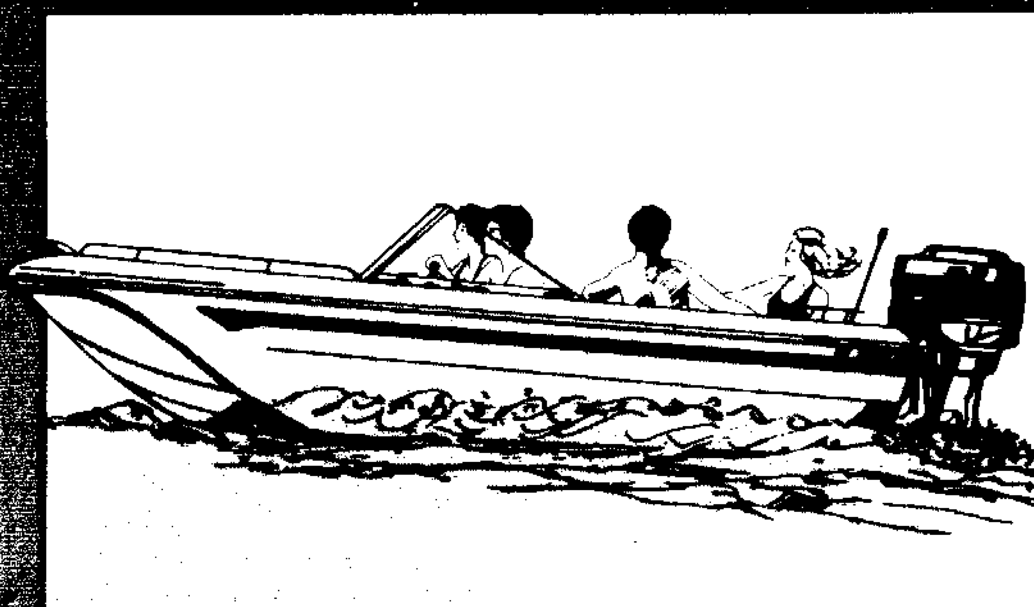
REDUCING FUEL COSTS:

A Guide for Recreational Boating



SPECIAL SECTION: *The Dangers of Unleaded Fuel*

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A Guide for Recreational Boating

Ryck Lydecker

Produced by the University of Maryland Sea Grant Extension Program in cooperation with the Energy Administration, Energy Extension Service of the Department of Natural Resources.

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Introduction

Maryland, with some 148,000 registered pleasure boats, ranks among the top boating states in the nation. Inboard engines, stern drives or outboards power a large percentage of that fleet while many sailboats make use of inboard or outboard auxiliary engines.

More than a decade has passed since the "gas crunch" shocked boaters and motorists alike, pushing gasoline, and then diesel fuel, to well over a dollar a gallon. We may be used to price fluctuations now, but a 1985 survey by the Maryland Sea Grant Extension Program revealed that boaters are concerned about fuel consumption and that they wanted information to help them save fuel and use their boats more efficiently.

Approximately 75% of Maryland registered boats are under 20 feet in length; a large number are outboards or stern drives kept on trailers or in dry storage. Motor fuels, particularly gasoline, are important ingredients in boating today. And *Reducing Fuel Costs: A Guide for Recreational Boaters* can help you get more out of every gallon.

The success of this guide depends on you. While it cannot solve specific problems for individual boats since combinations of engine, propeller, and hull are almost infinite, it will show you where to look for fuel savings in your equipment and will make you more conscious of operating habits that affect fuel consumption.

And for every boater the last section on coping with the shift to unleaded gasoline, "Caution! Unleaded Fuel," should prove informative and helpful in preventing possible equipment damage and even fire hazards.

So whether you are cruising the Eastern Shore, pulling water skiers on Deep Creek Lake, trolling in the shadow of the Bay Bridge or powering into a stiff head wind on the Patuxent River with all sails furled, you should find vital information in these pages to help get the most out of your boat.

Contents

Fuel Consumption Factors

How efficiently a boat uses fuel — whether a power boat or a sailboat under power — and what you can do to improve its efficiency is directly affected by three major factors:

- Resistance of the hull passing through the water.
- Degree of efficiency in the engine/drive/propeller system.
- Operation and handling of the boat underway.

Each of these factors has its own influence, to a greater or lesser degree, at various stages during an outing. For example, the popular, fast planing hull with stern drive, whether ski boat or small family cruiser, will not operate at its most fuel-efficient performance level while running at low speed. At low speed the fast planing hull experiences high resistance, while the propulsion system, particularly the propeller, operates at its least efficient level. The fuel consumption ratio would be high because the hull is designed for skimming over the water, rather than plowing through it, and the propulsion system is designed to get the boat up on top of the water and keep it at planing performance.

A large displacement-hull cruiser operating at high speed, on the other hand, may squander fuel because of the extra power required to push the boat beyond its hull speed, the optimum speed through the water as determined by hull dimensions. (See Appendix 1.) While this cruiser might be equipped with plenty of horsepower to cope with heavy weather, running it at three-quarter throttle may enable the boat to slip through the water with better fuel efficiency.

Either boat, however, could burn excessive fuel under any of the following conditions:

- If overloaded, requiring more power to either plane or reach hull speed
- If improperly trimmed, that is, moving at an angle to the water that increases resistance
- If running a meandering course and changing speed frequently
- If failing to take wind and tidal current into account during a trip.

In the chapters that follow we will discuss hull resistance, propulsion efficiency and boat operation and suggest ways to get more from your fuel dollar by considering how to opitimize these factors in your own boat.

The Hull

Types of Resistance

Once underway, your boat pushes water ahead and aside, creating a relatively large bow wave and a big "hump" in the wake just behind the transom. The bow wave and hump are components of residuary resistance. This resistance is any force, other than direct friction against the hull, that retards the boat's motion. Frictional resistance is the drag created by water passing under and along the sides of the boat.

Three factors determine frictional resistance: total hull area in contact with the water (called "wetted surface"), boat speed at any given time (greater speed means greater resistance), and condition of the hull. As speed is increased, frictional resistance is the primary component working against a planing hull.

A stern drive planing hull at low speed acts as a displacement hull, moving most of its mass through the water, not over it. In this condition, residuary resistance is the primary factor working against the hull.

A displacement cruiser, however, is designed to minimize this resistance and, generally speaking, a long, slim hull will slide through the water more easily than a short, beamy boat. The cruiser, in fact, actually may generate a smaller bow wave and wake hump at this slow speed than a planing hull of similar size.

Another component of residuary resistance that affects boats, although usually to a lesser degree in small pleasure craft, is called eddy resistance. This resistance is caused by the motion of water around various parts of the hull such as the skeg, shaft, propeller and through-hull fittings. As the name implies, it is a swirling effect that creates additional drag.

Resisting Resistance

Any measures you can take to reduce residuary, frictional or eddy resistance generally will translate into fuel savings. It's that simple. Running at optimum speed for the type of hull is an obvious measure. And for most boats, maintaining the condition of the hull is another.

Dedicated sailboat racers, for example, spend long hours sanding their hulls and fairing depressions and irregularities so that the surface presented to the water will be as smooth as possible.

A smooth hull can also reduce fuel consumption in a powerboat. For a wooden boat, this may mean taking pains to smooth out the seam compound, fill gouges in the planks and fair out any areas that may have been repaired crudely. For a fiberglass hull, this could mean repairing surface cracks or gel coat blisters. For an aluminum boat, it may require stiffening the hull to prevent distortions from developing in the bottom when underway.

For any boat, maintaining a smooth bottom means careful preparation of previously painted underwater areas. Rough or scaly bottom paint can create resistance; new paint should be applied evenly, without runs or sags. As insignificant as such imperfections may seem, they can add up and cause drag and wasted fuel.

Hulls must also be kept clean and free of marine growth. Even on a small boat, weeds or a crop of barnacles can make a significant difference in performance and in fuel consumption. According to some estimates, six months accumulation of marine growth can double a boat's fuel consumption.

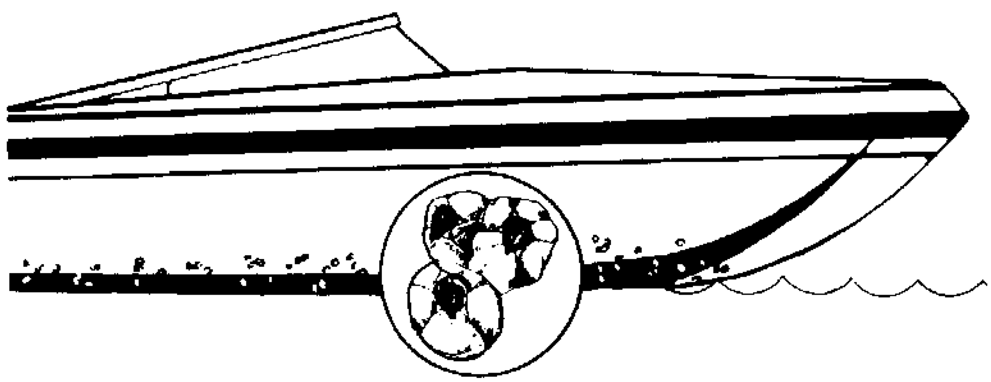


Figure 1. A fouled hull creates excess drag and wasted fuel.

While typical antifouling paints are worth the investment, even for fresh or brackish water, there are now bottom coatings on the market that claim to reduce resistance. Among them are self-polishing antifouling paints that gradually smooth-off as the boat passes through the water, thus removing "high spots" in the finish that add to resistance.

Other friction-reducing coatings — they are marketed under different trade names — purportedly give the bottom a more "slippery" surface when wet, thereby reducing friction.

The Fouling Season

This chart represents typical coastal water temperatures by month, in Fahrenheit degrees. Fouling organisms flourish in temperatures above 48° F.

Area	Lat. North	J	F	M	A	M	J	J	A	S	O	N	D
Breakwater, Delaware	38	39	38	44	50	60	69	74	73	71	63	52	43
Solomons, Maryland	38	39	38	44	53	65	75	80	80	75	66	55	43
Kiptopeke, Virginia	37	42	44	47	57	66	75	79	79	75	65	53	46
Old Pt. Comfort, Virginia	37	43	43	48	57	67	75	80	79	75	66	55	45

No claim can be made here for the effectiveness of these products but they should be worth considering when and if independent test data become available.

Performing a Check-up

One easy way to check the condition of your hull, particularly for larger vessels kept in the water most or all of the time, is through a deceleration test. If you do this periodically during the season, keeping a log of the results, the test will indicate when hull drag is increasing, a consequence usually caused by marine growth.

To perform a deceleration test, simply record the time that it takes your boat to stop dead in the water once you cut the power. Remember that you must duplicate as nearly as possible the same conditions each time. This means that such factors as wind, sea conditions (don't forget tidal current) and load should be consistent, and that the engine is run at the same speed (RPM) during each test. For any real degree of accuracy, your engine will need a tachometer. A deceleration test chart is provided in Appendix 2.

Get the Most from Your Motor

With regard to fuel economy, marine engines are no different than automobile engines. The first rule is keep your boat's engine running at peak performance. But for a boat engine, there are a few special and important considerations.

Outboard Engines

The modern outboard motor, compared with the motor of a decade ago, is a marvel of fuel efficiency. Today's outboard delivers more power for its weight than comparable inboards or stern drives. But it is important to remember that for optimum fuel performance, an outboard should be roughly 25% larger (more powerful) than a given boat actually requires. This is because an outboard burns fuel most efficiently at 65% to 80% of full power.

Most two-cycle outboards today burn gas-to-oil mixtures at ratios of 50:1 or 100:1, thereby using considerably less oil than the 24:1 or 16:1 ratios common years ago. What this means for today's boater is not only less expense for oil but, because of more efficient combustion, longer-lasting plugs and less carbon build-up.

Some contemporary outboards use oil injection systems that vary the amount of oil in the fuel according to engine speed, resulting in even better combustion. Major improvements in outboard ignition systems also provide improved fuel consumption, easier starts and better performance.

One means for improving fuel economy in an older outboard boat is to upgrade to a newer, and perhaps larger, engine. Yet not every boater will feel this major investment is worthwhile or desirable. Certain racing class boat enthusiasts as well as owners of antique and classic small craft may opt to stay with older models. Proper tuning, attention to accurate gas/oil mix and frequent plug cleaning may be all that is necessary to get the best possible fuel economy.

Inboard and Stern Drive Engines

Beyond the obvious maintenance and tune-up attention that any engine should have, the marine gasoline engine deserves a few special considerations. For one thing, unlike motor vehicle engines, marine powerplants operate under constant load. (A commonly heard analogy is that a marine engine operates like a car running constantly uphill in second gear.)

Marine engines are not subject to the emissions controls required for motor vehicles. Richer fuel/air settings can be used and compression ratios may be higher. Therefore, do not assume that a marine conversion of an auto or truck engine is tuned exactly as its land-based counterpart. The carburetor may have to be modified substantially or replaced by a different one. Moreover, different spark plugs may be required. Using the wrong plugs can waste as much fuel as worn plugs. Cleaning and gapping the plugs before, during and after the season can also help a great deal. (Be sure your operator's manual covers the marine conversion, not the automotive equivalent.)

One item sometimes overlooked in marine engine maintenance is the flame arrestor on the carburetor. It should be cleaned frequently, as often as every month during the season, not only for safety's sake, but to insure optimum fuel economy. A dirty flame arrestor can waste as much fuel as a sticking choke.

As with outboard motors, manufacturers have made great strides in improving the fuel efficiency of modern inboard and stern drive engines by packing more power in compact, lighter engines. Repowering, then, is always an option to consider for older boats.

A Note on Replacement Parts

Although many boat engines are marine conversions of car and truck blocks, don't assume that automotive replacement parts will work as well as marine versions. In fact, they may be dangerous if used in a boat.

Marine carburetors are internally vented and marine fuel pumps are vented back to the intake manifold or carburetor to keep all fumes going into the engine, rather than into the engine compartment. Marine electrical system components are ignition protected, meaning that they are designed so that a spark inside the device cannot ignite gasoline vapors that might be in the surrounding air.

Remember that standard automotive replacement parts have no such protections. They should be avoided, even though they may be cheaper and more readily available in parts stores and junkyards.

Propulsion — Getting Down to Business

The business end of a powerboat is its propulsion system, the drive train and propeller. The propeller is crucial to performance. No matter how precision-tuned the powerplant may be, the boat cannot deliver optimum fuel economy — nor even operate properly — with a mismatched propeller. It is the propeller that determines how much actual horsepower is delivered to move the boat.

The Propeller

For outboard motors, the prop that comes with the engine is generally the best all-around match for average use; however, if you use your boat primarily for a single activity, water skiing for example, you may want to consult your marine dealer for advice on the best prop to use.

As a general rule for planing hulls, assuming you have the proper engine, your fully-loaded boat should be able to get up on plane easily and stay there, even at reduced throttle. You should be able to operate the boat in the middle or upper half of the manufacturer's specified full-throttle speed range. If your motor operates below that range, or only at the upper limit, you are probably running the wrong propeller and you should consult your dealer.

Remember, the wrong propeller may not only waste fuel, it can also overload and damage your engine. This applies to inboard and stern drives as well as outboards.

Cavitation

Cavitation is the formation of a low pressure void behind the blades of a spinning propeller. It occurs when the prop's trailing edges lose contact with solid water. (Technically, water is discharged from the prop faster than its suction can replace it.) Cavitation can result from using the wrong propeller and it may lead to severe prop damage plus wear and tear on the engine and drive system. A damaged prop or one too small for the job can cause cavitation, too, as can ventilation, the momentary sucking of air in from the surface.

Because cavitation sets up a pressure differential between leading and trailing edges of the prop, water vaporizes instantaneously, then condenses into explosive little droplets that literally chip away at the blade surface, resulting in "cavitation burn."

Cavitation can be an extremely destructive fuel waster and you should inspect your prop frequently for its signs. If the problem is chronic, consult your marine dealer or the manufacturer.

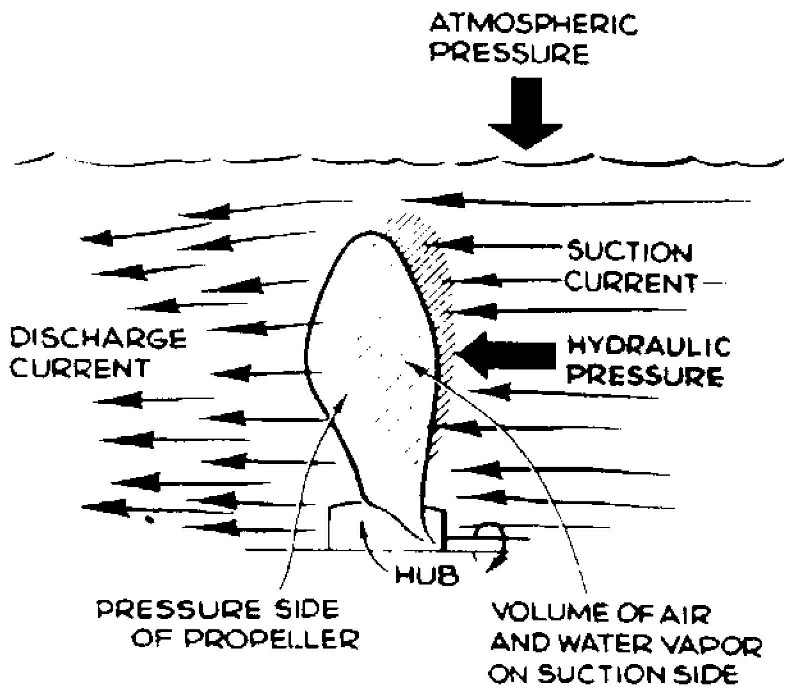


Figure 2. Cavitation occurs when the forward faces of the blades of a fast-revolving propeller lose contact with "solid" water. This occurs when water is pushed astern in the discharge current faster than the suction current can replenish it.

Propeller Maintenance

It is wise to check your propeller often during the season because even minor nicks and dents can affect its performance and, thus, fuel economy. If your boat's performance changes substantially, you might want to have the prop checked. A propeller shop can check the pitch to be sure none of the blades have been knocked out of line.

Here again, modern technology will repay the boater who wants to upgrade. Stainless steel and teflon-coated propellers have been shown to boost speeds by as much as three miles per hour which translates to increased fuel-to-distance ratios or greater fuel economy.

Electrolysis

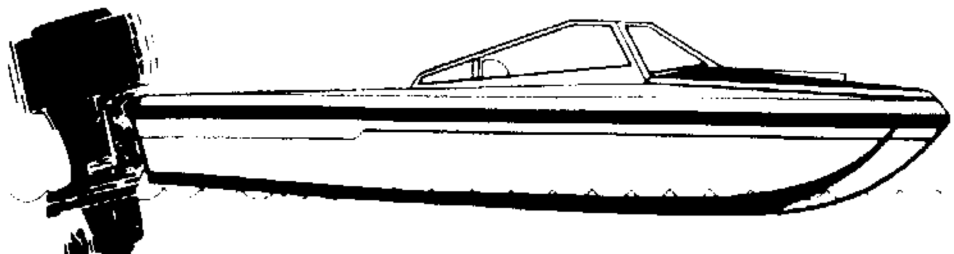
Outboard motor and stern drive lower units, like all submerged metal parts of a boat, are subject to a phenomenon know as electrolysis or galvanic corrosion. This is an electrochemical reaction between dissimilar metals connected or grounded through water. It is worst in salt or brackish water but can be a problem in polluted freshwaters, too.

During electrolysis, one of the metals is actually eaten away by the reaction. Many manufacturers install pieces of zinc — called sacrificial anodes — on the lower unit to absorb electrons. These should never be painted and should be inspected frequently and replaced when they deteriorate, or the reaction may begin corroding the propeller or lower unit.

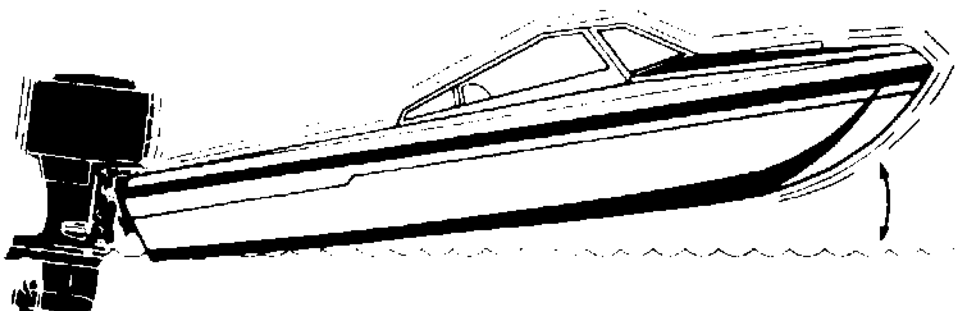
Trim and Tilt

Once you determine that the propeller is the correct diameter and pitch, check the boat's trim and tilt adjustments. The adjustable trim angle of the stern drive unit or outboard motor allows you to run at its best angle for minimum resistance and optimum fuel economy.

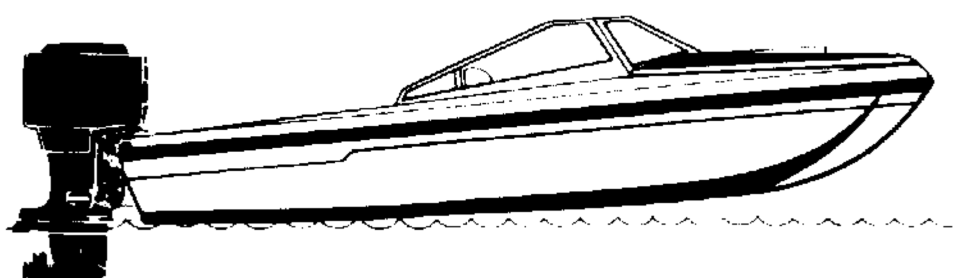
With the trim set too high, the boat will nose down and tend to "plow" but if set too low, it will squat; either way, poor trim will waste fuel. For small outboards, trim is set manually on the motor bracket before starting out. Large outboards and stern drives, however, often have hydraulic units that allow the operator to adjust trim underway, varying the angle for speed and load.



Bow of boat is too low.



Bow of boat is too high. (Boat bottom 6° to water.)



Bow/engine is properly trimmed. (Boat bottom 3° to water.)

NOTE: Although the engine is depicted as being in the best running angle with the antiventilation plate parallel to the boat bottom, this may not produce the optimum hull running attitude.

Figure 3.

The trim of inboard displacement and semidisplacement hulls is usually fixed, determined by the design. However, adjustable trim tabs can be attached to the transom of such hulls and sometimes fixed trim wedges are added on the bottom just under the stern. Trim tabs and wedges may also provide extra lift to the hull, thereby reducing resistance still more.

Outboard Installation

Whatever the age of an outboard, improper mounting will waste fuel. As a simple rule, the outboard on a pleasure boat should be mounted low enough so that the anti-

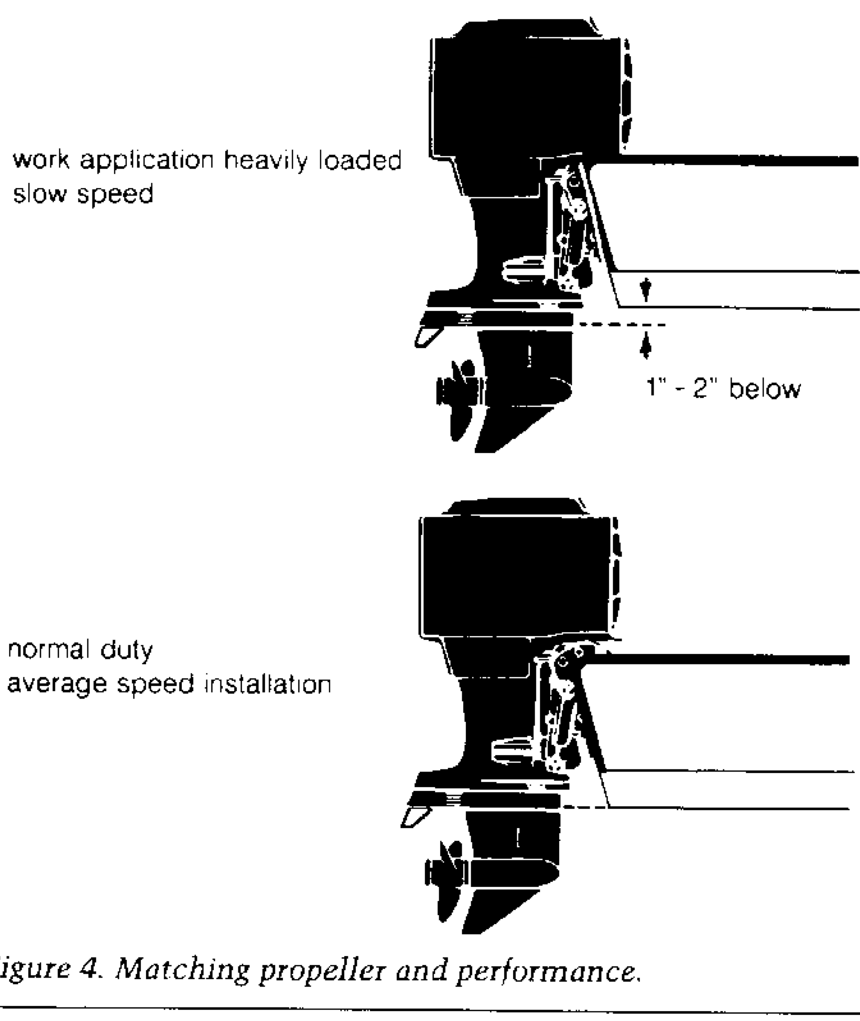
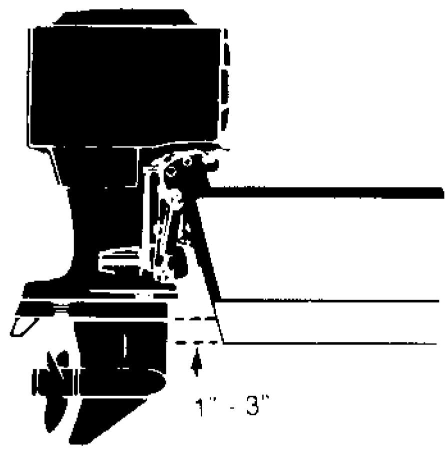


Figure 4. Matching propeller and performance.



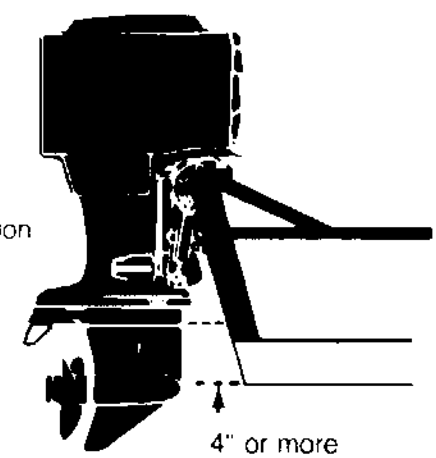


Figure 4, continued.

ventilation plate on the lower unit is even with the bottom of the hull, but no lower.

If the motor is set too low, the lower unit [gearcase] will create unnecessary drag. Yet, if the motor is set too high, the propeller may ventilate, that is, draw an air pocket or bubbles into the prop stream, leading to cavitation.

Boat Operation

The simplest, least expensive place to create fuel savings is at the wheel: fine tune your operating habits.

Throttle Back

Cutting speed will cut fuel consumption — it's that simple. Tests have shown that throttling back a planing hull boat 20% – 25% can cut fuel consumption as much as 50%. Once the boat is up on plane — and the quicker you get up, "out of the hole," the less fuel you'll burn — cut back to about two-thirds or three-quarter throttle so that you maintain the planing attitude comfortably with less power. You may be surprised at how little speed over the water is actually lost.

Watch Your Trim and Load

As discussed earlier, trim angle is an important factor in hull resistance. Therefore, once underway, adjusting the boat's trim can pay off at the fuel dock.

For a planing hull, the boat should ride with the bow slightly raised to minimize frictional resistance. If the motor is set too low, the lower unit (gearcase) will create unnecessary drag. Yet, if the motor is set too high, the propeller may ventilate, that is, draw an air pocket or bubbles into the prop stream, leading to cavitation.

A displacement hull should run at a speed that minimizes wave resistance. One way to check is to watch the "hump," the wave generated in the wake just aft of the transom. If the hump is a relatively large wave, try cutting power enough to reduce its size and you will be cutting resistance without sacrificing very much speed.

Perhaps surprisingly, load weight and distribution can add up significantly to affect fuel consumption. Look for ways to reduce what you carry aboard and distribute the load to trim the boat properly at cruising speed.

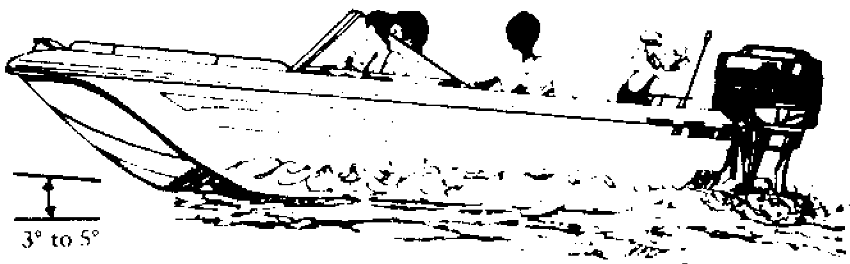


Figure 5A. Weight distribution affects a boat's running angle. For best top speed, all movable weight should be as far aft as possible to allow the bow to come up to a more efficient angle (3° to 5°). However as weight is moved aft, getting on plane becomes more difficult. Moreover, the ride in choppy water may become uncomfortable.

Figure 5B. Weight and passenger loading placed well forward increases the "wetted area" of the boat bottom and, in some cases, almost destroys good performance and handling characteristics; can even be unsafe in certain weather conditions.

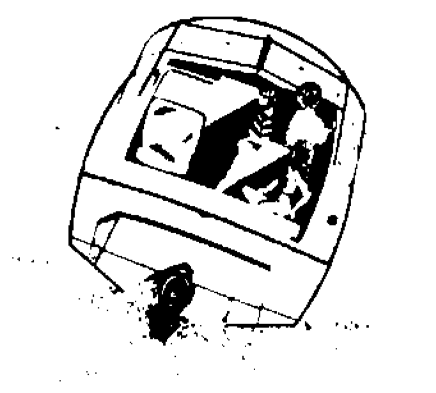


Figure 5C. Weight distribution also applies to lateral weight distribution. Uneven weight concentration to port or starboard of the centerline can produce a severe listing that can adversely affect boat performance.

Plan Your Trips

If you are heading for a specific destination, a favorite fishing spot or overnight anchorage, plan your trip. Take full advantage of tide, wind and current, if you can, or at least set a course that will minimize their adverse effects. Remember also that meandering, with frequent course changes, takes extra fuel; setting as straight a course as possible, taking wind, sea and safety into account, should save fuel.

Part of the pleasure of an activity like water skiing, however, is in the winding course and frequent turns. But here too you an save fuel if you get your skiier up out of the water quickly and throttle back to a fuel-saving speed. You might consider pulling more than one skier at the same time — if your boat can handle it — since once up, it takes little extra fuel to tow them. That saves on the number of fuel-consuming starts, too. (Remember to keep two people in the boat however, one to watch the skiiers and one to operate the boat. It's not only a good practice anywhere, it is state law in Maryland and both the operator and the observer must be at least 14 years of age.)

Some Thoughts about Sailboats

It has been estimated that sailboats on the Chesapeake Bay actually operate under power more than 40% of the time. That includes getting in and out of anchorages as well as powering home in a dead calm or out into a stiff head-wind. So, even in sailing there are some fuel savings to be gained. Here are a few things to consider.

Outboard Auxiliaries

Apart from the obvious, keeping your outboard auxiliary engine properly tuned and using the right propeller, sailboaters should be aware of potential problems if their engine is mounted in a lazarette or other enclosed space, rather than out in the open, for example, on a transom bracket.

Running an outboard in a closed up lazarette can mean that exhaust gases will collect around the top of the motor, diluting the air entering the carburetor and reducing engine efficiency, often without the operator noticing anything. This can also lead to mechanical problems later on.

Outboard compartments should be well ventilated — that may mean merely leaving the hatch open — to purge exhaust coming up out of the water from around the motor. While this can mean more noise in the cockpit, the potential benefits could be worth the minor annoyance.

Inboard Auxiliaries

Generally speaking, the remarks about inboard engines in powerboats (page 7) also apply to sailing auxiliaries. The growing concern about alcohol in gasoline as a replacement for lead is as much a problem for inboard auxiliaries as for powerboats and you should consult p. 21, "Caution! Unleaded Fuel."

To Spin or Not to Spin

One question often raised is whether to leave the auxiliary engine in gear or in neutral when under sail. With the motor in gear, the prop won't spin or "windmill" underway. In neutral, the prop will spin relative to the boat's speed.

Which condition has the least effect on underwater drag? Apparently, it doesn't matter: Tests by a major motor manufacturer have shown that the net affect on drag is the same either way, given the speed ranges that sailboats operate in. However, it is probably best to keep the unit in gear, rather than free wheeling, since the spinning shaft could accelerate bearing and seal wear, a potential for leakage.

Equipment for Saving Fuel

Tachometer

If your boat has a tachometer to measure engine speed (RPM), learn to use it to help you operate in the most fuel efficient range. Tachs can also be installed for most engines, including outboards.

A tach is important for an outboard because the ear can be deceptive in trying to judge engine speed; the only satisfactory way to be consistent in engine operation is to keep track of RPM. In addition, a tachometer can serve as an early-warning indicator of trouble, such as fouling plugs.

Speedometer

Using an accurate boat speedometer in conjunction with the tach can provide a simple method for determining your most fuel efficient running speed and the effects of other measures you take to cut fuel consumption.

Plot the boat's miles-per-gallon, much as you would for your car, and keep a performance log (see Appendix 3 for an example). Comparing fuel useage over time can indicate when a tune-up or a haul-out and bottom cleaning is necessary.

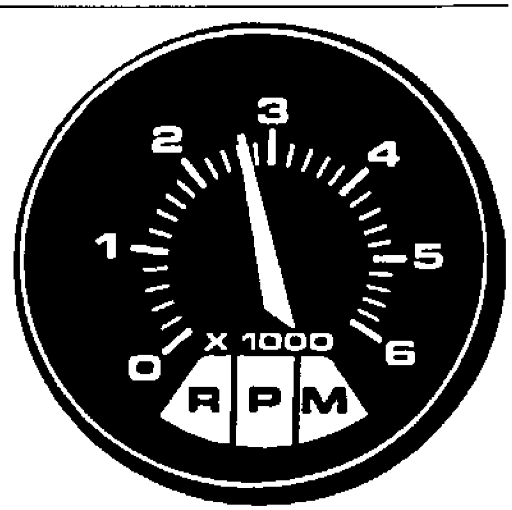


Figure 6. Tachometer measures engine revolutions per minute.

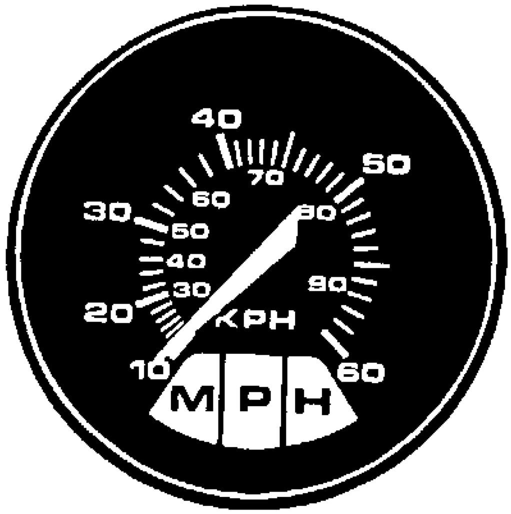


Figure 7. Speedometer measures miles or kilometers per hour.

Fuel Flowmeter

While fuel flowmeters that give a constant readout of fuel consumption underway were usually found only on large inboards in the past — they were expensive and required major installation — they are now becoming less expensive and more readily available to small boats. Monitoring a fuel flowmeter can give a good indication of overall engine performance. And it may be worth the investment, particularly if your boat has large fuel tanks that you don't want to refill after every trip in order to determine fuel usage. (A fuel tank gauge is not accurate enough for this purpose.) Consult your marine dealer to learn what is available for your boat and motor combination.

Trim Tabs

Fixed and adjustable trim tabs are available as accessories for most small boats. They can also provide a more comfortable ride while helping cut hull resistance. Consult your marine dealer.

Electronics

Marine electronics accessories are becoming more sophisticated, more compact and relatively less expensive. Increasingly, pleasure boaters use navigational devices such as LORAN C. These highly accurate instruments allow you to stay on the shortest course to a destination, thereby saving fuel.

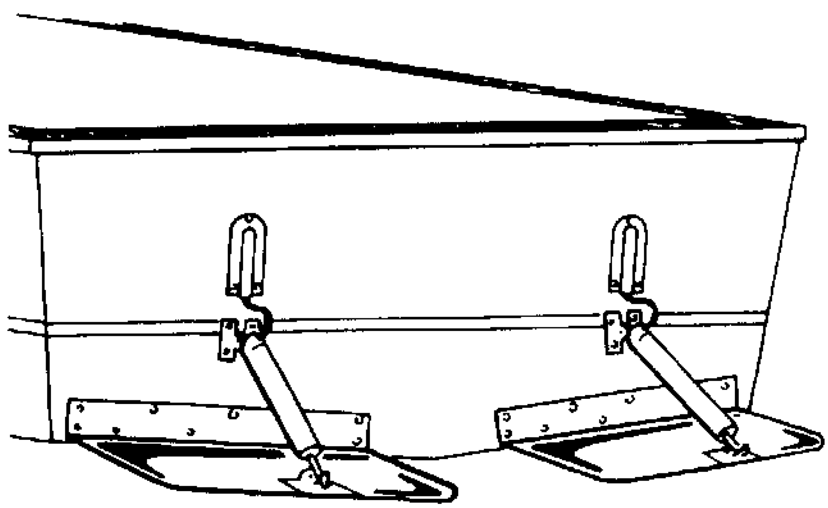


Figure 8. Trim planes are a pair of flat, movable surfaces that extend aft from the boat bottom, one on each side of center.

Caution! Unleaded Fuel

One of the biggest problems facing powerboaters today may be coping with the phase-out of lead from gasoline. A ruling by the U.S. Environmental Protection Agency cut the permissible lead content of gasoline to 0.5 grams per gallon as of July 1, 1985; a further reduction to 0.1 grams per gallon went into effect on January 1, 1986.

The agency's action is based on evidence that lead in the environment is linked to mental retardation in children and to circulatory problems in adult males. While most people would welcome any actions to reduce human health hazards, the rapid phase-out requires attention to equipment that is not designed for lead-free fuel.

Lead in Gasoline

Historically, lead has been added to gasoline to boost its octane level in order to suppress knocking (that is, irregular or premature burning of the fuel) and to provide a form of lubrication for the valve train components.

Because of federal air quality standards enacted some years ago, the lead content of gasoline had to be cut. To provide the anti-knock properties, refiners then turned to alcohol additives to boost octane ratings.

The nearly total phase out of lead now presents two problems for the boater. Low lead fuels may damage older engines due to lack of valve lubrication. And alcohol-blended fuels can cause rapid deterioration of the rubber and plastic components generally used in fuel systems, thus leading to leaking gasoline and gas vapor in the engine compartment — a serious fire hazard!

Potential Engine Problems

According to the marine industry, most inboard engines built in the last decade should not suffer mechanically from the absence of lead in gasoline. However the valves of older inboards which do not have hardened valve seats may wear more rapidly now. And since the average age of marine engines in use is 14 years, this could pose a problem for owners of antique and classic craft with original powerplants.

While most two-cycle outboards do not need lead for lubrication, older engines may experience pre-ignition problems from lower octane unleaded gasoline. (However, an unleaded gas labeled 87 octane at the pump may burn as if it were only 85 octane, the industry warns, and could ruin a large outboard in just a few hours of full-throttle operation.) Unleaded premium gas may be the only answer here.

Note: The National Marine Manufacturers Association recommends that if you cannot find alcohol-free gasoline, you should try to find fuel with an octane rating two numbers higher than the recommendation in your owner's manual.

Fuel System Hazards

Both ethanol (grain alcohol) and methanol (wood alcohol) in gasoline can deteriorate rubber fuel hoses, fuel pump diaphragms, o-rings, seals and other non-metallic components of a boat's fuel system. The result can be gasoline leaking into the boat's interior and explosive vapors collecting around electrical parts. This can be an extremely dangerous situation!

Nitrile rubber hoses, the most commonly used on boats, can swell and stretch from alcohol-blended gas. In fact, alcohol will actually permeate most fuel hose materials currently in use. (Methanol concentrations of 10% to 25% are the most detrimental and some bootleg gasoline blends contain as much as 30% methanol.) A ten-foot fuel hose can leak as much as a cup of gasoline a day through permeation.

Even plastics used in some fuel line components deteriorate progressively as methanol content increases; such blends can damage carburetors and plug filters with bits of deteriorated material. Moreover, cork used as gasket material or as fuel tank floats can also deteriorate in the presence of alcohol.

Since permeation of the fuel hose is essentially a chemical reaction, heat can accelerate the process. Therefore, places where the fuel lines are warmed by engine or exhaust — at the junction with the fuel pump on an inboard, for example — may be the most likely trouble spots.

Preventive Maintenance

Alcohol in fuel is a serious and dangerous problem for boaters, according to the U.S. Coast Guard. And since there are no uniform federal requirements for labeling fuel pumps with alcohol content, you should assume that your gas contains alcohol, the service advises. Maryland law requires fuel pump labeling for gasoline containing one percent alcohol or more and sets the maximum permissible content for ethanol at 10 percent and for methanol at 5 percent. (See Appendix 4 for a simple test to determine whether alcohol is present in your gas.)

Examine fuel hoses frequently. An empty hose that is a hazard will be stiff and brittle, and may have visible cracks. Replace it immediately! A hazardous hose with standing gas in it will appear soft and swollen. Get rid of it!

Boats manufactured before August 1978, the effective date of the Coast Guard Fuel System Standards, could be in particular jeopardy since the older hoses may fall apart rapidly in contact with alcohol.

Pay particular attention to connections. Inspect every fitting where a fuel hose connects, particularly at the fuel pump on inboards and stern drives.

Visible leaks are not enough. Do not assume your fuel system is all right just because you don't see any leaks. Hoses swollen by alcohol can allow explosive vapor to escape into the engine compartment.

Related Problems

Alcohol, particularly methanol, can also absorb water, leading to corrosion of the metal components of a fuel system, most notably, the tank. Moisture in solution in the fuel tank is bad enough but at certain temperatures, the water/alcohol mix can settle out of the gas and sink to the bottom of the tank, resulting in corrosion. This can affect portable outboard gas tanks as drastically as fixed tanks; the internal alloy plating will corrode first, leading to corrosion of the steel tank itself.

Corrosion inhibitors that some fuel suppliers are now adding to their gas may help to minimize the problem but even minor corrosion can lead to clogging of the fuel system. In addition, it may now be wise to drain all fuel tanks and lines completely before laying your boat up each year.

Appendices

Appendix 1
Calculating Hull Speed

Hull speed is the theoretical maximum speed of a vessel through the water found by mutiplying the square root of the waterline length by 1.34.}

Hull Speed = $\sqrt{\text{waterline length}}$ x 1.34

Example: A boat 20 feet long at the water line will have a hull speed of:

$\sqrt{20}$ x 1.34 = 5.99 knots or 6.88 miles per hour

Appendix 2

Deceleration Test Chart

Date	Stopping Time	Difference	% Change

Appendix 3

Fuel Consumption Chart

Date	Speed	Engine RPM	Gallons Used	Distance or Time

Appendix 4

Simple Test for Alcohol in Fuel

If you cannot tell whether the fuel you are using contains alcohol, try this simple test:

1. Fill a graduated cylinder halfway with fuel.
2. Fill the other half with tap water.
3. Cap and shake for 5 to 10 seconds.
4. Let the solution sit for several minutes. The water will settle on the bottom, the gasoline on top.

If the water level appears above the midway mark, alcohol is present since the alcohol dissolves into the water and increases its volume.

(In using a 100 milliliter measure, if the dividing line settles at 55 milliliters, the fuel is approximately 10% alcohol.)

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