressure. This action occurs on all blades at the same time as the motor rotates the propeller. Negative pressure pulls the prop along, while positive pressure pushes it along.

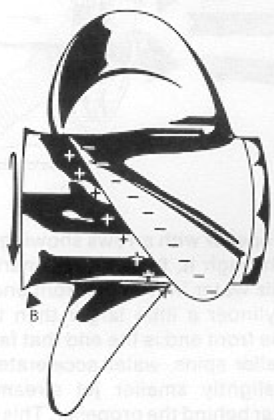


Figure 4A

What Are The Basic Propeller Parts?

A. Trailing edge of the blade is that part of the blade farthest from the boat. The edge from which the water leaves the blade. It extends from the tip to the hub (near the diffuser ring on Jet-Prop exhaust propellers).

B. Diffuser ring aids in reducing exhaust back pressure and in preventing exhaust gas from feeding back into propeller blades. (shown in Figure 4A)

C. Exhaust passage is the hollow area between the inner hub and the outer hub through which engine exhaust gases are discharged into the water. This is an example of a Jet-Prop exhaust propeller.

D. Blade back is the side of the blade facing the boat, known as the negative pressure (or suction) side of the blade.

E. Blade tip is the maximum reach of each blade from the center of the propeller hub. It separates the leading edge from the trailing edge.

F. The "cup" is a small curve or lip on the trailing edge of the blade, permitting the prop to hold water better, and adding normally about 1/2" (12.7mm) to 1" (25.4mm) of pitch.

G. Ribs are the connections between the inner and the outer hub. There are usually 3 ribs, occasionally 2 or 4. The ribs are usually either parallel to the prop shaft ("straight"), or parallel to the blades ("helical").

H. Leading edge of the blade is that part of the blade nearest the boat, that which first cuts through the water. It extends from the hub to the tip.

I. Outer hub (for Jet-Prop exhaust propellers) is the hub area in direct contact with the water and to which the blades are attached. Its inner surface is in contact with the exhaust gases.

J. Inner hub contains the rubber hub (described below). The forward end of this hub is the metal surface which transmits the prop thrust, through the forward thrust hub, to the propeller shaft and in turn eventually to the boat.

K. Blade face is that side of the blade facing away from the boat, known as the positive pressure side of the blade.

L. Flo Torq® shock-absorbing rubber hub is composed of rubber molded to an inner splined hub. Its purpose is to protect the propeller drive system and to flex when shifting the engine, to relieve the normal shift shock that occurs between the gear and clutch mechanism.

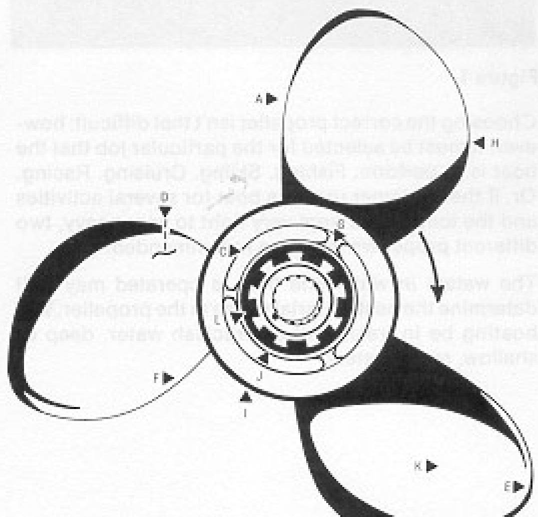


Figure 4B

Non-Jet Exhaust Propellers

Propellers may have the Flo-Torq shock absorbing rubber hub, without through-hub exhaust (Figure 5). These propeller blades attach directly to the hub. A blade design is required that will perform satisfactorily without an exhaust-gas enclosing outer hub.

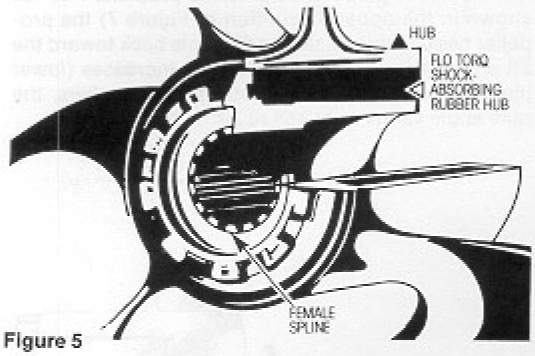


Figure 5

(Figure 5A) Propellers with solid hubs have no Flo Torq shock-absorbing rubber hub. Exhaust gases are discharged in a manner so as not to disturb the propeller action. Solid-hub propellers are generally used on racing motors which usually do not have a gear shift.

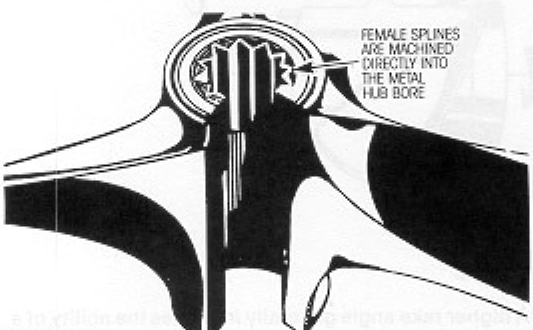


Figure 5A

What Is Pitch?

Pitch is the distance that a propeller would move in one revolution (if it were traveling through a soft solid — like a screw in wood) (Figure 6).

When a propeller is identified as 13x21, it has a 13" (33cm) diameter with 21" (53cm) of pitch. Theoretically, the propeller would move forward 21" in one revolution.

Propeller Pitch

Actual propeller pitch can vary from the advertised pitch stamped on the propeller. One cause is minor distortion that can occur during the casing and cooling process. Another cause is adjustments or modifications made by propeller repair stations. Finally, undetected damage may have altered the pitch.

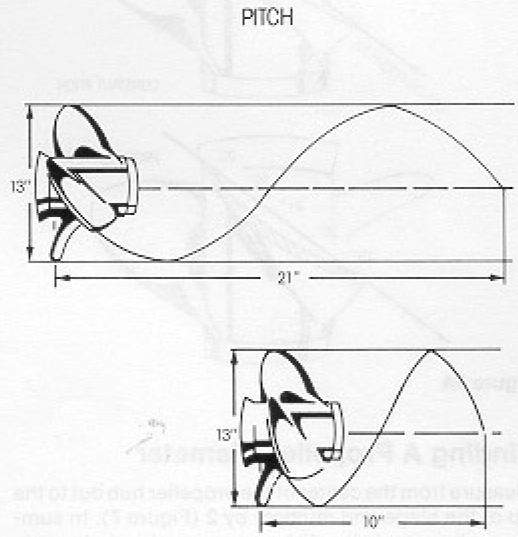


Figure 6

What is Progressive Pitch?

Progressive pitch (Figure 6A), also called blade "camber", is a blade design innovation that improves performance when forward and rotational speed is high and/or the propeller breaks the water surface.

Progressive pitch starts low at the leading edge and progressively increases to the trialing edge. The pitch number assigned (example, 21") is the average pitch over the entire blade. It is commonly used on mid-to high-horsepower Quicksilver® propellers.

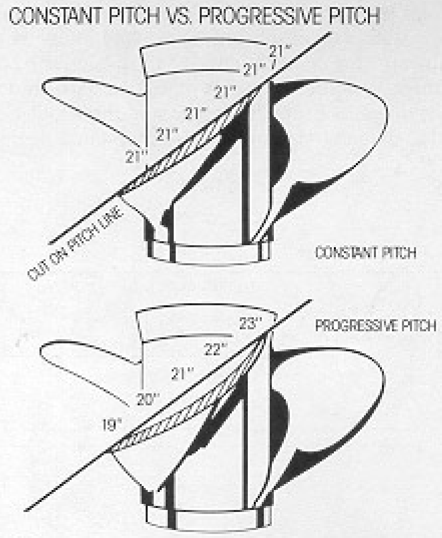


Figure 6A

Finding A Propeller Diameter

Measure from the center of the propeller hub out to the tip of the blade and multiply by 2 (Figure 7). In summary, diameter is the distance across the circle made by the blade tips as the propeller rotates.

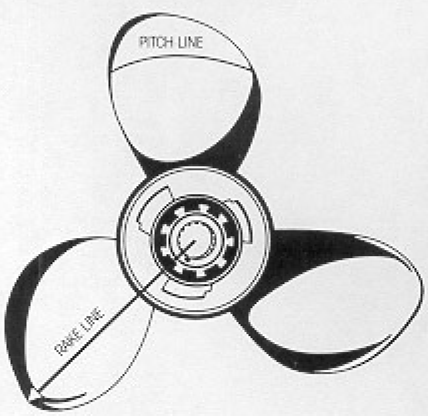


Figure 7

What Is Blade Rake?

When a propeller blade is examined on a cut extending directly through the center of the hub, as in Figure 7, the cross section of that cut blade (as viewed in Figure 8) would represent blade rake.

If the blade is perpendicular to the propeller hub (as shown in the upper illustration or Figure 7) the propeller has 0° rake. As the blade slants back toward the aft end of the propeller, blade rake increases (lower illustration, Figure 8). With standard propellers, the rake angle varies from - 5° to 20 °.

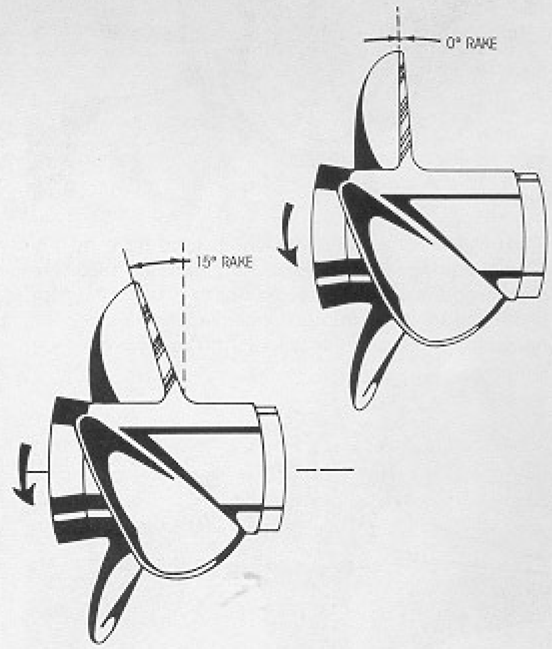


Figure 8

A higher rake angle generally improves the ability of a propeller to operate in a cavitating or ventilating situation (explained, following). On lighter, faster boats, with a higher engine or drive transom height, higher rake often will increase performance by holding the bow of the boat higher.

Why Does Blade Thickness Vary?

Like a tree growing from a tree trunk, so a blade is thickest where it meets the hub. As the blade moves out from from the tip, it becomes thinner (Figure 9). The basic reason: like any cantilever beam, the load that any blade or beam section must support decreases to zero at the tip or free end.

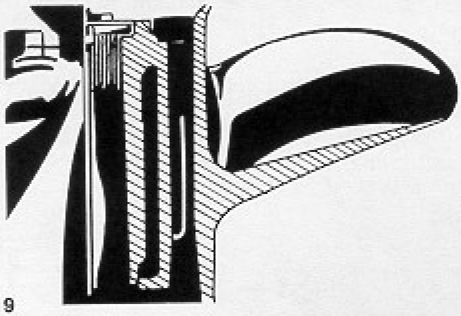


Figure 9

Since there is only so much power available, blades should be as thin as practical (considering the strength of their material) because it takes more power to push a thick blade through the water than a thin blade.

But what about the thickness variation from the leading to trailing edge? When viewing a common blade cutaway at a given radius from the center (Figure 10), an approximate flat surface will be observed on the pressure (positive) side and a circular arc surface on the suction (negative) side (with the thickest point in the center). Edges usually are .060" to 080" (1.5mm to 2.0mm) thick for aluminum props, thinner for stainless steel.

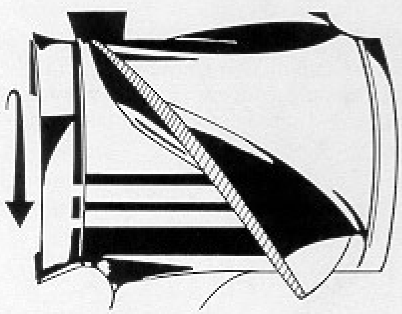


Figure 10

For propellers intended to run partially surfaced as in racing applications the "cleaver" blade shape is popular. Its blade section is usually a wedge. Blades with a thick trailing edge such as this should only be run surfaced. When they are run deep, where surface air can't ventilate the low-pressure cavitation pockets formed behind the thick trailing edge, they are less efficient.

What Is Cupping?

When the trailing edge of the blade is formed or cast with an edge curl outward (away from boat), it is said to have a cup (Figure 11). Generally, cupped blades improve the planing performance of a boat. The cup helps the blades "hold" (not break loose) when operating in a cavitating or ventilating situation. This, then, permits the stern drive to be trimmed out futher or be mounted higher on or in the transom, particularly on faster boats. Either adjustment usually adds to top speed.

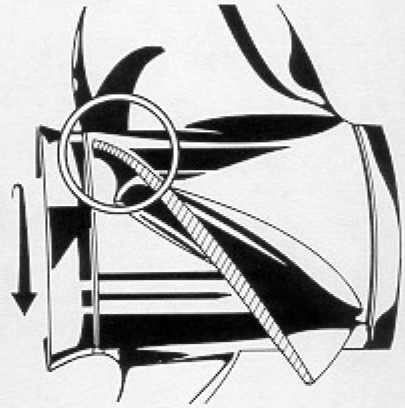


Figure 11

The cup may have the effect of adding pitch to the blade, as well as rake. Cupping usually will reduce full-throttle engine speed about 150 to 300 RPM below the same pitch prop with no cup. A propeller repair shop can increase or decrease cup to alter engine RPM below the same pitch prop with no cup. A propeller repair shop can increase or decrease cup to alter engine RPM to meet specific operating requirements. Cups are standard on most Quicksilver propellers.

For a cup to be most effective, it should be completely concave (hollowed) and finished with a sharp trailing edge. Any convex rounding of the trailing edge of the cup detracts from its effectiveness.

Cupping is usally of no value on props used in heavy-duty or work applications where the prop remains fully submerged.

Importance of Cup Location

Using a round bladed propeller as an example, if the cupped area intersects pitch lines, as in Figure 12, it will in effect increase blade pitch.

Cupping is this area will reduce RPM by adding pitch. It will also protect somewhat against propeller "blowout" (See "Index" for "Blowout" explanation).

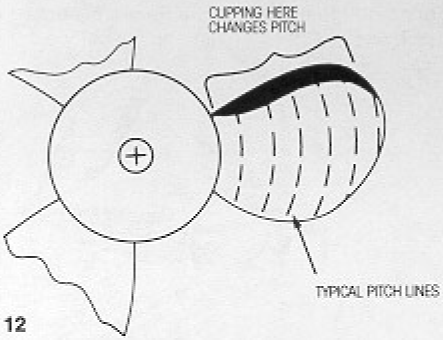


Figure 12

If the cup is placed so that it intersects rake lines, Figure 12A, it then has the effect of increasing rake. The benefits of blade rake are previously explained.

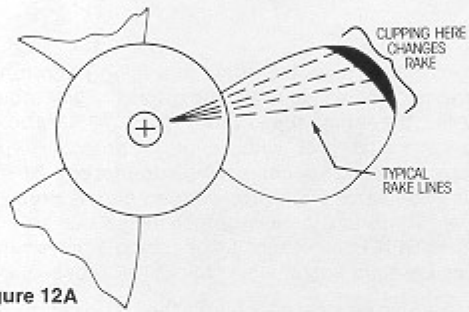


Figure 12A

There is clearly some overlap where cup affects both pitch and rake.

In some cases adding a normal cup has reduced engine RPM by an unusually high number, as much as 1000 RPM. This can happen if the uncupped propeller was running partially "blown out", a situation not uncommon and often undetected until a cupped propeller is tried. A partially blown out propeller has a mushy, somewhat unresponsive feel, and may produce excessive prop spray. An accurate SLIP calculation (explained following) can be beneficial here. Slip will generally jump from its normal 10% - 15% to over 20% for a partially "blown out" prop (on an average - to light-weight boat).

Adjusting the cup on a cleaver-style propeller is more difficult. Since the trailing edge is very thick and runs straight out on a rake line, any adjustment will have far less effect on altering rake. Pitch can be reduced substantially by filling or grinding away some of the cup. At the same time rake will be altered slightly. For less rake, decrease the cup in the area close to the tip. For more rake, reduce the cup in the area close to the hub. Obviously any cup reduction will also result in an RPM increase.

What Direction Does A Propeller Turn?

There are Right-Hand (Figure 13) rotating (RH) and Left-Hand rotating (LH) propellers. Most stern drive propellers are RH rotation.

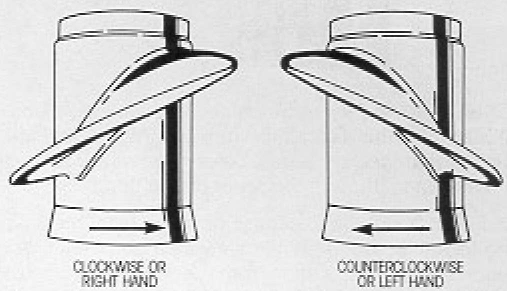


Figure 13

To recognize a Right-Hand propeller, observe the prop from a position shown in the "Clockwise" illustration and note that the Right-Hand prop blade slants from lower left to upper right. A Left-Hand propeller will have the opposite (counterclockwise) slant - from lower right to upper left, as shown.

Another method of recognition is to observe the propeller rotating in forward gear from behind the boat. A Right-Hand propeller turns clockwise, a Left-Hand counterclockwise.

Key: The Blade Slopes or Climbs Up in the Direction of Rotation.

What Exactly Is Torque?

Torque is the twisting or rotating effort of any shaft. The transfer of torque or twisting force from the drive shaft to the propeller shaft is made through gears. The torque developed at the engine thus is delivered through shafts and gears to the propeller; however, there usually is a 5% to 10% loss of torque due to the friction between moving parts. Torque is related to horsepower and shaft speed (RPM) by the following relationship

$$\text{Torque} = \frac{\text{Horsepower} \times 5250}{\text{RPM}}$$

What Does Motor Gearing Have To Do With Torque?

When there is no gear reduction in the stern drive, a 4000 engine RPM turns the propeller at 4000 RPM. This normally is used for high-speed racing applications. If a gear reduction is used, however, the 4000 engine RPM is reduced to 2000 RPM at the propeller, a two-to-one (2:1) gear reduction exists. Therefore, by cutting propeller shaft speed in half the torque has been doubled.

As the higher torque is transmitted to the propeller shaft with more gear reduction, a larger diameter propeller is required. A slower-turning, larger-diameter propeller is more efficient than a faster-turning, smaller-diameter propeller. This usually means better acceleration as well as better top speed, up to the point where the higher drag of the larger, higher reduction gearcase overtakes the propeller-efficiency benefit.

But what about the propeller pitch? The pitch acts like another set of gears with a given boat and load. Correct pitch is evident when, at wide-open-throttle, the engine runs within the manufacturer's specified RPM range.

One other fact: The faster the boat moves (given a specific engine and gear ratio), the smaller the ideal propeller diameter will be. As observed in a propeller chart, the propeller diameter goes down as the pitch goes up. (Fully submerged propellers only.)

How Does Propeller Torque Produce Boat Roll?

When observing from behind a boat, the propeller turns clockwise when underway (with normal right-hand propeller). As water resists the clockwise rotating propeller, it causes the boat to roll slightly in the opposite direction (counterclockwise) or down on the left (port) side and up on the right (starboard) side. To offset this slight imbalance, the driver's seat is placed on the right (starboard) side. Boats differ significantly in the degree of their reaction to prop torque.

What Is Propeller Slip?

In order to understand "slip" it is helpful to probe deeper into how a propeller works by first comparing it to an airplane wing. The wing of an airplane and its ability to carry the weight of the airplane by providing LIFT is very similar to the spiraling travel of a propeller blade which provides THRUST. It is important to appreciate the concept of "Angle of Attack" and how it relates to "SLIP"

If a wing with a symmetrical airfoil (Figures 14 and 15) is moved through the air so that air moves symmetrically above and below the wing, there is equal pressure above and below resulting in no "lift". The wing is said to be operating at zero degree (0°) angle of attack.

With an angle of attack (Figure 14A and 15A), there is a pressure change above and below the wing which creates lift [lower (negative) pressure on the top and higher (positive) pressure from below].

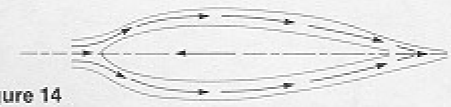


Figure 14

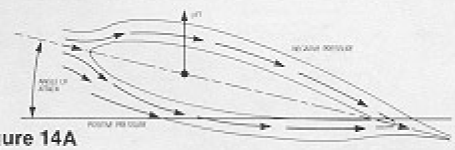


Figure 14A

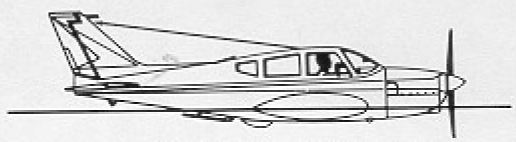


Figure 15

NO ANGLE OF ATTACK – NO LIFT – WILL NOT FLY

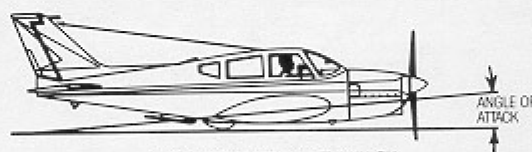


Figure 15A

WITH ANGLE OF ATTACK – LIFT – WILL FLY

Although it is clear that the airplane wing and the propeller blade move through air and water respectively, marine engineers prefer to talk about the situation in terms of the water moving into the blade. Allowed that freedom, consider the following diagrams showing the same angle of attack phenomena, only in this case, for the propeller blade.

Water entering at no (zero) angle of attack. This creates no positive or negative pressures on the blade, therefore there can be no lift or thrust (Figure 16).

Water entering with some angle of attack, which causes a pulling (negative pressure) on one side and a pushing (positive pressure) on the other side (Figure 16A). The combined pressures cause lift at approximately right angles to the blade surface. Lift can be divided into a Thrust component in the direction of travel and a Torque component in the opposite direction of propeller rotation.

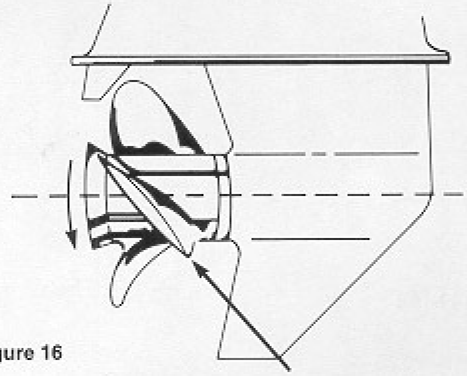


Figure 16

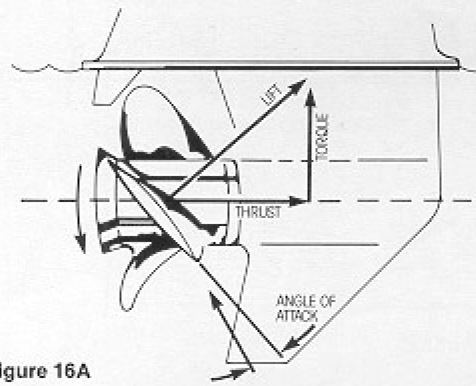


Figure 16A

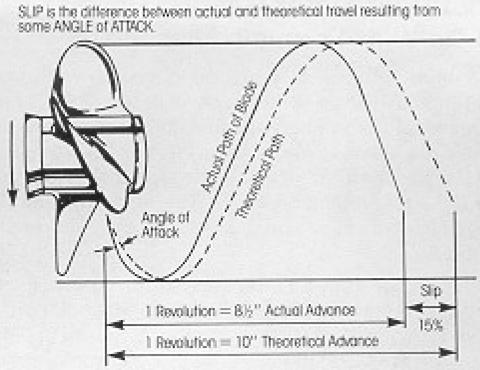


Figure 17

In the example Figure 17, a 10" pitch propeller actually advances only 8-1/2". This is 85% of 10" leaving a slip of 15%. If the blade had no angle of attack there would be no slip but, of course, there would be no positive and negative pressure created on the blades and therefore there would be NO THRUST. To create thrust there MUST be some angle of attack or slip. The objective of propeller design is to achieve the right amount of slip or angle of attack which is around 4°, give or take a degree. This is accomplished by matching the right amount of blade diameter and area to the existing engine horsepower and propshaft RPM. The chart in Figure 18 illustrates this point.

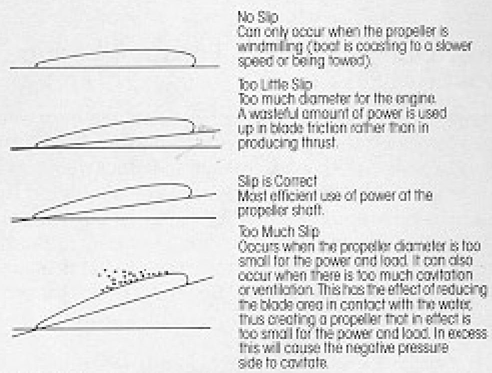


Figure 18

The following shows another way of tying in angle of attack and slip through considering rotational and forward velocities. Propeller engineers like to study propellers at the 7/10 radius (70% of the distance from the propeller center of rotation to the blade tip) which generally is the section of the propeller blade that is most typical of the whole blade. The 7/10 radius rotational velocity (speed in MPH at which the 7/10 radius is rotating) can be calculated by the following equation:

$$\text{7/10 radius Rotational Velcoity (MPH)} = \frac{\text{Propeller RPM} \times \text{7/10 Radius (in.)}}{168}$$

and can be shown by a vector (arrow) as illustrated in Figure 19. For those interested in Blade Tip Speed the following equation applies:

$$\text{The Rotational Propeller Tip Speed (MPH)} = \frac{\text{RPM Prop} \times \text{DIA in.}}{336}$$

The forward velocity can be shown by an arrow in the direction of travel (Figure 19A). The length of the arrows again reflects the speed in MPH for both the measured forward velocity and the theoretical (no slip) forward velocity (see equation).

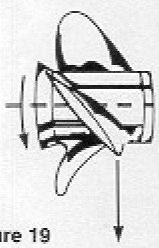


Figure 19

Figure 19A

When the rotational speed and forward speeds are combined in a simple vector (arrow) diagram some interesting things appear (Figure 20).

Consider the following actual example:

A 16' boat powered by, in this case, a 115 HP engine with 2:1 gear reduction, turning 5400 RPM uses a 13" diameter by 19" pitch, cupped propeller to push the boat 43.5 MPH. What is the slip and angle attack at the 7/10 radius?

Propeller Rotational Speed Equation:

$$\text{7/10 Radius Rotational Speed (MPH)} = \frac{\text{RPM Prop} \times \text{Blade Radius} \times .7}{168}$$

The equation applied to the example boat:

$$\text{Rotational Speed(MPH)} = \frac{\dfrac{\text{5400(Engine RPM)}}{\text{2(Gear Ratio 2:1)}} \times \dfrac{\text{13"(Prop. Dia.)}}{\text{2 (convert to radius)}} \times .7}{\text{168 (Constant for unit conversion)}} = \text{73.1MPH}$$

Theoretical Boat Speed Equation:

$$\text{Theoretical Boat Speed (MPH)} = \frac{\text{Prop Pitch (in.)} \times \text{RPM Prop}}{1056}$$

The equation applied to example boat:

$$\text{Theoretical Boat Speed (MPH)} = \frac{\text{19"+1" (pitch + cup)} \times \dfrac{\text{5400 (Engine RPM)}}{\text{2 (Gear Ratio)}}}{\text{1056 (Constant)}} = \text{51.1MPH}$$

Using some basic trigonometry, the angles and blade velocity come out as shown and

$$\text{SLIP (\%)} = \left[1 - \frac{\text{Actual Boat Speed (MPH)} \times 1056}{\text{Prop Shaft RPM} \times \text{Prop Pitch (in.)}}\right] \times 100 =$$

$$\left[1 - \frac{43.5 \times 1056}{2700 \times 20}\right] \times 100 = 15\%$$

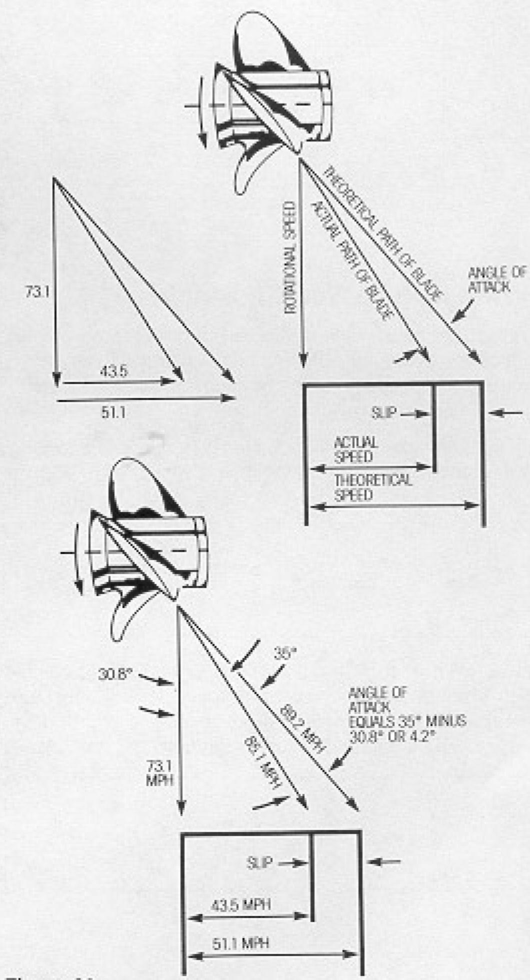
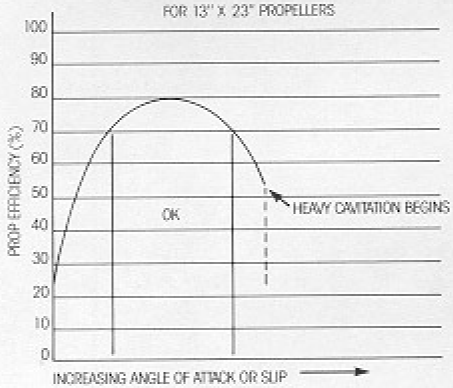


Figure 20

This graph depicts how propeller efficiency increases and, then, decreases as angle of attack is increased. In this example, efficiency peaks at approximately 80%, (3° - 4° angle of attack) and begins to decline as angle of attack increases beyond the optimum.

In a given propeller series, maximum efficiency decreases as pitch decreases. For example, a 23" pitch propeller with 13-1/2" diameter can have a peak efficiency of 80%, but a 13" pitch propeller with a 16" diameter can have a peak efficiency of only 65%.



What Is Propeller Efficiency?

Although the average boater is not going to be able to calculate propeller efficiency, it is worth explaining to assure that propeller efficiency will not be confused with SLIP, a common misconception.

In simple terms propeller efficiency is the power coming out of a propeller divided by the power going in (Figure 21).

$$\text{Prop efficiency (\%)} = \frac{\text{Power Out}}{\text{Power In}} \times 100$$

Figure 21

Let's use horsepower (HP) for our units. First, to calculate horsepower out, the boat speed (MPH) must be measured (relatively easy) and second, the propeller thrust (lbs.) must be measured (difficult) (Figure 22).

$$\text{HP}\ \underline{\text{out}} = \frac{\text{Boat Speed (MPH)} \times \text{Prop Thrust (lbs.)}}{375}$$

Figure 22

To calculate horsepower in, the propeller shaft (RPM) must be measured (easy). Next, the propeller shaft torque (lb. ft.) must be measured (difficult) (Figure 23).

$$\text{Propeller Shaft Speed (RPM)} = \frac{\text{Engine Speed (RPM)}}{\text{Gear Reduction}}$$

$$\text{HP}\ \underline{\text{in}} = \frac{\text{Propeller Shaft Speed (RPM)} \times \text{Propeller Shaft Torque (lb. ft.)}}{5250}$$

Figure 23

Notice that although all the characteristics of a propeller, diameter, pitch, number of blades, rake, even slip may affect efficiency indirectly, none appear in the efficiency calculation. For example, consider our 16' boat powered by a 115 HP engine (2:1 gear reduction) which runs 43.5 MPH while the engine turns 5400 RPM.

With sophisticated instrumentation the propeller shaft torque is measured to be 214 lb. ft. and the propeller thrust at 43.5 MPH is found to be 760 lbs. (Figure 24).

$$\text{The propeller shaft RPM} = \frac{\text{Engine RPM}}{\text{Gear Reduction}} = \frac{5400}{2} = 2700\ \text{RPM}$$

$$\text{Now HP}\ \underline{\text{out}} = \frac{43.5 \times 760}{375} = 88.2\ \text{HP}$$

$$\text{HP}\ \underline{\text{in}} = \frac{2700 \times 214}{5250} = 110.1\ \text{HP}^{*}$$

$$\text{Prop Efficiency} = \frac{88.2}{110.1} \times 100 = 80\%$$

Figure 24

H.P. in can often be approximated by reducing the advertised horsepower by about 5% to cover gearcase internal friction and water pump driving losses.

Example: 115 HP (.05 x 115 = 109.3 HP)

An easy-to-use, special slide rule designed specifically to calculate propeller slip is available from: **Quicksilver Division, 1939 Pioneer Road, Fond du Lac, Wi 54935, Attn: Plulcations Dept.** Order Part Number C-90-86147.

Materials And Construction

Stainless Steel (QSS)

The greatest advantage to using Quicksilver stainless steel propellers is their tremendous strength (Figure 1). The strength of stainless steel propellers will help maintain, if not improve, Power Package performance because they are resistant to the typical accumlation of small nicks and bends normally found on aluminum props after running for a short period of time. We use the finest stainless steel available because it provides the maximum combination of strength - about five times that of aluminum - and superb corrosion resistance. The stainless steel alloy used in Quicksilver props doesn't require cover-up coatings that soon wear away and do not enhance performance.

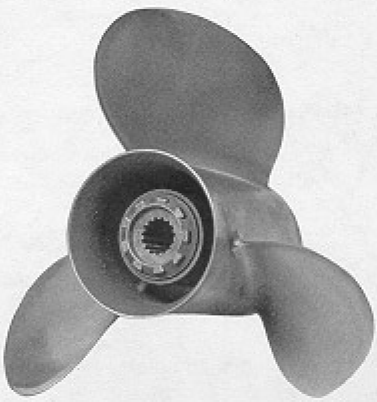


Figure 1

Aluminum

Aluminum is by far the most popular propeller material used today for stern drives (Figure 2). It is relatively low in cost, has good strength, good corrosion resistance and is easily repaired. Most Quicksilver aluminum propellers are produced by the die-cast rather than sand-cast method.

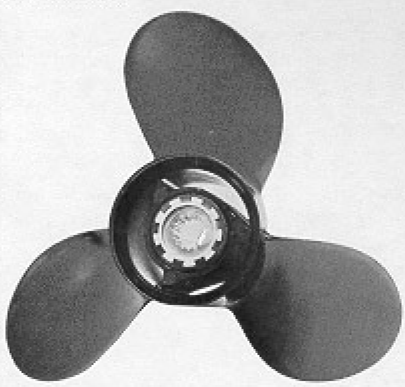


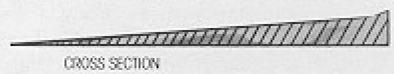
Figure 2

This is important, because die casting consistently produces propellers that more accurately duplicate the master prop. The die-cast propeller requires a minimum of machining and buffing prior to final painting. In addition, more sophisticated designs can be duplicated far more accurately with the die casting method. For instance, blade cupping is now die-cast in the blades.

For added corrosion resistance, all Quicksilver aluminum propellers are protected with a quality, durable paint. Propellers are iridite-etched to provide better paint adhesion. A thermo set epoxy paint system is applied by an eltrodeposition process as the final coating.

Cleaver

"Cleaver" is a name applied for many years to a propeller whose blades have their trailing edge cut on a straight line (Figure 3), generally on a rake line (a line passing through the center of the prop hub). Often accompanying this blade shape is a blade cross section that looks more or less like a wedge; that is, the leading edge is very thin and sharp while the trailing edge is the thickest point. This style is best suited for elevated installations which allow the propeller blades to break the water surface.



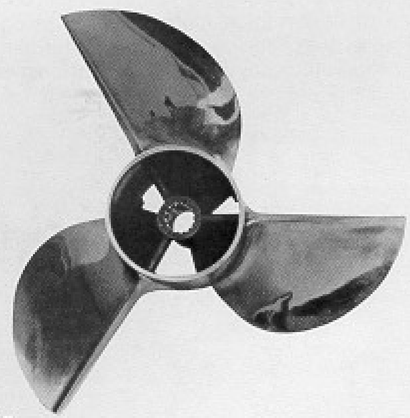


Figure 3

Stainless Steel Application

A frequent question boaters ask is "How much faster will I go if I install a stainless steel propeller, and which one should I use?"

These boaters automatically associate stainless steel propellers with greater speed and, in some applications, they are correct. However, few, if any, realize that increased speed with a stainless steel propeller usually entails more than just removing their three-blade aluminum propeller and installing a stainless steel version.

Increased speed and performance, in most cases, are usually only attainable by making changes in the stern drive installation, specifically, increasing its height on the transom and determining the proper trim or tilt angle.

Laser

The Laser Propellers (Figure 4) can be used on Mercury/Mariner V-6 outboards as well as MerCruiser I Stern Drives. These propellers were specifically designed for use on outboard equipped bass boats which have the engine mounted approximately 24" high on the transom. They provide an excellent combination of top speed, acceleration and holding ability. Our testing has shown that these propellers get the boat out of the hole and up on plane faster than any of the competitive propellers that we have tested. The excellent holding ability of these propellers allows the engine to be mounted higher on the transom and trimmed farther out for increased performance. Increased fuel efficiency also is realized in most cases by allowing the boat to remain up on plane at slower speeds.

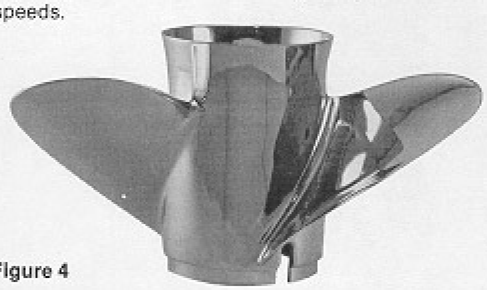


Figure 4

The Laser Propellers also are suitable for use on stern drive equipped sport boats, which require bow lift and have the stern drives mounted 1 to 2 inches higher than normal on the transom. On these applications, the Laser wil provide a nice balance of top speed and acceleration. The Laser can be used on stern drives up to 370 horsepower.

On hi-performance boats, which have the stern drives mounted high on the transom (and top speed is the major concern), the Cleaver Propellers will still usually work the best.

The Laser Propeller is of the Jet Prop™ exhaust design and is made of a corrosion resistant stainless steel alloy for maximum strength. A square rubber drive hub is employed to absorb shock when shifting, or if propeller should hit an underwater object.

Special acceleration slots are cast into the Laser Propeller. These slots improve acceleration by allowing a controlled amount of exhaust gases to be drawn into the propeller blades during acceleration. This unloads the propeller, allowing the engine to reach the higher RPM range more quickly, where it develops more horsepower.

A new Dura-Tech™ finishing process is used to polish the Laser. In addition to providing a better looking finish, the new polishing operation eliminates small scratches which could cause a fatigue failure. Our testing has revealed that the Dura-Tech™ finish provides a fatigue life 10 times greater than a hand ground finish.

QSS Hi-Performance "Cleaver"

Designed for MerCruiser Stern Drive-powered boats that are set up and capable of speeds over 50 MPH. QSS "Cleaver" propellers are strictly for "Surface" type of operation only. To install one on a boat not capable of this higher speed range, and to bury the propeller underwater, as in a standard installation, could noticeably reduce performance, RPM and boat speed.

Due to the design characteristic of a stern drive propulsion system, changes in transom height of the drive unit cannot be made easily, and usually not by the owner. Height changes required removal of the the engine and stern drive and recutting of the outdrive transom cutout hole. As a general rule, if the boat is designed to run at speeds above 50 MPH, the boat manufacturer will have mounted the engine and stern drive at the proper height and equipped the boat with the correct propeller, including a QSS stainless steel "Cleaver".

Whenever stainless steel propellers are used in conjunction with aluminum drive units, galvanic corrosion may be greatly accelerated. Consequently, we strongly recommend the use of a Quicksilver MerCathode System (88334A2) or a large anticorrosion anode kit (71320A3) to combat galvanic corrosion.

The MerCathode System will give permanent protection and is recommended where a high degree of corrosion exists.

How To Read A Selection Chart

Quicksilver propellers are designed with the correct pitch, rake, contour, blade area and diameter to give peak performance and increased fuel economy from MerCruiser Stern Drives.

The propeller charts include a boat speed range that is directly related to gross weight and boat length. The interrelation of these factors has a marked effect on the speed and performance of boats that fall within any given category. Generally, gross weight is the major factor (total weight of the entire package - boat, power package, fuel, passengers and miscellaneous equipment) and, when choosing a propeller, this should be the primary consideration.

For example, the gross load of a 24 ft. boat package equipped with a MerCruiser 120MR Stern Drive is 2750 lbs. To find the proper propeller, refer to the Propeller Selection Chart in the "Quicksilver Parts and Accessories" catalog for the power package and locate this gross load in the chart. The chart indicates that a 15 in. or 14 in. pitch propeller has a gross load range of 2300-3100 lbs. Therefore, a 14 in. pitch aluminum, or a 15 in. pitch aluminum or stainless steel should be selected.

When a propeller is matched to actual gross weight, the boat speed and full-throttle engine RPM usually will fall within the stated range. Best all-around performance is achieved when the engine runs near the top of (but within) specified full-throttle operating range. Propeller lines normally are designed so that the next size pitch will change engine RPM by 300 to 500. If the engine RPM falls, for example, too low on your first propeller selection, try a lower pitched propeller to bring the RPM up. (Higher pitched propellers reduce engine RPM).

	Diameter	Pitch	No. of Blades	Material	Approx. Gross Boat Wgt. (Lbs.)	Approx. Boat Length	Speed Range (mph)	Propeller Part Number
MerCruiser	13-3/8"	25"	3	Alum.	1600-2000	Up to 17'	40-48	C-48-78126A4
120R&MR	13-3/8"	25"	3	S. Steel	1600-2000	Up to 17'	40-48	C-48-79796A4
	13-1/2"	23"	3	Alum.	1700-2100	Up to 18'	37-45	C-48-78124A4
	13-1/2"	23"	3	S. Steel	1700-2100	Up to 18'	37-45	C-48-75724A4
	13-3/4"	21"	3	Alum.	1800-2200	Up to 19'	34-42	C-48-78122A4
	13-3/4"	21"	3	S. Steel	1800-2200	Up to 19'	34-42	C-48-73982A4
	14"	19"	3	Alum.	1900-2300	17'-21'	30-38	C-48-78120A4
	14"	19"	3	S. Steel	1900-2300	17'-21'	30-38	C-48-73980A4
	15-1/2"	18"	3	Alum.	1900-2300	17'-21'	29-37	C-48-11324A4
Black Max Props	14-1/2"	17"	3	Alum.	2100-2600	19'-23'	25-33	C-48-78118A4
Thrust Hub:	14-1/2"	17"	3	S. Steel	2100-2600	19'-23'	25-33	C-48-79794A4
77987	15-3/4"	16"	3	Alum.	2100-2600	19'-23'	24-32	C-48-11322A4
	15-1/4"	15"	3	Alum.	2300-3100	21'-25'	16-27	C-48-78116A4
	14-1/2"	15"	3	S. Steel	2300-3100	21'-25'	16-27	C-48-93272A4
	16"	14"	3	Alum.	2300-3100	21'-25'	15-26	C-48-11320A4
	16"	13"	3	Alum.	2600-3600	23'-27'	6-18	C-48-78114A4
	16"	11"	3	Alum.	3000 Plus	24 Plus	To 8	C-48-78112A4
As inventory is depleted, the following MCM I propellers will be superseded by the above Black Max propellers.								
MerCruiser	14 1/2"	25"	3	Alum.	1600-2000	Up to 16'	39-47	C-48-79580A4
120	13 1/2"	25"	3	S. Steel	1600-2000	Up to 16'	41-49	C-48-88446A4
	15"	23"	3	Alum.	1700-2100	Up to 17'	36-43	C-48-79578A4
	13 1/2"	23"	3	S. Steel	1700-2100	Up to 17'	38-45	C-48-88444A4
	15 1/4"	21"	3	Alum.	1800-2200	16'-18'	33-39	C-48-79576A4
	13 3/4"	21"	3	S. Steel	1800-2200	16'-18'	35-41	C-48-88442A4
	15 1/2"	19"	3	Alum.	1900-2300	18'-21'	29-35	C-48-79574A4
	14"	19"	3	S. Steel	1900-2300	18'-21'	31-37	C-48-88440A4
	15 3/4"	17"	3	Alum.	2100-2600	19'-23'	24-31	C-48-79572A4
MCM I Props	14 1/2"	17"	3	S. Steel	2100-2600	19'-23'	25-32	C-48-88438A4
Thrust Hub:	16"	15"	3	Alum.	2300-3100	21'-25'	14-25	C-48-79570A4
56292A2	16"	13"	3	Alum.	3100 Plus	23' Plus	2-15	C-48-79568A4
MerCruiser	13-3/8"	25"	3	Alum.	1700-2200	Up to 17'	42-51	C-48-78126A4
140R&MR	13-3/8"	25"	3	S. Steel	1700-2200	Up to 17'	42-51	C-48-79796
	13-1/2"	23'	3	Alum.	1900-2400	Up to 18'	40-48	C-48-7812
	13-1/2"	23"	3	S. Steel	1900-2400	Up to 18'	40-48	C-48
	13-3/4"	21"	3	Alum.	2100-2600	Up to 19'	37-44	
	13-3/4"	21"	3	S. Steel	2100-2600	Up to 19'	37-44	
	14"	19"	3	Alum.	2300-290	17'-21		
	14"	19"	3	S. Steel	2300-29	17'		
	15-1/2"	18"	3	Alum.	230			
	14-1/2"	17"	3	Alum.				
Black Max Props	14-1/2"	17"	3	S. Steel				
Thrust Hub:	15-3/4"	16"	3	Alum.				
77987	15-1/4"	15"	3					
	14-1/2"	15"	3					

MerC

Propeller/Boat Matchup

Water Skiing

To take advantage of as much of the engine's horsepower as possible for pulling up water skiers, a propeller with a lower pitch should be selected. With higher initial engine RPM, more thrust is developed to pop skiers out of the water and get the boat on plane faster. Each 2" drop in pitch provides about 10% more thrust.

It's important that the operator watches the tachometer to make sure that the engine RPM does not continuously exceed the maximum specified full-throttle RPM without a skier. Propping the engine above the maximum specified RPM limit is called "under-propping".

Cruising

Since cruising does not require top acceleration, a little added fuel economy, less engine wear, and a lower sound level can be gained by selecting a higher pitched propeller. Here the engine can be propped out at the low end of the specified maximum engine RPM range. Most engines burn less fuel per horsepower at this lower RPM end than at the higher RPM end of the specified range. Here again the tachometer must be checked to be sure that, with a maximum load, the engine is not pulled below the bottom of the RPM range, or "over-propping" occurs. This can cause engine-damaging detonation.

One reason for getting better fuel economy is that propellers tend to have a slight increase in efficiency as the pitch is increased within a given prop line.

Bass Boating

Bass boats have become a very significant and very specialized breed. Designed to fit the every need of the serious fisherman, these boats tend to be narrow for their length, making them more difficult to plane off. This problem is further complicated by the considerable convience equipment carried and the weight of one or two filled live wells on the trip home. The result is that careful propping at the top of the RPM range is essential for best overall performance.

Sport Boating

When a compromise between wide-open-throttle speed and acceleration is needed, propping out in the upper half of the specified RPM range with a light load is suggested.

This should be the best prop, unless planing off with a heavy load is unsatisfactory, in which case dropping to the next lower pitch should solve the problem. But, again, it is important to watch top RPM.

Workboats

This specialized class of boats - such as pontoon boats and houseboats - use larger-diameter, low-pitch, lower-rake propellers with large blade surface areas. Here durability generally is more significant than top speed.

With lower water velocity, it is important to keep the propeller low in the water to avoid ventilation of surface air around the antiventilation plate via little whirlpools. It is imperative here to run the highest possible pitch that will satisfy all engine and usage requirements since the basic efficiency of low-pitch propellers is steadily dropping off as the pitch/diameter ratio declines.

What Is "Trim Angle" Of The Sterndrive?

Trim angle of stern drive is how far in or out from the transom surface the lower unit is tilted.

The trim angle of the lower unit has a distinct effect on the planing angle of the boat which, in turn, significantly alters top speed and handling.

What Is Power Trim?

Trimming can be controlled far more conveniently by Power Trim which is standard on MerCruiser Stern Drives. Power Trim permits control of the angle of the drive unit relative to the transom merely at the touch of a button. While on plane, the angle of the boat bottom to the water has much to do with maximum top speed, fuel economy, handling and choppy water ride.

Boat bottoms have the least drag at an angle of from 3° to 5° with the water. If they run flatter than 3°, as most light planing boats tend to do, or steeper than 5°, as stern-heavy boats just barely on plane may do, efficiency suffers.

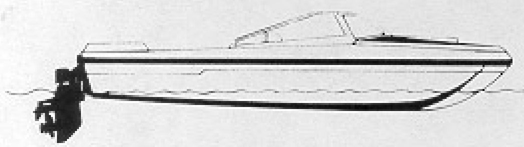
Trim Angle And Its Effect On The Boat

If trimmed "In" too far (Figure 1): Top speed drops, fuel economy decreases, the boat may oversteer in one direction or the other, called "bow steering", and steering torque will increase. Occasionally, extreme trim "under" can cause a boat to list badly to the left (with right-hand prop).

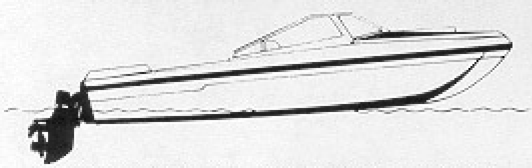
Getting on plane should be easier with some V-bottom hulls. The ride in choppy water, on plane, at part throttle should be smoother.

If trimmed "Out" too far (Figure 1): Propeller may lose its hold on the water; fast V-bottom may start to "walk" from right to left to right, etc; steering torque will increase in the opposite direction to that when trimmed "In" (Figure 1), and getting on plane may be difficult or labored. Porpoising of the boat may also occur.

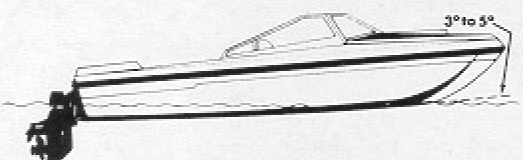
It is not considered wise to operate on plane when trimmed beyond the maximum "trim" position, as the drive unit no longer receives side support from the gimbal ring. Severe damage could occur if the lower gear housing should strike a submerged object.



BOW TOO LOW — TRIM DRIVE UNIT "OUT"



BOW TOO HIGH — TRIM DRIVE UNIT "IN"



DRIVE UNIT PROPERLY TRIMMED

Figure 1

How Does Trim Angle Affect Steering Torque?

When the propeller is run fully submerged and with the propeller shaft approximately horizontal (parallel) to the surface of the water, as shown in Figure 2, there should be little (if any) steering load. Although this also applies to stern drives, there are other complications due to a stern drive's tilted steering axis which can independently cause steering torque.

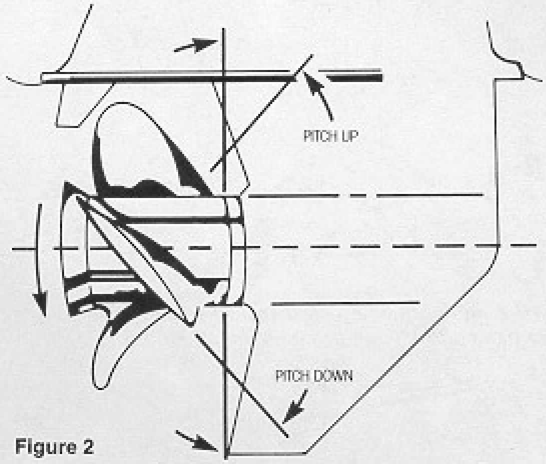


Figure 2

However, with the drive unit (RH rotation propeller) trimmed "in", as in Figure 3, because of the propeller shaft tilt, the downward-moving blade on the right side of the propeller shaft has effectively more pitch, while the opposite is true of the upward-swinging blade on the left side. This right/left imbalance pulls the drive unit to the right and, thus, makes the boat want to go into a right-hand turn. Naturally, the driver must resist this force if the boat is to continue in a straight line.

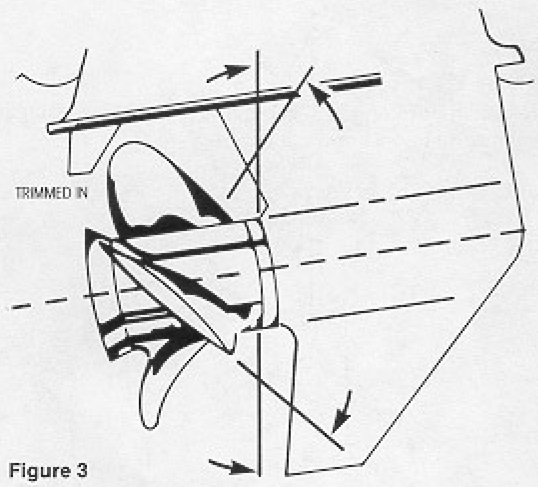


Figure 3

Figure 3 depicts the lower gear housing and propeller of the trimmed "In" drive unit as viewed from the surface of the water. Notice that the propeller blade on the right side produces more thrust than the blade on the left (indicated by different-size arrows), and that the boat is actually being pulled into a right turn.

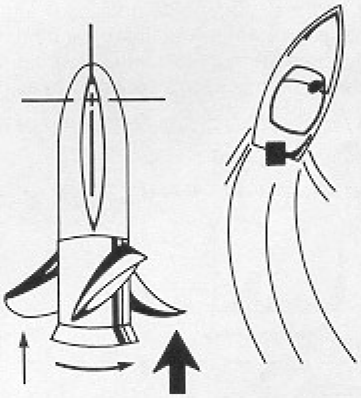


Figure 3

The entire situation reverses when the drive unit is trimmed "out" well past horizontal (Figure 4).

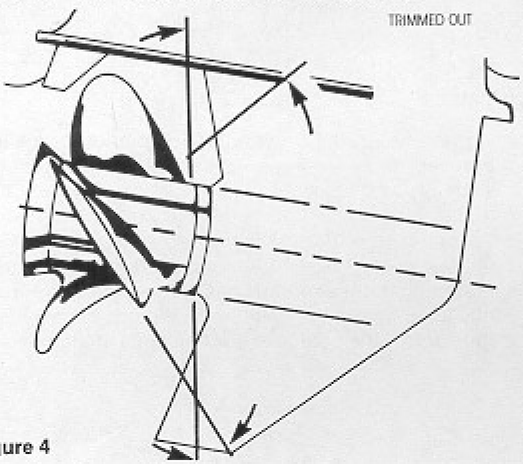


Figure 4

Now, the drive unit is pulled to the left, and the boats want to go into a left-hand turn (Figure 4).

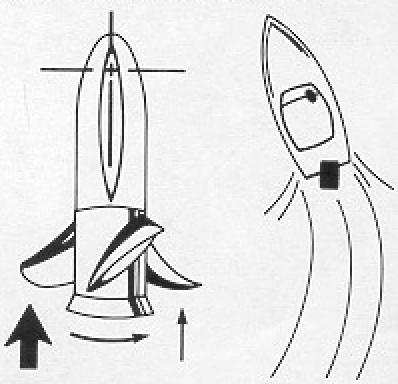


Figure 4

To help counteract this steering imbalance, all MerCruiser Stern Drives are equipped with an adjustable trim tab. Since the tab must be set in one selected position, the driver must choose the trim position that he desires to balance (Figure 5)

In most installations the drive unit will be operated in a slightly trimmed "Out" position. As explained previously, this will move the stern of the drive unit to the left, causing the boat to turn to the left. The trim tab, if properly adjusted, can steer the drive unit back in line, if in this case, the trailing edge of the trim tab is moved to the left as in Figure 5. For right-hand steering torque the opposite is true.

As a majority of MerCruiser Power Packages are equipped with Power Steering, the trim tab is set with its trailing edge straight back.

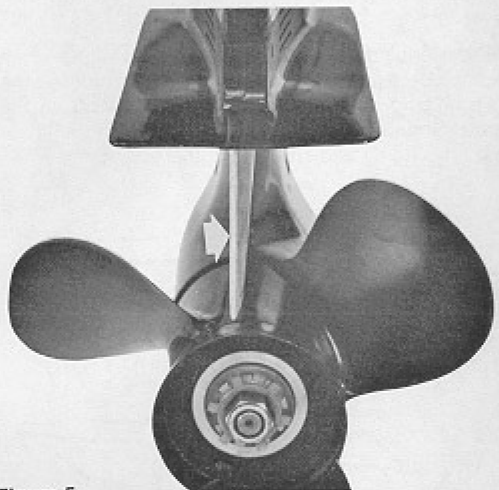


Figure 5

Evolution Of The Boat Bottom

FLAT BOTTOM

As the "V" (Figure 8) in a bottom is reduced to zero, the boat generally is referred to as a flat bottom (Figure 6). It may have squarish corners (chines) (Figure 6) or rounded corners (Figure 7). This hull shape now is far less popular than it used to be, as the ride, though potentially fast, is rather rough.

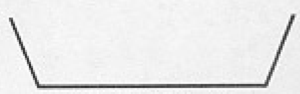


Figure 6

FLAT BOTTOM WITH HARD CHINE

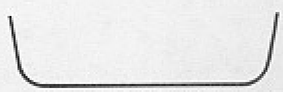


Figure 7

FLAT BOTTOM WITH ROUND (SOFT) CHINE

"V" BOTTOM

This is presently the most common bottom design (Figure 8), offering good speed with a soft ride that depends upon the angle of the "V" (called deadrise), the radius of the keel line, and the use of strakes. To increase top speed with only a little loss of softness in the ride, some boats are made with a small flat at the very bottom called a "pad" (Figure 8A).

Each boat manufacturer chooses how many and how far back (toward the transom) to bring each strake in order to achieve desired performance characteristics.

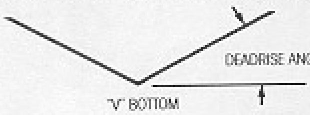


Figure 8

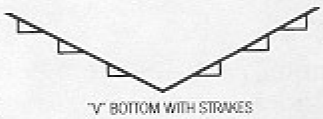
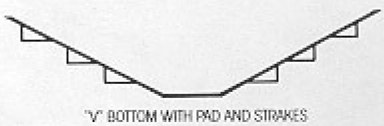


Figure 8A



TRI-HULL & CATHEDRAL HULL

These hulls usually are "V" bottoms with some degree of added outside hull, often most predominant near the bow (Figure 9). The benefit is a boat that is more stable, particularly at rest. The penalty is a rougher ride in choppy water.

Figure 9

TUNNEL BOTTOM

This is a rather new shape to come out commercially and is most popular in racing circles. It differs from the older catamaran bottom (Figure 10) in that the inside corners (between the bottom and the tunnel) are quite sharp (Figure 10A). This allows incredible sharp high-speed turns and a very soft ride. Some of these hulls have experienced handling problems at low speeds.

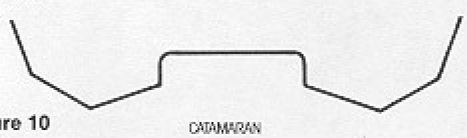


Figure 10

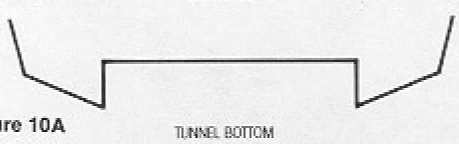


Figure 10A

TUNNEL VEE

The latest new shape (Figure 11) combines a shallow "V" bottom with twin tunnels, one on either side of center pad. Top-end performance is usually superior to true "V" bottom, but rough water handling characteristics are reduced.

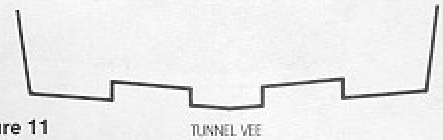


Figure 11

Is The Condition Of The Boat Bottom Important?

For maximum speed, a boat bottom should be as flat as possible in a fore-aft direction (longitudinally) for approximately the last 5 ft. (1.5m) (Figure 12). For best speed and minimum spray the corner between the bottom and the transom should be sharp.

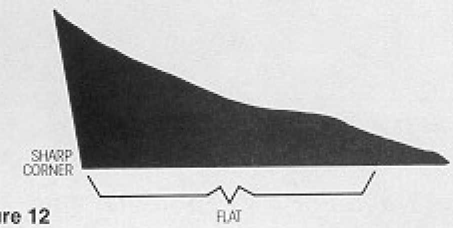


Figure 12

The bottom is referred to as having a "hook" if it is concave in the fore-and-aft direction (Figure 12A). A "hook" causes more lift on the bottom near the transom and forces the bow to drop. This increases wetted surface and reduces boat speed, but it helps planing and reduces any porpoising (rythmical bouncing) tendency. A slight "hook" is often built in by the manufacturer. A "hook" can also be caused by not trailering or storing the boat with support directly under the transom.

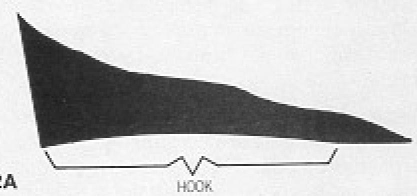


Figure 12A

A "rocker" is reverse of a "hook" (Figure 12B). The bottom is covex or bulged in the fore-and-aft direction. It can cause the boat to porpoise.

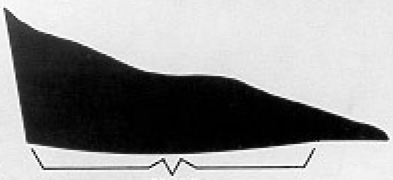


Figure 12B

Any "hook", "rocker" or surface roughness on the bottom, particularly in the all-important center-aft portion (Figure 13), will have a negative effect on speed, often several miles per hour on a fast boat.

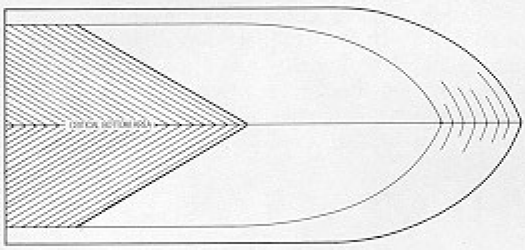


Figure 13

The Need For A Tachometer And Speedometer

The tachometer (Figure 14) measures engine RPM, while the speedometer (Figure 14A) measures boat speed in miles or kilometers per hour. An engine is designed to be run, when at wide-open throttle, within certain RPM limits. Without a tachometer, the operator has little opportunity to know if his engine is at a dangerously high or low RPM level. Once the correct propeller is selected the engine will run at wide-open throttle within the specified maximum RPM range. And deviation to this established W.O.T. RPM, other than that associated with climatic conditions, elevation, or gross load changes, is an indication of a performacne problem.

A speedometer, when used with a tachometer, also will give hints of engine or boat problems, should an unusual speed drop occur. With more experience, the combination of "tach" and speedometer can indicate problems at part throttle. For a good solid speed reading, it is important to install the speedometer pickup as low and close to the center of the boat as possible without creating water disturbance ahead of the propeller.

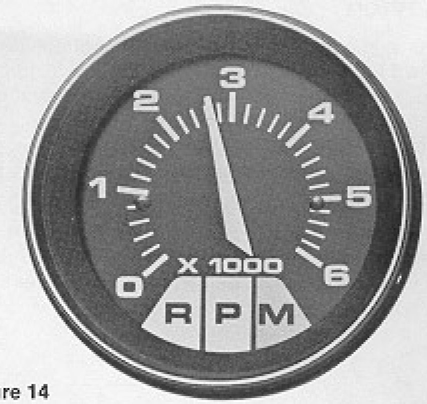


Figure 14

TACHOMETER MEASURES ENGINE REVOLUTIONS PER MINUTE.

Tachometer And Speedometers As Performance Indicators

For engineering tests extremely accurate and expensive tachometers are used. RPM information from these instruments provides unquestioned input for engineering evaluation. Tachometers commonly installed in boats are not intended to provide this same degree of accuracy. Therefore, a slight variance from the true RPM is common in these instruments.

The common type of boat speedometer consists of a Pitot tube, an instrument panel-mounted gauge which is calibrated to indicate miles per hour (MPH) and/or kilometers per hour (KPH), and the connecting tube or hose. The Pitot tube is usually mounted on the transom so that the lower portion of the Pitot tube remains submerged in undisturbed water when the boat is under way. The forward portion of the Pitot tube incorporates a hole which points toward the direction of travel. Some newer engine models have the Pitot tube built into the leading edge of the gear-housing strut.

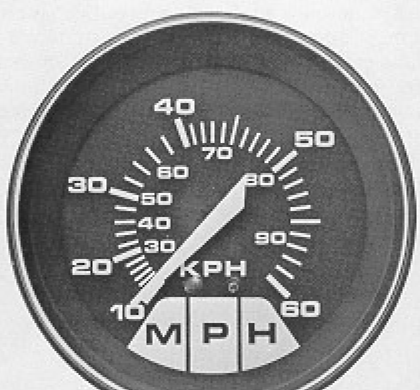


Figure 14A

SPEEDOMETER MEASURES MILES OR KILOMETERS PER HOUR.

As the boat moves forward, water enters the Pitot tube through this hole and compresses the air trapped within the connecting hose and the bellows or bourdon tube in the gauge. This air pressure, which varies in relation to the boat speed, actuates the needle movement mechanism indicating the speed of the boat. The accuracy of the speedometer may suffer from winter-freeze damage caused by trapped water in the line or instrument head, from a damaged Pitot tube, or from improper installation location. For engineering tests, common speedometers are rejected in favor of more accurate timing devices such as stop watches used on measured courses or radar speed indicators. The reason for explaining these variables is to prepare you for any unusual results that you may obtain in calculating your boat speed, propeller slip or angle of attack, when using the preceding or following equations.

How Does Elevation And Climate Affect Performance?

Elevation has a very noticeable effect on the wide-open throttle power of an engine. Since air (containing oxygen) gets thinner as elevation increases, the engine begins to starve for air, like using a supercharger in reverse. Humidity, barometric pressure and temperature do have a noticeable effect on the density of air. Heat and humidity thin the air. This phenomenon can become particularly annoying when an engine is propped out on a cool, dry day in spring and later, on a hot, sultry day in August, doesn't have its old zip. (See the accompanying HP/weather relationship chart, Figure 15.)

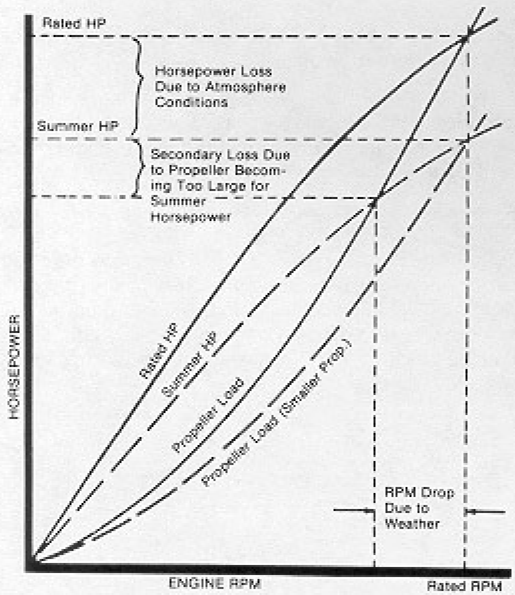


Figure 15

Although some performance can be regained by dropping to a lower-pitch propeller, the basic problem still exists. The propeller is too large in diameter for the reduced power output. The experienced marine dealer or a Quicksilver Propeller Repair Station can determine how much diameter to remove from a lower-pitch propeller for specific high-elevation locations. In some cases, a gear-ratio change to more reduction is possible and very beneficial.

It is a known fact that weather conditions exert a profound effect on power output of internal combustion engines. Therefore, established horsepower ratings refer to the power that the engine will produce at its rated RPM under a specific combination of weather conditions.

The marine engine rating code J1228 of the Society of Automotive Engineers (SAE) standardizes the computation of horsepower from data obtained on the dynamometer, correcting all values to the power that the engine will produce at 80.6° F (27° C) temperature, relative humidity 60% and a barometric pressure of 29.53 inches (750 millimeters) of mercury.

Summer conditions of high temperature, low barometric pressure and high humidity all combine to reduce the engine power. This in turn, is reflected in decreased boat speeds - as much as 2 or 3 miles per hour in some cases. (Refer to Figure 15.) Nothing will regain this speed for the boater, but the coming of cool, dry weather.

In pointing out the practical consequences of weather effects, an engine - running on a hot, humid summer day - may encounter a loss of as much as 14% of the horsepower it would produce on a dry, brisk spring or fall day. The horsepower, that any internal combustion engine produces, depends upon the density of the air which it consumes and, in turn, this density is dependent upon the temperature of the air, its barometric pressure and water vapor (or humidity) content.

Accompanying this weather-inspired loss of power is a second but more subtle loss. At rigging time in early spring, the engine was equipped with a propeller that allowed the engine to turn within its specified RPM range at full throttle. With the coming of the summer weather and the consequent drop in availiable horsepower, this propeller will, in effect, become too large. Consequently, the engine operates at less than its specified RPM.

Due to the horsepower/RPM characteristics of an engine, this will result in further loss of horsepower at the propeller with another decrease in boat speed. This secondary loss, however, can be somewhat regained by switching to a lower-pitch propeller that allows the engine to again run at specified RPM.

For boaters to realize optimum engine performance under changing weather conditions, it is essential that the engine be propped to allow it to operate at or near the top end of the specified maximum RPM range at wide-open throttle with a normal boat load.

Not only does this allow the engine to develop full power, but equally important is the fact that the engine also will be operating in an RPM range that discourages damaging detonation. This, of course, enhances overall reliability and durability of the engine.

What Are After Or Trim Planes And What Do They Do?

They are a pair of flat, movable surfaces that extend aft from the boat bottom, one on each side of center (Figure 16). Each surface is individually adjustable up or down and, on the more sophisticated installation, by a remote control switch.

After planes offer another method of trimming your boat,in addition to Power Trim. When a boat's running attitude exceeds 5°, it is beginning to run increasingly less efficient. Therefore, stern-heavy boats that need to run at a slow plane (20-25 MPH) will be greatly aided by after planes both in the efficiency and comfort departments.

Other benefits of after planes are: Faster planing, control of list and additional fuel savings made possible by allowing the boat to run at a lower engine RPM while remaining in an efficient planing attitude.

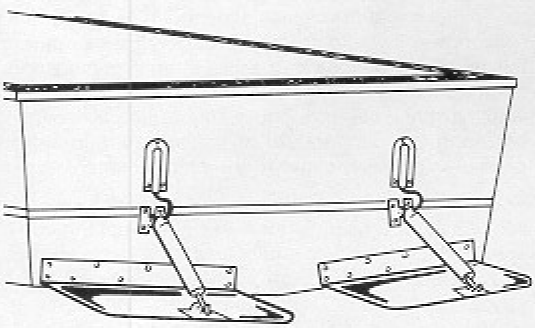


Figure 16

What Does A Chipped Or Bent Propeller Do To Boat Speed?

Even slight propeller damage can mean the loss of one MPH. Greater damage can mean considerably more speed loss. Worse yet, damage usually is not done to each blade uniformly and, therefore, sets up imbalance vibrations that can cause fatigue damage to other parts of the engine or drive.

Up to a point, dealers can have a propeller restored to like-new condition; however, extreme damage can be more expensive to repair than the cost of a replacment. Remember to carry a spare!

How Does Weight Distribution Affect Boat Performance?

Weight distribution is extremely important; it affects a boat's running angle or attitude. For best top speed, all movable weight — fuel, battery, anchor, passengers —should be as far aft as possible (Figure 17), to allow the bow to come up to a more effecient angle (3° to 5°). But on the negative side of this approach is the problem that, as weight is moved aft, some boats will begin an unacceptable porpoise.

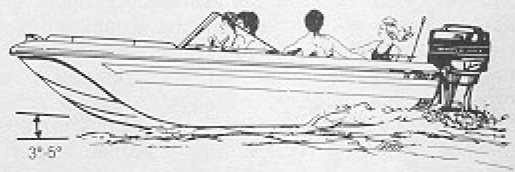


Figure 17

Secondly, as weight is moved aft, getting on plane becomes more difficult.

Finally, the ride in choppy water becomes more uncomfortable as the weight goes aft. With these factors in mind, each boater should seek out what weight locations best suit his needs.

Weight and passenger loading placed well forward (Figure 17A) increases the "wetted area" of the boat bottom and, in some cases, virtually destroys the good performance and handling characteristics of the boat. Operation in this configuration can produce an extremely wet ride, from wind-blown spray, and could even be unsafe in certain weather conditions or where bow steering may occur.

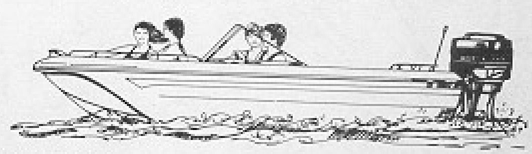


Figure 17A

Weight distribution is not confined strictly to fore and aft locations, but also applies to lateral weight distribution (Figure 17B). Uneven weight concentration to port or starboard of the longitudinal centerline can produce a severe listing attitude that can adversely affect the boat's performance, handling ability and riding comfort. In extreme rough water conditions, the safety of the boat and passengers may be in jeopardy.

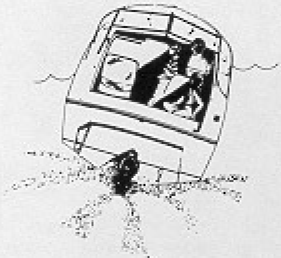


Figure 17B

Performance/Maintenance

What is Ventilation?

Ventialtion occurs when air from the water's surface or exhaust gases from the exhaust outlet are drawn into the propeller blades (Figure 1). The normal water load is reduced and the propeller over-revs, losing much of its thrust; however, as the propeller momentarily over revs, this brings on massive cavitation which can further "unload" the propeller and stop all foward thrust. It continues until the propeller is slowed down enough to allow the bubbles to surface. This action most often occurs in turns, particularly when trying to plane in a sharp turn or with an excessively trimmed-out engine or drive unit.

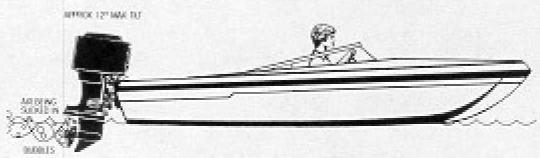


Figure 1

Stern drive units are designed with a large "anti-ventilation" plate cast integrally into the lower gear housing directly above the propeller (Figure 2). This plate is frequently and incorrectly referred to as a "cavitation" or "anti-cavitation plate". The purpose of this plate is to eliminate or reduce the possibility of air being sucked into the tips of the propeller blades from the surface.

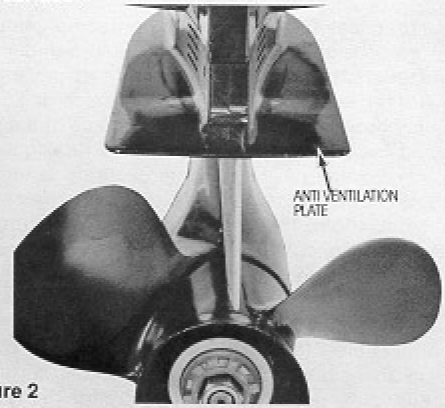


Figure 2

For improved engine and boat performance, most Quicksilver props feature a hub design with a flared trailing edge or "Diffuser Ring". This assists exhaust gas flow and provides a pressure barrier that helps prevent exhaust gases from feeding back into the blades (Figure 3). This design is vital to our Jet-Prop exhaust propeller system to get the maximum performance.

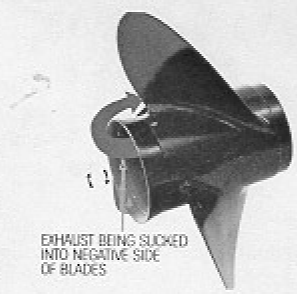


Figure 3

High-Speed Gearcase Blowout

Many high-performance boaters are aware of a phenomenon that limits their top speed below what would otherwise be possible with the available horsepower. This phenomena is commonly called "gearcase blowout" or just "blowout". Following is an explanation of why blowout occurs and how to correct it.

To be practical, the torpedo of a nonracing gearcase must be of a diameter and length just sufficient to house the shafts, gears, bearings, shift mechanism and a few other related parts. Hydrodynamics designers can only hope to make the exterior shape of the gear housing the best they can (within their design constraints) to deter cavitation from occuring at the torpedo nose or any surface interruptions, such as a lubricant filler hole. Inevitably, as speed is increased, cavitation will occur. Since low pressure is the cause of cavitation, anything that further reduces the pressure on any side of the torpedo will hasten cavitation. Trimming the unit out will cause lower pressures on the underside of the topredo, around the skeg, but an even more insidious culprit is the effect of a surfacing propeller pulling the aft end of the torpedo to the right with a right-hand rotation propeller. This causes lower pressure on the left side because of the angle which the gearcase is forced to run through the water. This is commonly called the "crab" angle (Figure 4).

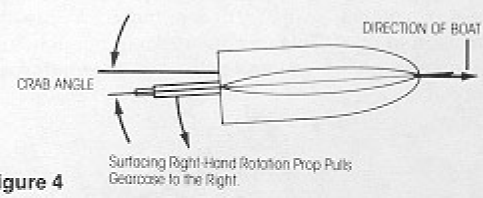


Figure 4

The typical combination of a surfacing right-hand propeller and trimming out for best speed creates an extra-low pressure pocket on the lower left side of the torpedo.

However, cavitation in itself does not cause the "blowout". Blowout occurs when the very low pressure cavitation bubbles eventually reach back to the aft end of the torpedo in sufficient quantity to suddenly pull in, or connect up with the engine exhaust gases. The cavitation and exhaust gas linkup are more prevalent with a Nonjet-Prop exhaust propeller.

Once the connection is made, the exhaust floods out over the low-pressure side of the gearcase (the left side with a right-hand rotation propeller) and feeds back into the prop blades, causing a sudden and drastic reduction of lift or thrust generated by the low-pressure side of the propeller blades. This partial unloading of the propeller creates four sudden reactions: (1) The bow-lifting effect of the rake diminishes, causing the bow to drop. (2) The hard steering torque to the right is suddenly reduced, causing the boat to veer slightly to the left. (3) The reduced, load on the propeller allows the engine to rev up by 200 RPM to 300 RPM, and (4) the wetter boat bottom and reduced propeller efficiency cause the boat to go slower by perhaps a couple of miles per hour.

Gearcase design with regard to this problem has generally been improving, but you may wish to try a trick or two. There are nose-cone kits on the market that help by adding more rudder area which reduces the "crab angle" and provides a larger torpedo nose radius which reduces nose cavitation. However, the nose cones are a bit of a chore to install and may be easily damaged. Other than running with excessive trim "Out", the most significant cause of blowout is a torpedo that has been buffed in a way that rolls off the trailing edge of the torpedo (Figure 5)

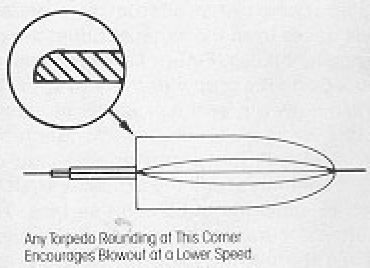


Figure 5

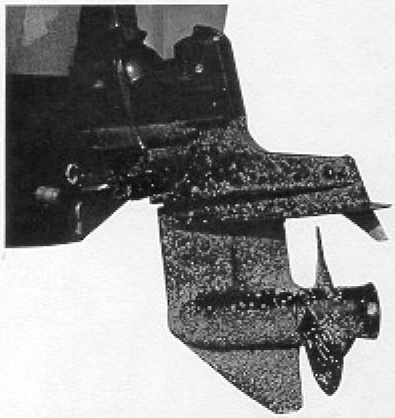
More recently cupping, bending, or adding material to the trailing edge of the skeg to the right (starboard) both helps raise "blowout" speed and reduces steering pull.

What is Marine Fouling?

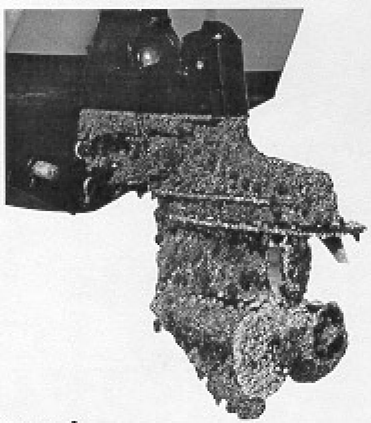
Fouling is a kind of unwanted buildup (usually animal-vegetable-derived) occurring on the boat's bottom and drive unit. Fouling adds up to drag, which reduces boat performance. In fresh water, fouling results from dirt, vegetable matter, algae or slime, chemicals, minerals and other pollutants. In salt water, barnacles, moss and other marine growth often produce dramatic build-up of material quickly. So it's important to keep the hull as clean as possible in all water conditions to maximize boat performance.

Special hull treatments, such as antifouling paint, will reduce the rate of bottom fouling. However, due to the fact that drive units are made primarily of aluminum, be sure to select an antifouling paint having a copper-free, organo-tin base. The BIS (Tri Butyl Tin) Adipate (TBTA) base paint will not set up a galvanic corrosion "cell" as it is completely compatible with aluminum and avoids any electrolysis problems connected with many other paints. Applied according to instruction, it is also very effective.

Florida test site photographs indicates the rapid growth of barnacles, algae and slime. Buildup should never be allowed to reach the stage in Figure 6, which would alread by extremely difficult to remove.

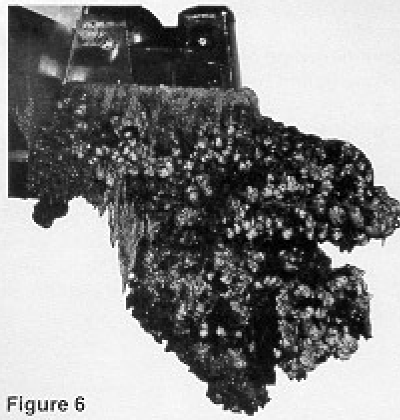


TWELVE DAYS EXPOSURE



THIRTY-SIX DAYS EXPOSURE

Figure 6



THREE AND A HALF MONTHS EXPOSURE

Figure 6

What is Cavitation?

We all know that water boils at 212° F (100° C) at normal sea-level atmospheric pressure. But water also boils at room temperature, if the atmospheric pressure is low enough.

As a shape passes through water at an increasing speed, the pressure, that holds the water to the sides and back of the shape, is lowered. Depending upon the water temperature, when the pressure reaches a sufficiently low level, boiling will begin. This occurs most often on a propeller at the leading edge of the blade. When speed is reduced and the pressure goes up, boiling will subside. As the water vapor bubbles move downstream into a higher pressure region that won't sustain boiling, they collapse (condense back to liquid). The collapsing action of the bubbles releases energy that chips away at the blades, causing a "cavitation burn" or erosion of the metal (Figure 7).

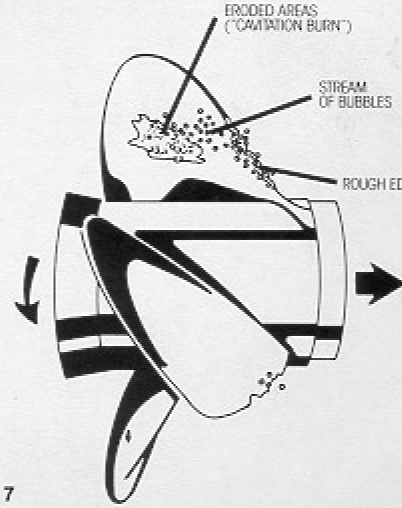


Figure 7

The initial cause of the low pressure may be nicks in the leading edge, too much cup, sharp leading edge corners, improper polishing or, sometimes, poor blade design. Massive cavitation by itself is rare, and it usually is caused by a prop that is severly bent or far too small in diameter for the engine.

Figure 8 depicts the cross section of a propeller blade which shows an example of one cause of cavitation. In this example, a sharp leading edge produces cavitation and resultant cavitation burn as the bubbles condense further back on the blade face. Such a cavitation burn can usually be corrected by repairing or rounding off the leading edge directly in front of the burn.

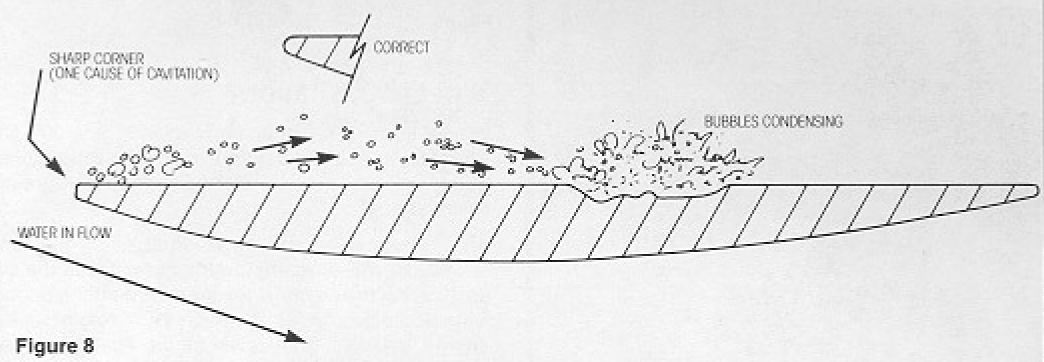


Figure 8