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Edited by Jan Mundy

Caution: Mussels Coming to your Lake

We keep our 11-Meter Trojan on 66-mile long Grand Lake in Oklahoma. The presence of zebra mussels has just been confirmed in the lake. Will the mussels attach to the boats and docks like barnacles? Will they settle in engine exhaust systems that may run only every few weeks? Should we find a means to close off exhaust ports that are immersed? Are they likely to cluster on or in underwater seawater strainers? I assume we have some time before they become a real issue but I would like to be as prepared as possible to protect our floating docks and boats that stay in the water year around.
Darrell Gentry, Independence, Kansas

Nick Bailey

Highly visible zebra mussels on outdrive and trim tab won't hinder operation of the boat but will make it very inefficient.

Your question prompted us to investigate further into mussel affairs. Given the insidious spread of this invasive species, it's not surprising that they have spread from the Great Lakes to Oklahoma. (Blame trailerable boats, especially those that are water-ballasted.) In a few years, depending on the speed with which they multiply and spread, you'll find mussel colonies on dock pilings and other objects that are stationary and submerged. In our area, the hype in the past 15 years has been much stronger than the bite. What it has done is increase the duck population (food for them), hindered sports fishing (consumed spawning grounds) but, because mussels are bivalves (like oysters) they do a great job of filtering water and so are also responsible for the cleanest water we've had in a very long time.

Zebra mussels cling to any hard surface. You can protect marine engine water intakes with products made in Canada, where they have had lots of experience in the last 15 years with these wee beasties. Bill Milne of Alex Milne & Associates recommends installing the firm's Zebrex (US$50), which simply fits on the engine intake cooling line that holds a replaceable puck about US$50. A similar device is the Zebra 2000 (US$100). It turns on automatically for five minutes every 24 hours to zap the mussels in the cooling line. "You should inspect the water intake and exhaust systems prior to operating the engine if the boat has not been run for more than a week or so," recommends Bill. Also, fit a Head-O-Matic Tankette (US$115) on the intake line to your head to prevent zebra mussels clogging the hose while the toilet also benefits from the automatic chemical treatment of the head with every flush.

According to Nick Bailey, DIY's maintenance guru, damage to engine interiors and the "hidden" threat is exaggerated. "I have yet to see an inboard engine have serious mussel issues on either the water intake or exhaust side," explained Nick. Mussels prefer outdrives or any other external surfaces that have not been painted with antifouling. "On a rarely used outdrive without antifouling paint, they tend to choke off the water intake slots and cause engine overheating," says Nick.

It's good practice to close all water intake seacocks when not in use to alleviate the remote possibility of mussels making their way into the engine. Outboard owners should raise the engine above the water intake when not in use. You might have to dive underneath the boat to check about twice a year but, other than that, it's not yet a real issue though, with time to study the situation, could become a treatable threat.

Most states have a Zebra Mussel information line through the State Sea Grant organizations. Another good source of mussel info is the U.S. Army Corp of Engineers.

Stay Connected at Sea

Need better cellular phone reception on your boat? You can boost the phone signal up to 50 miles offshore by connecting to an external antenna that plugs into your phone.

Today's mobile phones use a 3db-gain antenna. Connecting to an external 9db-gain antenna gives you the power to reach out farther. This antenna flattens out the RF signal so it resembles more of a pancake instead of an omnidirectional concept. Manufacturers advertise that this advantage, combined with an antenna mounted atop the mast or on an 8' (2.4m) stern-mounted pole, will boost reception to the 30 to 50 nautical-mile range. This range is an improvement over your VHF radio reception and means you'll be able to keep in touch all the way across any of the Great Lakes, possibly even during a passage to the Bahamas. For phones without an antenna plug-in, you'll need to purchase a new phone or an amplifier repeater, such as Digital Antenna's 3-watt PowerMax (about US$350). This connects through the airwaves to a local receiver to boost the power of your phone. For the ultimate wireless, use a Bluetooth headset for hands-free communicating as you move about the boat.

EPIRBs For Rent

Whether you cruise or race you need to be prepared for the unexpected. Next time you head offshore or plan an overnighter, if your boat is not equipped with an emergency position indicating rescue beacon (EPIRB) consider renting one from BoatU.S. Foundation's EPIRB Rental Program. As a public service, it supplies these $900 life-saving devices for just US$50 a week.The EPIRB Rental Program is funded by the voluntary contributions of 590,000 BoatUS. members. For more information, call 888-663-7472 or visit www.BoatUS.com/foundation/epirb.

Peel, Don't Grind

Peeling is recognized by some experts as a better alternative to removing coatings and gelcoat by grinding, sand or other particle or soda blasting.

During Strictly Sail Chicago, I showed Jan Mundy pictures of the badly cracked gelcoat on the bottom of my boat and she suggested that I contact Clare's Mobile Marine (519/734-7043) about having the bottom peeled. Instead, the company rented me the peeling machine. It took me less than 8 hours to remove the antifouling paint and gelcoat below the waterline on my 31' (9.4m) sailboat. The peeler really worked great and was fairly easy to use once I got started. I highly recommend this procedure versus grinding.
Mark Carlson, "Goda Tider," Ashland, Wisconsin

Cheap Source for Methanol

Further to our article in DIY 2005-#1 issue titled, "Generating Power with Fuel Cells," a DIY reader informed us that firms that supply methanol to fuel racing cars, which run on 99.8% pure methanol, are inexpensive sources for this fossil fuel substitute. A gallon costs US$3 and they will deliver in bulk (e.g., 55-gallon (208L) drums. Check the Yellow Pages for your nearest supplier. Sure beats paying the US$40 for a 1.3gal (5L) jug as mentioned in the article.

Nearly Prop Nuts

The "Scuttlebutt" column in DIY 2004-#4 issue explains that the half height propeller nut goes against the propeller and the full height nut slides on the end of the shaft to lock it in. However, the article on page 18 in DIY 2005-#1 issue shows an illustration with the half nut at the end of the shaft. Which is correct?
Alan Porter, "Te Tiaroa," Victoria, British Columbia

Jan Mundy replies: *The illustration on page 18 labeled Figure 1 in DIY 2005-#1 issue shows the small nut first with the full height nut after it, as it should be. If you're talking about the image at the top of the page, that was purely for design and though I should have caught it, hopefully it doesn't create much confusion as it's not labeled. Actually, there are additional photos in the article with the incorrect nut configuration, which only leads to the point that few builders and service facilities are aware of the correct installation.*

Are you Covered?

Patricia Kearns

According to a press release received from Global Marine Insurance, at least one major insurer, Allstate, has exited the boat insurance market in Florida. American Modern Insurance has also opted out. Most insurers have increased their "named storm deductible" for boats moored in a geographic range from the Chesapeake to the southern tip of Texas. Many companies have increased this deductible up to 5%. Virtually all insurance companies have raised rates for Florida boaters by anywhere from 10% to 60%. In addition, some companies have also raised rates for all North American boaters as they seek to spread the pain and recover losses.

Some options for the boat owner who is seeing changed coverage and increasing rates include visiting a multiple listing website such as www.quotemyboat.com to compare quotes for comparable coverage from "A" rated insurance providers and bind insurance online. Increasing your policy's basic deductible by about 1% to 2% can save you approximately 8% on the policy premium. If you moor your boat in the hazard zone, be sure to complete a thorough safety and storm preparedness plan that appoints dependable people to care for your boat in your absence. Now is the time to read your insurance policy and make sure you understand its terms and conditions. Meet with your insurance agent to clarify anything that concerns you and make necessary coverage changes now. It's too late to do this once a named storm is on track. Also, remember that your agent is not the insurance company and vice versa. Many boaters confuse the two entities. Preparing for storm damage includes making sure you have good, current photographs or a video of your boat and its equipment. Keep your ship's papers in a safe place, away from the boat. Keep copies of those papers onboard so that, if you boat is clobbered, salvors and/or insurance adjustors will be able to identify it.

MORE DIY KUDOS

We love to toot our horn and extend a big thank you to all our readers. Keep those emails coming to info@diy-boat.com.

I have learned a great deal over the years by reading DIY cover to cover and I save every issue. In fact, the old issues are presenting somewhat of a storage problem. I'm glad you put old issues on CD-ROMs.
Jack Harari, Ft. Lauderdale, Florida

Your magazine and website are a tremendous source of information. I plan to keep my 1975 Silverton for as long as it makes sense. I'll be making frequent withdrawals from your knowledge "bank" as my list of projects is long.
Bob Hubert, North Lindhurst, New York

Posted on the liveaboard forum *(live-aboard@crux.astro.utoronto.ca):* Just when we were talking about fuel polishing, there is a five-page spread on fuel polishing solutions for diesel installations in the 2005-#1 issue of DIY boat owner, the marine maintenance magazine. I'm a six-year subscriber and each of their annual quarterly issues gives me a lot of ideas and good how-to knowledge. They also have back issues on CDs, which we will take cruising. I recommend this magazine to anyone interested in keeping their boat in top shape. New ideas and good tips come in every issue. I have no financial interest in the magazine. I'm just a happy subscriber and past attendee of Jan Mundy's seminars at boat shows. This is one of the few magazines that Sue and I both agree that we will keep subscribing to when we go cruising.
Ed Kelly, Bayfield, Ontario

He with the most documentation (paperwork) wins when it comes to proving condition and value following storm damage.

Sunscreen for Tires

Have you ever wondered why tires are black? Well, manufacturers add carbon, a black powder known in the trade as a "competitive absorber" and a wax. Carbon is blended with a rubber polymer to stabilize tires against dry rot and discoloration caused by ozone, an odorless gas that is part of the air we breathe, and UV exposure. The black carbon absorbs UV radiation and converts it to heat, which is dissipated harmlessly. Tire manufacturers also add a wax compound to the mix. As tires flex when rotating, wax molecules migrate to the surface to form a protective barrier between the air (ozone and oxygen) and the tire polymer. In the tire trade this is called "blooming."

When boat trailers are parked for extended periods, blooming doesn't occur and ozone and UV attack the tire polymer at an accelerated rate, resulting in drying, discoloration and cracking. To retard ozone and UV damage, give tires a monthly spray with UV screen. Recommended products are 303 Aerospace Protectant and Lexol Vinylex. Both contain strong UV inhibitors that retard tire damage.

Troubleshooting Combiners:

A Boat Tested Case

Your article on charging systems, combiners and isolators in DIY 2004-#4 issue was very good but you just hinted at a problem that I had to endure for several years before I discovered a very simple solution. My boat has an 880 ampere hour (Ahr) house bank and a much smaller start battery. I have a combiner and normally keep the battery switch on "Both." After anchoring for a day or so, the batteries simply wouldn't charge when I started the engine. You could hear the combiner and alternator kicking in and out but it would sometimes take the better part of the day to charge the batteries. After a lot of effort and expense, I learned that the boat was correctly wired and the alternator checked out fine. After doing some reading on combiners, I finally figured out the problem. The combiner

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TIP: Replacing Damaged Threads

Suppose you break off a mounting stud while you are servicing your windlass. Attempts to drill and remove it with a screw extractor are unsuccessful. This results in an oversize hole for the new replacement stud and there's no space to tap for a larger stud. There are two products to replace damaged threads: Heli-coils and Keen-Serts. Both are available in kits for both SAE and metric threads. Use your Internet search engine to locate a supplier in your area.
— Steve Auger

senses voltage on both battery banks. If voltage is high enough, depending on how it's set, the combiner switch closes and both banks are connected. When voltage is low, for example, when there's a drain on one of the batteries, the combiner opens and separates the two battery banks from each other. The house batteries are probably eight times larger than the start battery. When I started the engine, the combiner closed to charge both sets of batteries but voltage on the depleted house batteries made the average voltage on the entire set of batteries very low, so the combiner disconnected. The combiner would then sense the higher voltage on the start battery and reconnect, only to disconnect again when it sensed the low voltage house batteries. That was the cycling I experienced.

As soon as I realized the problem, the solution was simple. After starting the engine, I simply turn the battery switch to "1," which is the house bank in my case. This took the combiner out of the system and allowed the alternator to refill the house bank. After an hour or so, when the voltage comes back up, I switch to "Both" and let the charging finish. If your boat doesn't have a "1-2-Both" battery switch, Xantrex makes a combiner manual cutout switch that does the same thing.
Peter Ellison, "Chance," Mamaroneck, New York

What's Accurate with Anodes?

I want to comment on some errors in Steve Auger's article on sterndrive corrosion, in DIY 2005-#1 issue. First, a sacrificial anode loses material by ionic flow not by electron loss. The ions of metal are positively charged and flow from the aluminum through the water. Secondly, zinc is not the correct alloy for use in saltwater on all sterndrives. In fact, Mercury specifies that aluminum anodes must be used to ensure coverage by their warranty. Aluminum anodes, made from an alloy of aluminum, zinc (5%) and traces of Indium, are more active than zinc (-1.10 volts versus 1.05 volts for zinc) and have more ampere hours capacity. This common misinformation should never come from a magazine of your caliber and practical standpoint.
Martin Wigg, president, Performance Metals

Steve Auger replies: *I'm neither a metallurgist nor an anode specialist but I am a qualified marine technician and my*

DIY READERS WIN BIG

The six winners of DIY's Product Information Card Giveaway from DIY 2004-#4 issue who received a cartridge of 3M Marine 4000 UV adhesive sealant, are: Bill Barker, Annapolis, Maryland; J.D. Levin, Lafayette Hill, Pennsylvania; Dan Adams, River Drive Park, Ontario; Mike Murray, Halifax, Nova Scotia; Larry Vinck, Baltimore, Maryland; and Paul Hagen, Portland, Oregon.

Winners of DIY's Product Information Card Giveaway from DIY 2005-#1 issue who received a jug of 3M Marine Deck and Hull Cleaner, are: Shelley Rubzow, North Vancouver, British Columbia; Robert Krizansky, Laurel, Maryland; and Rick Cass, North Port, Florida.

When you need information from marine manufacturers, log onto DIY ONLINE at www.diyboat.com and click on "Information on Marine Products." This automatically enters you into this issue's draw of three Pela 2000 oil change vacuum pumps.

approach to explaining galvanic corrosion is done in such a manner than boat owners understand the basic concept and they can equate the reason to protect their sterndrive engines. As for zinc, this was changed from my original text during the editing process. It should read: "aluminum for saltwater, magnesium for freshwater." Thanks for bringing it to our attention.

DSC for VHF Radios

Digital Selective Calling (DSC) isn't new; in fact it has been provided in many VHF radios since 2002. VHF-DSC is an internationally recognized standard that operates on Channel 70, a channel that commercial ships are required to monitor. Just press the radio's mayday button to initiate an automated distress call transmitted to all nearby boats and the Coast Guard. The digital (not voice) transmission contains an encoded distress call that includes the user's personal information (if provided to the Coast Guard) and the current position (when connected to a GPS). For this safety feature to work, DSC radio owners need to register the radio's identity (boat and contact information) with the Coast Guard so this information is added to the search and rescue database. Effective this year, commercial ships no longer need to monitor Channel 16, a channel that Coast Guard radio stations will continue monitoring.

DSC technology is a godsend provided someone's listing. The U.S. and Canadian Coast Guard will not monitor Channel 70 until communications systems are upgraded, which is projected for 2006 in the U.S.. In the meantime, some USCG cutters and stations, as well as many towboat operators, have installed equipment for direction-finding DSC transmitted radio signals and digital voice recording.

Just for Eggs

On the last weekend in July the Egg Harbor Owners' Association is hosting its 10th Annual Rendezvous at Block Island in Rhode Island. More than 150 Egg Harbors are expected to attend. For further information go to *www.eggharborowners.org.*

BOATERS LIKE POLY

"When storing your boat what type of cover do you use?" was the question asked on DIY ONLINE earlier this year. Of the six choices listed, 37% use a polyethylene tarp, 22% shrinkwrapped their boats, 15% don't use any cover, 13% protect their boats with a canvas tarp, 12% have a custom cover and 1% selected "Other." To enter DIY's current poll, log onto *www.diy-boat.com.*

There's Truth in Numbers

Every boat sold in the U.S. is assigned a hull identification number that gives the buyer a clue to the boat's builder and true age. Here's how to crack the code.

By Patrica Kearns

In the U.S., every company who builds or imports boats for recreational use must assign and permanently affix a hull identification number (HIN) to the boat hull and this must be done in accordance with U.S. federal law. In the U.S. Code of Federal Regulations, CFR 33, section 181.23, a subpart states that "A manufacturer (or importer)…must identify each boat produced or imported with two hull identification numbers that meet the requirements of this subpart." "A person who builds or imports a boat for his or her own use and not for the purposes of sale, must identify that boat with two hull identification numbers…." Both numbers are identical but they are prescribed to be marked in two different locations, one marking being designated as the "primary" and the other being the "duplicate." No two boats can bear the same numbers. These numbers differ from the United States Coast Guard (USCG) official number on a documented boat or the state numbers on a registered boat or the numbers required by Canadian registration requirements. Those numbers originate when a boat becomes the property of the end user. The HIN is the domain of the manufacturer, individual builder or importer.

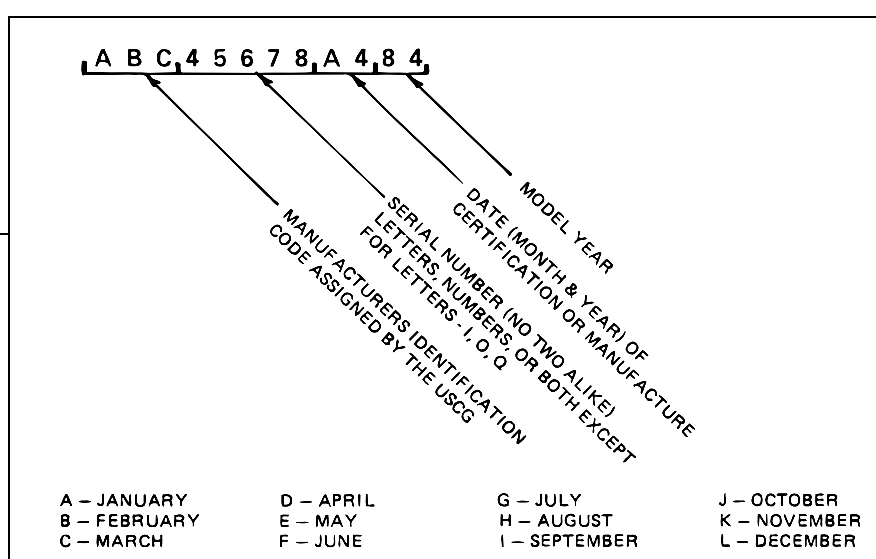
MIC Requirements

Every domestic boatbuilder or seller who imports a boat to the U.S. can't have a HIN without a manufacturer's identification code (MIC). The MIC is assigned by the USCG Recreational Boating Product Assurance Division in Washington, D.C., and becomes part of the HIN. In fact, the position of the MIC characters is dictated by law as being the first three characters in the HIN. That means that, when you look at the HIN, those first three characters are the code that tells you who built the boat. The USCG maintains its MIC database at www.uscgboating.org/recalls/mic_database.htm, which is searchable online with several options for initiating a search. If you know the company name, you can find out the rest. If you know the MIC, you can search that way. The records include all the builders ever assigned MIC codes, even if the company is no longer in business.

Why a HIN?

The HIN is the recreational boat equivalent to the vehicle identification number (VIN), a familiar numbering system for motor vehicles. The HIN is a valuable clue to the boat's identity from the day the keel is laid, in the case of a wood boat, or, for fiberglass boats, when the hull is molded, to the days, decades later, when the boat is sold and resold over the period of its useful life. The information contained in the HIN is definable and irrefutable unless miscreants bent on fraud or other criminal activity have defiled the HIN. Law enforcement agencies, banks and insurance companies rely on the infallibility of the HIN to track the authenticity of the boat's origins, age, etc. The regulations applying to the HIN number apply to all recreational boats, one of the few requirements in the U.S. Code of Federal Regulations CFR that does so. No exceptions, with allowances only for those boats built before the HIN requirements were legislated into law for compliance in 1972.

What does the HIN mean to you? Let's start with an example based on a hypothetical situation. You've fallen for a Dreamboat 34 and the boat is everything the broker described. You've made a good faith deposit, signed a purchase agreement and you're now checking on the surveyor's availability. The yard is set to haul the boat and all you need is the survey report so that your bank and insurance company can get onboard at the closing of the sale. There are a few "uh-oh" moments during the survey but you're a reasonable sort and you take the boat's age into account when assessing the purchase value, taking a "Nothing that can't be fixed" attitude. "Uh-oh!" is again heard from the stern as the surveyor notes the HIN, the 12 characters embossed on the upper starboard corner of the transom. Based on



ABYC T-10 Hull Identification Numbers (HIN) applies to boats built or certified on or after August 1, 1984.

Notes:

1. *The 12 characters of the HIN shall be consecutive with no extra space between characters or groups of characters.*
2. *The HIN shown may appear on boats built or certified on or after January 1, 1984.*

the broker's listing you told the surveyor that the boat was launched in 1992 but the HIN reveals that the boat was built in 1990. "Launched" and "built" are not the same thing. Let's see what this HIN told the surveyor.

HIN Decoding

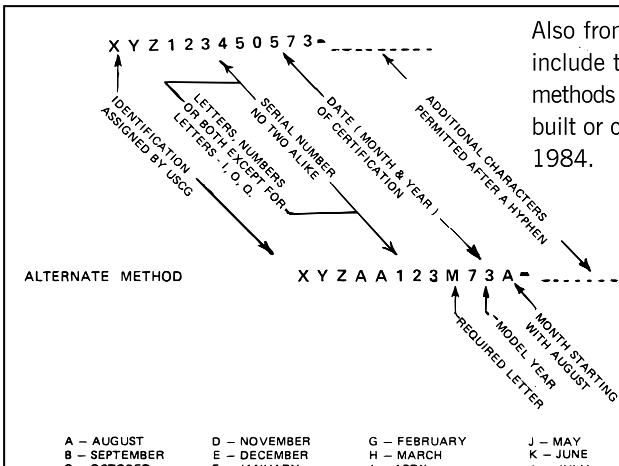
Let's use the hypothetical HIN number XXX340078B091. According to the Code for boats built after August 1, 1984, the first three characters, XXX, form the MIC, which in this instance is the fictitious Dreamboat Company. The next group of numbers comprises the actual model and hull number and this is an area of discretion for the builder. In this case, the boat is model 34 with the hull number in the model series being 0078, or 78. The last four digits tell the truth about when the boat was really born. Starting from the last two characters, we see "91," which converts to model year 1991. The B0 (zero, not the letter "O") tells us that the boat was actually built in February 1990. Boats, like cars, are subject to model year designations. We all know about the leftovers in a car dealer's inventory when the new model year is introduced. Same for boats, although model year changeover dates are not consistent with every builder. Our hypothetical Dreamboat was built in 1990 as a 1991 model year but not sold to its first retail customer until 1992, hence the "launched" implication that it's a '92. Not an unusual scenario but, later in the boat's life, this information does have an effect on the boat's value. A 1992 boat may be worth more than a 1990 boat, condition notwithstanding, and the true 1992 built boat may also have features that were incorporated in this later model year than the one built in 1990 as a 1991 model.

Decoding a HIN is definitely within a DIYer's capability. You can find all the requirements for HIN marking in the U.S. Code of Federal Regulations, Title 33 (CFR 33), subpart C-Identification of Boats, Section 181.21. You can find entire codes on the USCG website at www. uscgboating.org. That site is a world of information related to recreational boats and boating.

Armed with the code, you can encrypt the who, what and when of any boat that is branded with a HIN. Unfortunately, the use of the HIN in boating law enforcement is still evolving to the sophisticated levels of the capabilities of the VIN in the automotive world but it's coming. In any case, the presence or absence of a HIN, cleanly marked or one that has been sullied by the unscrupulous for scurrilous purposes is a bold clue to the boat's past.

Pay attention to the HIN. Bankers do. Surveyors do. Marine insurers do. The government does. Buyers beware! Every buyer also has to beware of any boat that is offered for recreational use that does not have a HIN. Boats built for commercial use are not held to the same standard by the U.S. government.

About the author: Besides being DIY's proof editor, Patricia Kearns formerly was assistant technical director of ABYC. She is a NAMS certified marine surveyor and operates Recreational Marine Experts Group, a marine surveying and consulting firm based in Naples, Florida.



Also from ABYC T-10, guidelines include the primary and alternate methods of creating a HIN for boats built or certified prior to August 1, 1984.

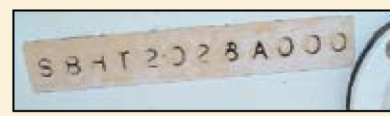
Notes:

1. The 12 characters of the HIN shall be consecutive with no extra space between characters or groups of characters.

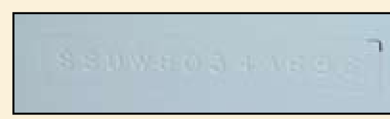
2. Additional characters, if used, shall be separated from the HIN by a hyphen.

HIN Explained

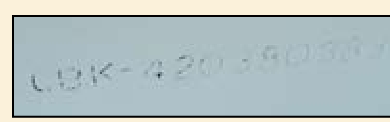
These photographs illustrate some examples. The method of marking the boats varies but all comply with the letter of the law. Remember that the first three characters indicate the MIC.



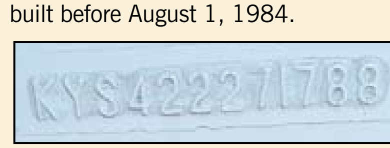
SBH is Seagull Boats, formerly builders of power catamaran hulled boats in Naples, Florida, now out of business. The boat was built in January (A) 2000; model year 2000.



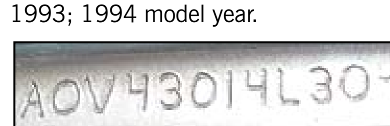
SSU is S2 Yachts Inc., builders of Tiara power boats. Boat built in January (A) of 1996; model year, 1996.



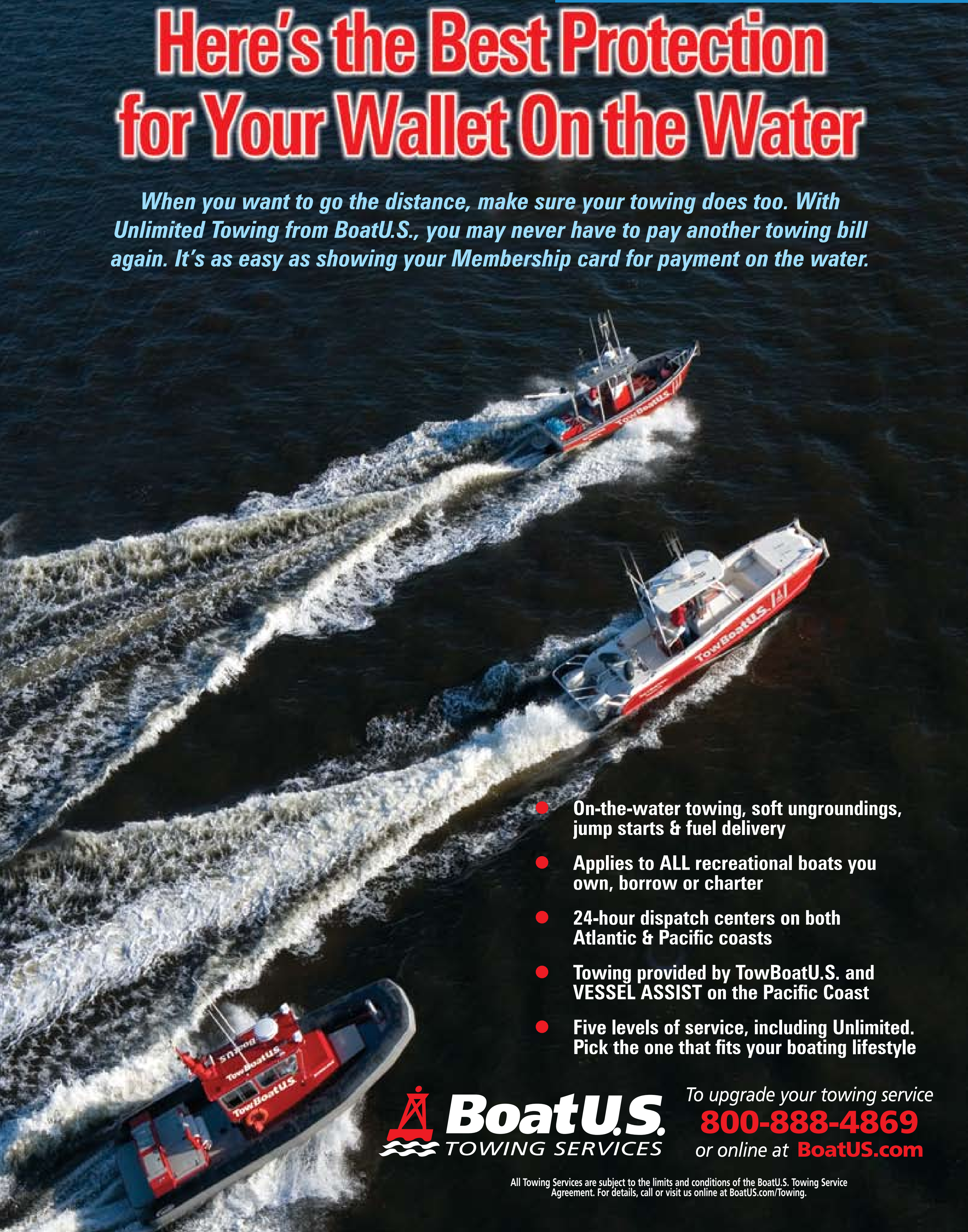
CBK is Kadey Krogen Yachts. The boat is a Krogen 42, built in 1983; model year, 1983. This number is an example of compliance with the law for boats built before August 1, 1984.



AOV is Nortech High Performance, builders of custom high performance powerboats. Boat built in December, 1993; 1994 model year.



KYS is Kentuckiana Yacht Sales, importers of Jefferson Yachts. Boat is a Jefferson 42 built in September, 1987; model year 1988.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Talkback Q&A

Helpline info@diy-boat.com

DIY boat owner Magazine reserves the right to publish Technical Helpline questions in the "Talkback" column of both print and electronic (DIY EZINE) issues and on CD-ROMs.

Near Sinking the Unsinkable Whaler

A Boston Whaler has a very thin fiberglass laminate backed up by foam, which is structurally integral to the strength of the hull.

Q: My '60s vintage Boston Whaler Montauk has a 2' (61cm) diameter gash in the side. This is a great bay boat and I would prefer to fix it, if feasible.
Forrest Fennell, Green Brae, California

A: This is no mean task. As is the case with all foam-filled boats, the foam gets battered from wave pounding or becomes saturated and breaks down from water migrating through drilled holes in the deck (i.e. fasteners holding the center console), all conditions found on a boat as old as yours. As foam becomes more and more saturated, not only does the boat become heavier, but also in stress areas the laminate (outer skin) cracks and can peel off. To repair, you'll need to extend the repair area using a scarf ratio of 20:1 or 30:1. Normal repair practice uses a 12:1 scarf. The large scarf is necessary to provide additional adhesion. Your repair will never be as strong as the original and even following these procedures the different flex characteristics may crack the laminate and cause it to peel off in the future, but at least it will stay afloat. Now dig out any wet foam. Wet foam has the consistency of apples; the same amount of moisture and little strength. Replace with pour-in-place polyurethane foam. Though not as dense as the original foam, it does the job. Sculpt foam to shape, leaving about 1/4" (6mm) for laminating the outer skin or so it's flush with the underside of the inner laminate. Seal the foam with one coat of polyester resin. Apply one layer of mat using lots of resin for a very wet laminate. Follow with one layer of 1810 Stitchmat. Apply another layer, orienting this at a 45° angle. Alternatively, use 18oz to 24oz mat and two layers of 3/4oz to 1.5oz cloth. Finish with color-matched gelcoat. When fully cured, usually within 24 hours, wet sand with 400-grit paper, then 600, then 800 paper and finish with rubbing compound. Alternatively, you can paint the hull.
— *Nick Bailey*

Troubleshooting A-C Noise

Q: I have two SX12-M7 water-cooled, 12,000 BTU Cruisairs in my 1995 Sea Ray. One unit makes a buzzing noise when the cooling unit is running and sometimes when just the heat is on. It sometimes makes a buzzing noise, and then shuts down. The other unit runs fine; no noises. Both units are fed by one water pump. What are the possible sources of the noise and power trips?
Steve Zimmerman, "Shuttlecraft," Milwaukee, Wisconsin

A: This is not easy to solve without inspecting your unit. Low-water flow or high intake water temperature generally causes a high pressure cutout condition. Check that the cooling circuit is clean and strainers are clear. You might be losing flow with two units suctioning from one supply but I doubt it. Run the noisy one on its own and if the noise continues it's not a water problem. A low gas charge level in the compressor can create noise due to inadequate cooling and possible low pressure cutouts do occur. A defective compressor is also a possible cause of noise as are worn and out of tolerance components. Low voltage, which often happens in marina power supplies especially under load, can cause voltage drop, resulting in motor efficiency drop and buzzing and humming, especially at start up. A tripped breaker would indicate an overload condition. If voltage drop isn't an issue, then the compressor may be mechanically overloading the circuit, although you can't rule out an electrical problem with the motor.
— *John Payne*

Clean Tape Release

For outdoors use, you cannot beat 3M Marine 2080 Safe-Release 60-day tape.

Q: In the maintenance seminar held by Jan Mundy at the Chicago boat show she mentioned that 3M 233+ tape was excellent for outdoor use. She also mentioned how long it could be left on without removal problems but I don't recall what she said.
Bill Bailey, Seymore, Indiana

A: Some specialty 3M Marine tapes can be left on surfaces exposed to sun without danger of adhesive transfer or the tape ripping. Here are the product numbers and recommended 3M tapes for long term use: 233+ (lime green color) good for up to 14 days; 346 Marine Heavy Duty Protection Tape (white) for 30 days; and blue 2080 Safe-Release (my favorite) for up to 60 days, though DIY tested it for 120 days and it removed cleanly.
— *Jan Mundy*

Talkback Q&A

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Cures for Odor Fatique

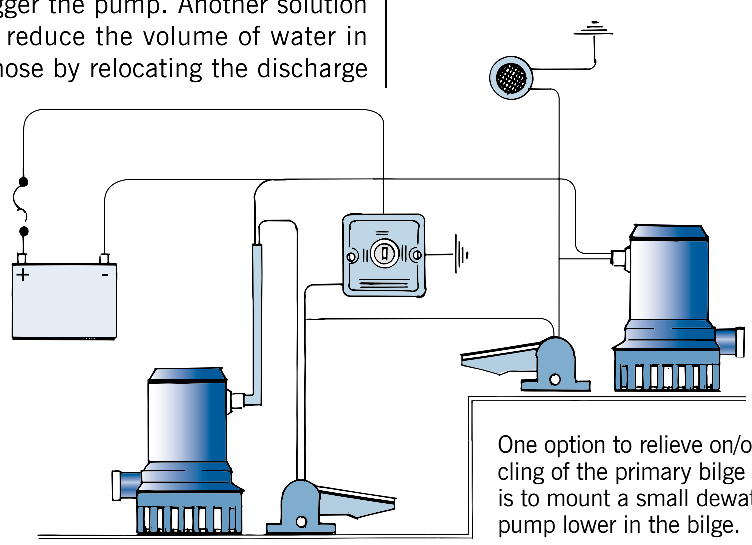
Q: I've recently purchased a 38' (11.6m) Island Packet. My wife has a very sensitive nose for head odors. At present, the boat has some unpleasant odors. What products and cleaning techniques do you recommend to keep our head smelling good?
Michael Dunn, "Alcyone," Annapolis, Maryland

A: There's no reason for a boat to smell like a sewer. First, you'll need to check the pumpout (discharge) hose. Run a rag over the hose and smell it. If it smells like sewage, the head odors have permeated the hose and you must replace it with either the best and usually most expensive sanitation hose you can get (don't cheap out here) or better yet, install Schedule 80 ABS or PVC pipe (available at Home Depot). Pipe is the only product that ensures no odor permeation. If you go the pipe route, you'll need to support it every 18" (46cm) and use flexible couplings or flexible hose at the bends. Install a Head-O-Matic Tankette unit #4106, available at most marine stores on the intake line to your head. This eliminates the need for head chemicals and automatically treats every flush. It also treats the raw water if the head uses seawater for flushing, and removes "salty" odors (developing from the sealife in the water) that could otherwise emit from the bowl. If your boat has a holding tank, install a second vent line. Most tanks only have one and the additional oxygen added by the second vent helps to speed up the aerobic activity and reduce odors. If the boat doesn't have at least one solar-powered vent, install it and another for good measure. Finally, wipe down all surfaces with a citrus-based cleaner and your wife will love the boat (and you).
— Jan Mundy

Cycling Bilge Pump

Q: A 15' (4.6m) long discharge hose runs from the bilge pump to the transom on my boat. When the pump shuts off, water runs back down the hose to the pump, mixes with the little remaining bilge water and the process starts over again without any water actually pumped overboard. How do I fix this?
Thomas Richardson, "Liquid Asset," Annapolis, Maryland

A: This is a common complaint with float switch triggered, submersible automatic bilge pumps. This problem is primarily a case of the bilge pump switching off or sucking air and losing its prime before it has cleared the water from the discharge hose and then gravity takes over. It's a particular problem in a narrow bilge where small volumes of water equal large changes in the float position and also with high capacity bilge pumps with large diameter hoses that hold a lot of water. There are a several different ways to tackle the problem. You can install a check valve, though these can eventually be fouled or disabled by bilge debris. (Never use a check valve on a hose exiting below the waterline.) You could use the manual switch position to scavenge as much water out of the bilge as possible beyond the level that triggers the float switch but this tactic may or may not make a difference and defeats the whole idea of an automatic pump. A timer circuit that forces the pump to continue for an adjustable period of time after the float switch triggers would work but I don't know of any firm making such a device. That trick would duplicate manually forcing the pump to stay on long enough to clear more water out of the hose. It would also allow the float to be mounted higher so that any back flow would not immediately retrigger the pump. Another solution is to reduce the volume of water in the hose by relocating the discharge to shorten up the hose (if practical) or routing the hose as directly as possible to siphon break installed above the level of the discharge thru-hull. This means only the section of hose between the pump and the siphon break drains back. This might be difficult to do if the discharge thru-hull is already about as high up as possible (as they usually are on sailboats). Installing a small primary ("dewatering") pump that uses a small diameter hose will keep the bilge pump as an emergency pump triggered by a second float switch higher in the bilge. Yet another option is to relocate the float switch into a wider or shallower part of the bilge away from the pump if necessary. The downside here is that the automatic setting may not pump out as much water as you might like. Lastly, consider removing the submersible pump and installing a diaphragm pump. These positive displacement pumps won't have the same rated capacity as the centrifugal style submersible but they have built-in check valves to prevent back flow. Also, they will not quit pumping water the minute the pump sucks a little air. They are a bit sensitive to debris so be sure to install an inline filter between the pickup and the pump. Of course, there are all sorts of variations and combinations of the solutions listed above.
— Nick Bailey



One option to relieve on/off recycling of the primary bilge pump is to mount a small dewatering pump lower in the bilge.

Venting AirLock in Trim

Q: After servicing the trim/tilt pump on my Mariner 150 hp outboard engine, it fails to rise all the way and I suspect an airlock. I reinstalled the tilt motor and filled the reservoir with 10-30 oil. The motor only went up a few degrees. I saw that the reservoir was empty so I filled it again. This was repeated several times with the motor going up a bit more after every refill. Now, the motor raises about a quarter of what it should and reservoir remains full.
David Page, "Sea Jay," Pelican Point, Alberta

A: To determine if the trim system is contaminated with air, trim the motor up until it stops. Now push down on the gearcase and, if the ram feels is spongy, there is air. Where there's no air, it will feel quite solid. To bleed the trim system, trim the motor fully down (in). Check that the manual release valve, located on the pump body between the two hydraulic hoses, and the O-rings on the release valve (it unscrews by hand) are in good condition. Be sure the manual release valve is turned clockwise into the valve body until seated and the fill/vent screw (located directly above the manual release valve) is open (backed off seated by one to one and a half turns). Trim up until the motor stops and then trim down and refill reservoir to full. This may take three to 10 attempts to get maximum trim. Place rags under reservoir to catch foam (and air) as it flows out.
— Steve Auger

Servicing CS22 Centerboard

Q: My 1974 CS22's centerboard is fairly loose and I'm considering taking it apart and changing the pin. Visible inside the hole for the pivot pin are two vertical metal rods about 1/4" (6mm) in diameter that extend top to bottom on each side. They appear fixed in place by corrosion. I'm not sure if I should try to cut them out, bang them out or see if they can be reached from the top of the centerboard trunk when the keel is lowered from the hull. I'm also wondering if it's just a matter of using a chisel-type tool and a sledge hammer to bang out the pivot pin while supporting the centerboard.
Jean Marc Scazzosi, Beaconsfield, Quebec

A: I contacted Pat Sturgeon (Pat Sturgeon Yachts, Toronto, Ontario), an ex-CS Yachts employee who dates back far enough to have worked on the 22. Apparently, the whole centerboard and pin assembly is dropped into the top of the ballast keel before bolting the keel onto the boat. The vertical metal rods you see are locating pins that also pass through from above. The normal method of removing and replacing the pivot pin is to first remove the keel and then extract the locating pins from above. Unfortunately, Pat was a bit vague on the details but he indicated it may also be possible (not easy) to cut the locating pins and extract the pivot pin from the side. This sounds like a big job either way. Although a loose pin is not ideal and may be subject to failure, I've not encountered one yet.
— Nick Bailey

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Overheat Monitoring

Q: My 2002 40-hp Mercury two-stroke outboard motor has very little water coming out the water "telltale" outlet but the engine doesn't overheat. I changed the water pump impeller, totally flushed the system, ran a wire down the outlet hose and blew it out with air, checked for a pinched hose and rechecked the impeller again for proper installment but nothing.
John B. Smith, Titusville, Pennsylvania

A water pressure gauge taps into an outboard's cooling system and water pressure flowing through the tube registers on a gauge in pounds per square inch (psi) to prevent an overheat condition.

A: This is not uncommon. If the engine runs without overheating then the soft rubber telltale outlet is likely pinched in the lower cowl. Disconnect the hose from the telltale fitting and run the engine with a water supply for 10 seconds. If water streams out the telltale hose then it's the cowl fitting. If no water, remove the fitting from the block and run the motor for 10 seconds again. If still no water, check your impeller replacement. Your engine should be equipped with an audio alarm but this only tells you of a problem once it's occurred. Consider installing a water temperature or water pressure gauge, available from any authorized Mercury dealer for around US$100. This allows you to monitor the water pressure or temperature (or both) with the engine running. Gauges warn you of high temperatures or inadequate water flow before engine temperatures reach a critical overheat condition. Installation is fairly simple and each gauge comes with instructions. [Ed: Details for doing this appeared in DIY 1997-#1 issue and the article is available on the MRT "ENGINE" CD-ROM.]
— Steve Auger

Smoking Lehman

Q: While helping my friend sail his Countess 44 ketch, I noticed white smoke coming from the exhaust and fuel in the water. He said that, while the Ford Lehman engine ran smoothly, it belched white smoke ever since he had it rebuilt. The service shop has again pulled the engine but couldn't find a solution. The owner removed the injectors and they tested okay and compression was checked. After installing a new fuel pump, the engine still smokes like crazy. Is there anything else we can check?
Adam Ellis, Aquarius, Burnham Harbor, Illinois

A: When trying to resolve a problem, such as white smoke, I must know the model of the engine. For the sake of giving you a quick answer, your engine is likely a 590E Dagenham, which was the 108 Lehman. It's quickly identified where the injection pump is driven by an external shaft (you can see it turning) and the raw-water pump attaches to the rear of the injection pump. This engine has a problem of running too cold and the original bypass thermostat has not been available in recent years. As a result, people install the wrong thermostat and the engine operating temperature never gets up to the 185F (85C) it likes. If this engine runs at or around 145F (63C), it makes white smoke. Also, the injection pump timing might be set incorrectly. American Diesel (804/435-3107) has manuals for this engine. Never trust the temperature gauge at the helm. Use a thermometer in the expansion tank!
— Bob Smith

Removing Bird Fouling and Other Stuff

Q: We have a tan Sunbrella dodger that was inundated with bird droppings last fall when we were away from the boat for a few weeks. Cleaning with freshwater and a soft brush did not completely remove the discoloration. Adding Joy, a mild soap, likewise did not fully remove the discoloration. Will the sun tend to gradually remove the darkening stain? Are there any other cleaning steps you would recommend? *Tom Reinsma, "Mariah," Charlevoix, Michigan*

A: I would try straight detergent and let it soak in, then rinse thoroughly. If no

To treat particular stains on Sunbrella covers refer to the company's stain chart at www.sunbrella.com/usa/stainchart.shtml.

luck, try white vinegar. If this works, follow with the "after cleaning" instructions below. If not, prepare a special cleaning mixture of 4oz (118ml) of chlorine bleach and 2oz (59ml) of natural soap in 1 gallon (3.78L) of lukewarm water. Allow mixture to soak for up to 20 minutes and then agitate the mixture on the fabric with a soft bristle brush. Rinse thoroughly, repeat if necessary and then air dry. After cleaning, you'll need to retreat the fabric for water repellency. Sunbrella fabrics are treated with a fluorocarbon finish to enhance water repellency but this must be replenished after a thorough cleaning or after five years of use. The manufacturer recommends 303 High Tech Fabric Guard as the preferred retreatment product for its fabrics. To clean stains such as acid rain, bird droppings, insect stains, metal run-off, pollution, rust, tree sap, etc., Sunbrella suggests using the following off-the-shelf products: Goo Gone Grease Cutter, Gojo or other petroleum-based hand cleaner; Greased Lightning, Clean Rite Purple Power (available at Wal-Mart, K-Mart, etc.) or Release (available from Awning Rejuvenation Systems in Ft. Lauderdale, Florida; tel: 800/776-5664). Rub product into fabric, allowing it to penetrate. Brush with a soft brush, rinse thoroughly and repeat if necessary.
— Jan Mundy

Talkback Q&A

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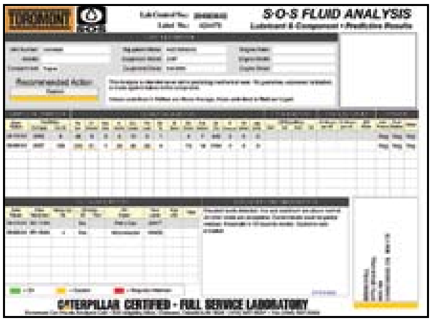
Baster Treatment for Steering Systems

Q: I have a Holiday Mansion powered by a 5.7 Volvo with a 290 outdrive and ram-type power steering system. The engine has a power steering reservoir like the steering pump on a car. Is there a procedure to change the fluid?
Doug Booth, "McKena," Ivy Lea, Ontario

A: The reason the system appears to be the same as an automotive unit is because the pumps are identical. The safest way to extract the oil from the pump reservoir is to use a food baster as a syringe. This removes most of the oil. To completely purge the system, remove the smaller hose that uses a gear clamp to attach the hose to the pump. Place the hose in a 1 gallon (3.78L) jug. Remove the coil to distributor cap wire so the engine won't start and crank the engine for 10 seconds at a time. Refill the reservoir with power steering fluid between each 10 second cranking session. Half a gallon (1.9L) should completely replace the old oil with new. ***Caution:*** This hose can have up to 100 psi oil pressure at 600 rpm. Be sure to secure the hose so it stays inside the jug at all times while cranking. Otherwise, the hose can come out and spray oil everywhere.
— Steve Auger

To Rebuild or Repower Corbin

Q: We have a 1982 Corbin 39 with a Westerbeke 33 diesel that we are told needs a rebuild. When we bought the boat a year ago, there was a cold start problem, which the previous owner was solving using ether. We have had the injectors serviced and replaced glow plugs, which seemed to address the issue of cold starting. On a recent cruise, whitish smoke was evident passing out the exhaust, fuel consumption seemed to be higher than normal and, on several occasions, the engine was unusually hard to start. We suspected fuel contamination but the primary Racor fuel filter showed no water. Since then, we've had the engine compression tested and were told that three cylinders were in the 400 psi range and one was near 300 psi (400 psi is supposedly within the 20-point tolerance level). The original owner told us that the engine was pulled about 1,200 hours (now there are 2,500), the head removed and valves serviced with lapping compound. A new Hurst V-drive transmission was installed at 500 hours. An oil sample taken shows high levels of metals that suggest bearing problems. It is likely we will keep the boat as we plan an Atlantic crossing in 2007. Should we have the engine rebuilt ($6,000 estimate) or repower ($15,000 less maybe $2,000 for our old engine)? Our mechanic is recommending we repower with a Westerbeke 40, which should fit where the 33 now lives and attach to the same transmission, but I know other Corbin owners have gone to larger engines.
Brian Hall, Grand Bend, Ontario


TOROMONT

S·O·S FLUID ANALYSIS

CATERPILLAR CERTIFIED - FULL SERVICE LABORATORY

Oil sample taken from 1982 W33 shows extensive engine wear and helps to determine whether an engine rebuild is a viable expense.

A: DIY contacted Westerbeke on Brian's behalf and received this detailed response from service manager, Joe Joyce. "The oil analysis shows bearing, bushing and cylinder and piston wear taking place at abnormal levels. Standard compression value for each cylinder is 455 psi; minimum is 370 psi, while overhaul is at 312 psi. The whitish exhaust smoke most likely was steam and vapor trail, not unburned fuel as the oil analysis showed no fuel dilution of the oil, which should have taken place if there was legitimately unburned fuel. As the owners plan to be long-distance cruisers and their boat is in need of more power, I recommend investing in a current production, higher horsepower engine rather than rebuilding the existing engine. The W33 is rated at 33 hp at 3,000 rpm. The best replacement is the Westerbeke 44B/four, rated at 44 hp at 3,000 rpm. This engine, when operated in the same cruise rpm range as the w33 (2,000 to 2500 rpm), produces more horsepower. Looking at comparisons between the W33 and the 44B/four: weight (less transmission) for the W33 is 466lb (211kg), compared to 384lb (174kg) for the 44B/four; length is 27.64" (70cm) and 25.5" (65cm) for the 44B/four; width equals 20.54" (52cm) versus 18.6" (47cm) and height is 24.81" (63cm) versus 23" (58cm). The existing V-drive transmission mounts directly on the 44B/four. A propeller size and pitch change is needed to properly load the new engine."

Switching to Prevent Brown Outs

B: When we stop sailing our 38' (11.5m) sailboat and start the engine, the Raytheon R-20 radar, Garmin GPS and other electronics usually restart. This doesn't happen all the time when the engine is warm. On previous boats that I owned, the electronics remained on without recycling. On all boats when the battery switch is switched to off, the electronics are off, so nothing is directly wired to the batteries. So how do we avoid the recycling problem?
Barry Shapiro, "Fantasia," Portsmouth, New Hampshire

A: What you are experiencing is commonly called a brown out caused by a voltage dip or surge occurring when the starter motor load temporarily drops the battery voltage level. The only way to avoid this is to install a separate two battery system. Either power all electronics off the house battery or separate the house from the start battery when cranking the engine. Brown outs happen less with a warm engine because it requires less starting current, which translates into less voltage drop, than a cold engine. When using a two-battery switch system, start and warm up the engine on the

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Isolate the 1-2-Both battery switch when starting the engine so supplied power comes from the start battery only.

start battery, say “1” position, then switch to “Both” to allow charging of both batteries. When the engine run period has fully charged the start battery, switch to just house battery, in this example the “2” position, to continue charging the house bank and supply the electronics.
— *John C Payne*

Bertram Appeal

Q: The stanchion bases on my 1980 42' (12.8m) Bertram need rebedding but they appear to be thru-bolted with no access, unless gutting the interior by removing paneling, etc. The stanchions are outboard of the side deck and attach to a raised area. How is this raised area constructed? If solid glass there may be no need to remove and rebed the stanchion bases. Failing this, do you have any remedies other than tearing the interior apart?
Doug Wade, “Reel Action,” Vancouver, British Columbia

A: Rebedding the stanchions is a maintenance exercise that DIY recommends at least every 10 years and it's one of those four-handed jobs. My experience confirms that all deck hardware is thru-bolted on your Bertram and the installations all include good backing reinforcements. To access the stanchion bases, you’ll need to remove some interior liner panels (designed to be removable). The deck molding structure is cored to the toerail (the “raised section” you describe) and at the radius to the raised toerail the laminate becomes solid glass to which are bolted cleats, stanchions, etc. This 4" (10cm) or so wide toerail then turns downward as a flange that fits over the vertical panel of the hull molding, like a lid on a shoebox. Bertram Yachts has archives on every boat design it built. The company also has a history of good service to owners of older boats so it could probably provide you with a drawing of the toerail-to-hull deck joint. While the effort to access these fittings for lifting and rebedding might be a daunting task, it’s a worthwhile and honorable duty to preserving a fine boat’s service life, to say little of stopping leaks or the hazard of losing a fitting to a bent or corroded fastener. Nothing lasts forever but keeping a Bertram healthy is a rewarding step towards its long life. Elderly Bertrams are treasures for restoring. Bertram Yacht is now owned by the Ferretti Yacht Group. A Bertram is still among the best in class by anyone’s definition. Here are some Bertram contact information, tel: 305-633-8011; service: service@bertram.com; parts: parts@bertram.com; web: www.bertram.com. [Ed: For additional information refer to Pat’s article on used boats on page 42 in this issue.]
— *Patricia Kearns*

Tech TIPS

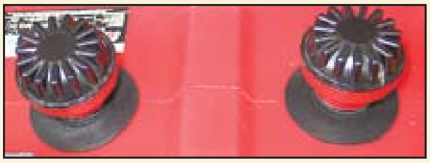
Four connect rule: ABYC Standard E.11.16.5.1.11 states, "No more than four conductors shall be secured to any one terminal stud." It's likely that vibration will loosen the one screw that holds the negative wires affixed to the grounding post (below) on the hour meter. Best to relocate terminals on a busbar (bottom photo).

Hold the fries: White vinegar's natural antibacterial properties make it an excellent cleaner. Mix at a ratio of 5 parts water to 1 part vinegar and clean counters, stoves, tables, handrails, mirrors and wood surfaces.
Richard Asztalos, Livonia, Michigan

Vent cleaners: Old-fashioned wire-cored pipe cleaners do a great job of cleaning debris and spiders that would otherwise clog the small screens on tank vents.

Paint better than barnacles: It's now an acceptable practice to apply a very thin coat of antifouling paint to the face of a depthsounder transducer. It won't cause erratic readings and is certainly better than sea growth.

Ship alert: Stow a searchlight or at least three white collision flares in a halyard stowage bag in the cockpit so the light and/or flares are readily accessible when needed and there's no time for burrowing in lockers.
Hal Roth, "Whisper," St. Michaels, Maryland



Reduce battery gassing: Charging causes a lead-acid (wet cell) battery to heat up and sometimes, in overcharging, to "boil" and release hydrogen and oxygen gases that reduce the water level in the cells (you need to top up with distilled water) and vent smelly sulphuric acid (the electrolyte). You'll save yourself maintenance chores and boiled to death batteries by replacing the conventional battery caps with hydrocaps. Hydrocaps catalytically recombine the hydrogen and oxygen gases given off during battery charging and turn them back into pure water for the battery. At US$14 or less each (times six for a 12-volt battery), they are not cheap but if you're not diligent about checking your lead-acid batteries at least once a month and the water goes down below the top of the plate, the cost of the caps will reward you with healthier batteries and easily recapture the expense to replace the batteries you ruin pinching pennies on the cap cost.

Keep 'em onboard: To prevent deep sixing any "tool" that you use to collect water (bucket) or fend off (boat hook) or scrub the decks (mop), attach to it a length of shock cord with a carabiner hook on the end and clip this hook over the lifelines.

A bright idea: Replace burned out panel indicator lights with 12-volt, US$4, LED lights from Radio Shack, part number 276-270, that draw 15mA and fit in a 9/32" (7mm) hole. To each lead, crimp on an extra 12" (30cm) length of wire, heat-shrink the joints for a waterproof installation and then cut to length when installing.
Doug Booth, Kingston, Ontario

Flush and clean: To eliminate odors created when using seawater to flush the MSD (toilet), install a tee fitting and seacock into the water intake hose, shut off the seawater supply, fill up the head sink from the boat's freshwater supply and flush the head as needed. Add some Oxy Clean to scrub out the system (check first with the toilet manufacturer for compatibility with rubber components). [Ed: Carefully replumb the fittings so you don't send (or allow) sewage into the potable water system.]
John Dawson, Westville, New Jersey

Drilling hardwood: When drilling a hole in teak or mahogany, be sure to pull your drill bit back out every few seconds to extract the drill filings and keep your drill from over heating.

Non-scratch snow (and fish) removal: A large plastic storage container or a plastic bucket, is a great tool for removing several feet of snow from a boat's deck for it won't scratch gelcoat or teak decking. Also works great for removing wayward fish.
Bob Bea, Moraga, California

Easy foam cutting: An electric cutting knife easily glides through foam when you need a custom fit for cushions.

Tech Tips Wanted

Do you have a boat-tested tip or technique? Send us a photo (if available) and a description, your name, boat name and homeport and mail to:

DIY TECH TIPS
P.O. Box 22473
Alexandria, VA 22304

Or E-mail it to:
info@diy-boat.com.

Reader tips are not tested by DIY, but we won't publish anything we feel might harm you or your boat.

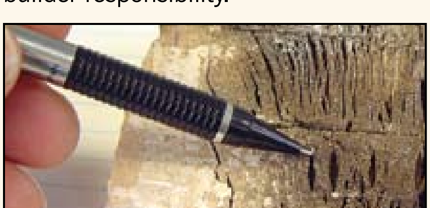
PRO SERIES

Core Doctor

Balsa, plastic foam and plywood cored decks and hulls can be slowly poisoned by the insidious infiltration of minute amounts of water over the years. You can avoid problems by applying proper techniques to install new hardware and reseal any leaking hardware now. It's better late than never!

Story and photos by Nick Bailey

Wet core is extremely common in older fiberglass boats and has, perhaps unfairly, given the whole concept of cored laminates a bad reputation. I'm the guy in the repair business who often is seen as wearing the black gown when I have to be the bearer of bad news about sandwich fiberglass laminate core damage. The marine surveyor's report lands on my desk containing the dreaded phrase, "Suspected core separation with high moisture meter readings…" and, for many of my customers, that survey report inspires an intense discussion of "everything you wanted to know about cores but were afraid to ask." It's one of the grimmer aspects of boat repair and maintenance 101. Once the full significance of the surveyor's findings is explained and after the wailing and lamentation ends, the first reaction is to blame the boat builder. Since almost every fiberglass deck built in the last 35 years contains some kind of core material, my unhappy customer's 1985 WaveWacker 24 is no exception. In this case, the warranty lapsed 19 years ago and there have been four previous owners. The condition is far removed from builder responsibility.



Bad news core shows water saturated balsa core beginning to rot. Note how the water damage followed an unfilled kerf, an opening in the core that acts as a water channel, allowing moisture to spread into the core. The water originated at a nearby leaking handrail fastener.

Despite appearances to the contrary, cored laminates were a revolutionary development in the early days of fiberglass composite construction and are still an essential element today. The use of a lightweight core sandwiched between fiberglass skins solved the problem of how to build a rigid panel out of flexible fiberglass without it weigh in like King Kong. The simple fact is you can't really build a decent boat larger than a daysailer or a simple launch without using core, especially in the deck. Cored construction has proven to be essential not just in boats but anywhere a high performance (i.e. strong and light) composite structure is needed. From aerospace to Indy cars to America's Cup yachts, cored laminates are the norm, not the exception.

Good core shows the underside of a balsa and glass deck panel in good condition. Note the (mostly) resin filled kerf.

Inevitably the next question is "How did it come to this?" Although original construction quality has a big influence on how quickly water spreads in core, the more relevant question is "How did the water get in?" This puts the responsibility firmly back into the hands of the boat owner's seasonal maintenance (or the

"Neverbond" or dry delamination where the upper glass skin bridges between two mismatched pieces of core depicts an original construction problem that allows water to spread quickly through cored laminates.

One of these fittings is leaking. Note the moisture meter pegged at full-scale reading.

lack of it). A quick look with the moisture meter usually leads us to some mundane fitting such as a cleat. It may have been correctly installed at the factory decades ago but it worked loose and has been leaking unnoticed for years. Now there is a 25 sq. ft (2.3 sq. m) area of deck that pegs the moisture meter and 9 sq. ft (.83 sq. m) adjacent to the cleat that sounds really soft under his hammer. Although wet core without delamination may not affect structure much (see "Wet Core Can Survive" on page 22), the insurance company requesting the survey is not impressed by the punky delamination discovered and refuses coverage until it's fixed. Then the marina refuses the mooring until it's insured. And the cost of repair is $5,000 (thus the wailing). All because of one leaking cleat. [Ed: A load bearing cleat can let go under strain when the deck supporting its fasteners has degraded. The insurance company's concern is well found.]

Read on to find out some of the techniques used by professionals to install new or reseal existing hardware mounted on cored laminates. These techniques help to minimize or even eliminate the

FIGURE 1

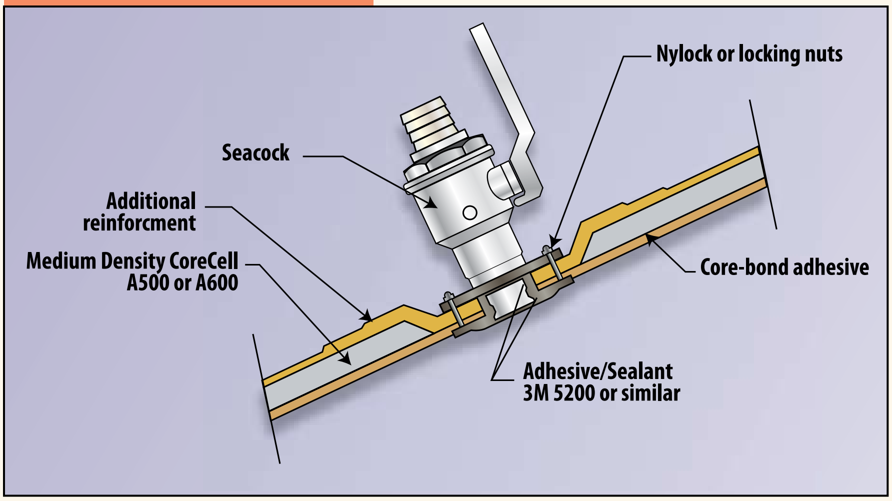


Diagram shows the preferred single-skin hull construction at a thru-hull.

possibility of water entry and expensive core repairs in the future.

Installations Below the Waterline

Any fittings installed through the hull below the waterline require more elaborate precautions due to the constant presence of water under static head pressure.

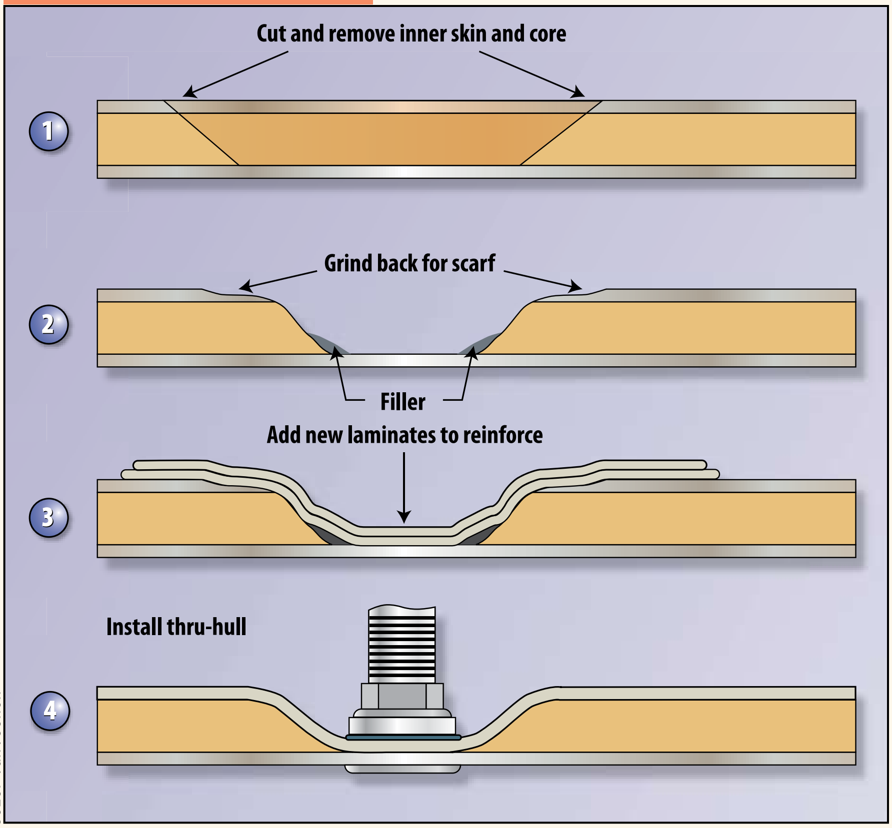
When faced with a thru-hull installation into a cored hull, the best option is to find a core-free location, an area prepped by the boat builder without core, where the inner and outer skins are brought together to form a single skin (**Figure 1**). To find these areas, look for a dip or recess in the inner skin approximately 0.5 to 1" (12mm to 25mm) deep and 12 or 24 sq. in (7.7 or 15 sq. cm) in area. A fingertip probe works well in hard to see areas. If in doubt, look for the areas where good builders revert to single skin at thru-hull installations or they reinforce those points to seal off the core at the opening for the installation. To put a knotmeter thru-hull into a fin keel sailboat the technician looks for solid laminate on centerline a few feet forward of the keel. On a powerboat the forward part of the engine room is a likely location.

If there are no single skin areas at the desired location, the core must be removed as part of the thru-hull installation. Professionals know you absolutely cannot just drill a hole in a cored hull, tighten it down install a thru-hull fitting, apply some sealant and walk away whistling. It may not leak tomorrow but it's guaranteed to allow water into the core sooner or later. A well-built hull can survive this abuse with only localized wet core but I have seen lesser hulls, built with lots of unfilled gaps in the core that ended up water-saturated write-offs within a few years. There are two common methods of removing core from adjacent to the thru-hull. The first option is to form a single skin area; the second is to replace the core with filler.

Option 1: Make a Single Skin

After shrouding and masking the boat's interior against glass dust, cut the inner skin at a 45° bevel angle using a mini-grinder fitted with a diamond-edged cutting wheel (**Figure 2**). Alternatively, use a high-speed die grinder or even a coarse grinding disk applied edge on. The inner skin cutout measures approximately 8" to 12" (20cm to 30cm) square. It is okay to cut well into the core but take great care not to damage or cut through the outer skin. Pry off this skin panel to reveal the core. Remove the exposed core to uncover the inner surface of the outer skin. A well-bonded core may need to be chiseled out. Prepare the cavity and edges to accept the new glass laminates that replace the removed skin. Use a grinder with a coarse disc to remove any surface paint and bevel the inner skin out to about 3" to 6" (7.6cm to 15cm) from the cutout. Presuming the inner skin is .125" to .25" (3mm to 4mm) thick, this bevel should provide a generous scarf ratio (minimum is 12:1)

FIGURE 2



Steps to create a single skin thru-hull.

CONTENTS/ PREVIOUS/ NEXT/

to ensure a good bond between the new and old glass. During prep grinding, scuff the inner surface of the outer skin to remove core remnants and key the surface for bonding to the new glass. Round the corners and top edges of the cutout with the grinder. It may also be necessary to apply a fillet of resin thickened with colloidal silica around the bottom perimeter and corners of the cutout so the new glass is not required to turn any sharp corners (mix the filler to consistency equivalent to creamy peanut butter). Prep sand and deburr any fillet work, vacuum up the dust and wipe the work area clean with acetone as the final step prior to applying the glass for the new inner skin patch.

To preserve hull strength, the new glass skin should be the same thickness or more than the original and use alternating layers of 1oz to 1.5oz chopped strand mat and 18oz to 24oz woven roving. Alternatively, use a Stitchmat made up of a combination of similar weight mat and roving. If the inner skin was .125" (3mm) thick, expect to use at least three layers (mat-roving-mat) or a single layer of 1810 or 1808 Stitchmat plus an extra layer of mat. Scale up this rudimentary laminate schedule for more thickness as required.

Lay-up procedure is in keeping with standard laminating practice. Observe all resin safety and temperature requirements. Precut and dry-fit the glass layers. Graduate the size of the layers: the smallest goes in first with each succeeding layer 1" or 2" (2.5cm or 5cm) larger. If more than one layer of roving Stitchmat is used, change the roving orientation 45° with each new layer. First, thoroughly wet the cutout and any exposed core with resin. Pre-wet each glass layer prior to applying. Chase out any bubbles in each new layer with a brush, bubble buster roller or squeegee before applying the next layer. After cure, lightly grind or sand with 60-grit sandpaper to remove surface bumps. Vacuum up the dust and wipe the surface clean with acetone. Apply epoxy paint or air-dry gelcoat to match the rest of the inner skin, if appropriate. After the coatings have cured, install the thru-hull in the center of the new core-free recess in the usual way including a backing block and lots of polyurethane sealant.

Option 2: Replace the Core with Filler

This technique (often referred to as "potting") is less elaborate than creating a single skin laminate but is still effective if properly executed.

The thru-hull hole is cut through both skins by using a holesaw after first drilling a pilot hole. In order to avoid ragged edges, bore through the inner skin from the inside and the outer skin from the outside. Once the holesaw coupon has been removed and the core revealed, excavate the core away from the edge of the hole to a depth of at least one hole diameter. For example a 2" (5cm) diameter hole should have the core excavated from around the edge of the hole to a depth of about 2" (5cm). Removal is done manually with a hooked tool or with a power tool fitted with a rotary cutting bit. Expect healthy core to put up stiff resistance to removal. After removing the core to the appropriate depth, it's important to scrape away any residual material adhering to the inside surface of both skins and then prep sand surfaces with 60-grit paper. It's very important that there is a solid bond between the skins and the filler and there is no opportunity for moisture to wick along a piece of core debris and bypass the filler plug.

After cleaning, thoroughly wet the exposed core and inner skin with resin. Prepare a mayonnaise consistency filler mixture of resin, colloidal silica and chopped glass fibers (for crack resistance). Grout this filler into the cavity and work thoroughly into place with a probe (i.e. fillet stick, awl, screwdriver, etc.) to ensure any voids are filled. When the filler cures, sand it to achieve a good fit with the thru-hull and install the fitting.

Installations Above the Waterline

Deck hardware is subject to all manner of mechanical stresses and strain as well as the effects of exposures to the elements.

After removing core, the gap between the skins is grouted with chopped fiber and resin.

Any hole larger than a bolt elevates the risk of water entry. Items such as deck plates for fuel, waste or water, ventilators, ports, recessed instrument displays and chainplate openings (sailboats) all require openings that expose the raw edge of the laminate. Exposed core is an open invitation for water entry and time has shown that cutouts are a serious problem.

There is only one guaranteed technique: dig out the exposed core at the cutout and pot it with chopped glass filler using a method similar to the one described for below the waterline thru-hulls shown on page 19. If the hardware also has screws or thru-bolts within reach of the cutout, excavate the core and "pot" to these fasteners and beyond. If done properly, water will never enter the core again, regardless of whether the fitting leaks into the cabin.

Fastener Hole Options

The odds of a fastener leaking depend on the installation technique and the loads a particular piece of hardware must sustain.

For hardware under light to medium loads (screwed or thru-bolted), some

To prepare to pot a fitting remove the core with a rotary cutting tool.

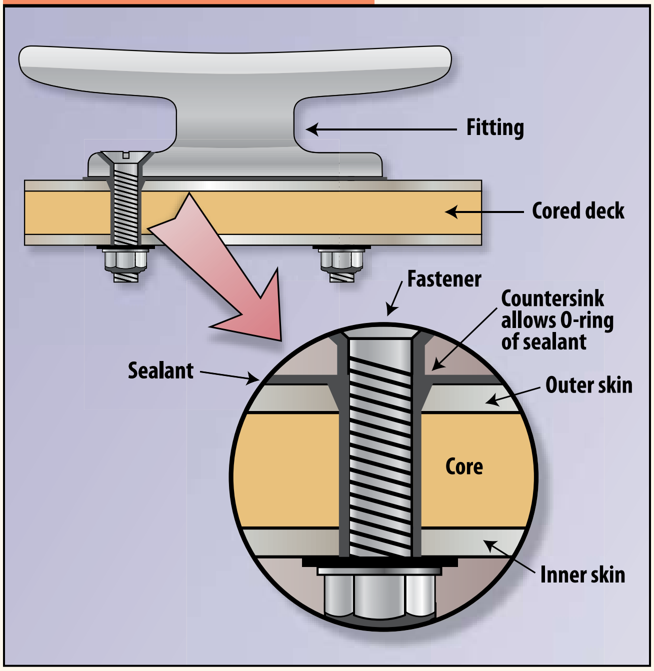
A deck cutout after potting with solid glass.

small improvements to basic bedding techniques provide adequate leak protection. Before applying sealant use a countersink bit or a drill bit twice the diameter of the fastener to countersink the gelcoat slightly at the fastener hole (**Figure 3**). This creates a recess that holds sealant next to the fastener, in effect creating a tiny O-ring. [Ed: As a secondary benefit, countersinking a hole also prevents cracking that would otherwise radiate out from the gelcoat at the hole.] Use a toothpick to work the sealant into the fastener hole and put a generous dab of sealant into the hole and also onto the fastener threads, working it into the threads. If a thru-bolt, do not rotate the bolt after it's inserted. The rotating threads act as an auger, stripping the sealant out of the hole. Keep the bolt fixed and tighten by rotating the nut. With respect to bedding compounds, silicone sealant is okay for light duty fittings but polyurethane (i.e. 3M 4200 or 3M 5200) is better and is the only sealant to use when rebedding existing hardware where the core is already damp as is often the case when playing catch-up to leaks.

A better method is the potting technique (**Figure 4**). Hardware under high loads is more likely to squirm around, break the sealant and start to leak. The problem is attacked from two different directions. First, address the security of the fastening method. Use the highest adhesive strength polyurethane sealant (3M 5200 or Sikaflex 252) with backing plates (or at least large fender washers) to better clamp the deck and distribute the loads over a wider area. Use only locknuts. As compression loads increase, a point is reached where the core itself may start to compress. This causes fasteners to loosen and fittings to shift leading to failure of the sealant bond and leaks. To help cores survive under working hardware requires a second line of defense. This demands potting the fastener holes to replace the core around the fastener with solid epoxy resin. This is superior to the simple bedding techniques outlined above for two reasons. First, the epoxy "sleeve" formed around the fastener adds strength under compression allowing tightening of fasteners without crushing the deck. More important is that it also prevents leaks into the core even if the sealant at the fastener fails. Unfortunately, this technique won't work if the core is already wet.

The usual potting procedure uses epoxy resin, because it's stronger and

FIGURE 3



Adding a slight countersink to a drilled fastener hole provides room for more sealant as well as prevents fiberglass from cracking.

shrinks a bit less than other resins, and follows these steps.

1 Drill a pilot hole as a guide (unless you are dealing with an existing hole). Put masking tape over and around the top of hole in anticipation of epoxy drips.

2 Select a Speedbore bit or a small holesaw. Recommended size is three times the fitting's fastener diameter. To minimize cosmetic issues try to keep the potting hole hidden under the footprint of the fitting.

3 Bore down through the tape, the outer skin and core. Stop when you feel the tool bottom out on the inner skin or measure the depth you need and mark it with tape on the bit.

4 Mix up a batch of epoxy resin and a little chopped glass or, even better, cotton powder plus a small amount of

WET CORE CAN SURVIVE

At the recent annual general meetings of both yacht surveyor organizations NAMS and SAMS, scientific studies were presented with some good news about water problems in cores.

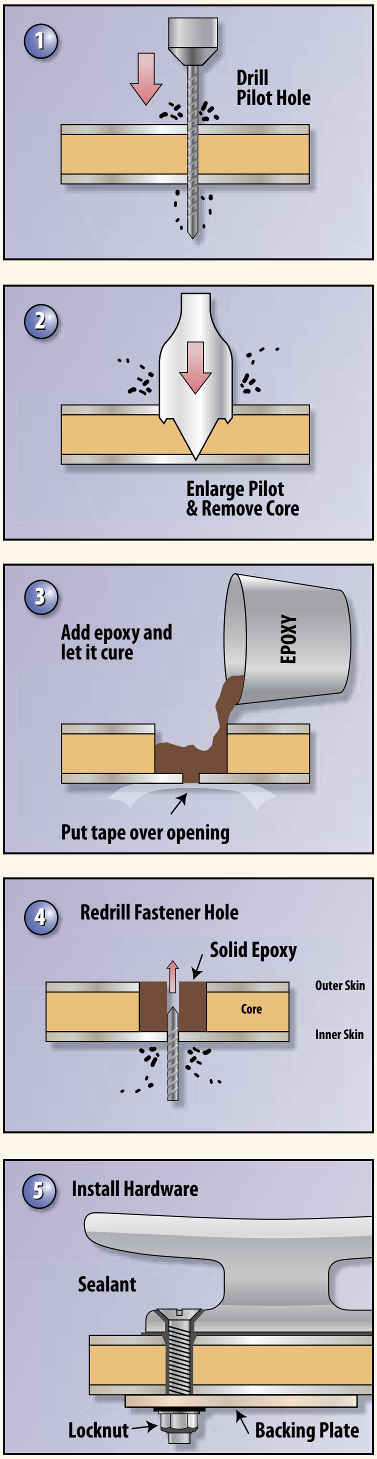
If no one ever had reason to drill a hole into a cored laminate we would not have all these problems today. Contrary to popular belief, scientific studies (1) have shown that core, be it end grain balsa, plastic foam or plywood, does not absorb water directly through the laminate skins below the waterline even when osmosis blisters are present. I can also add from my own practical experience that deck core will not absorb water through mere hairline gelcoat cracks. Water gets into core through cracks and openings that fully penetrate the glass skin. These can be accidental punctures but are typically holes made for fittings and hardware. Keep these openings sealed and the core will survive indefinitely. The source of water intrusion is yours to control.

Another study using balsa core (2) showed that even after the core has become wet, provided the core has not separated from the bonded skins (delaminated), it suffers only a moderate loss of strength. If there is an area of high moisture that still sounds firm under the surveyor's hammer, there is no immediate reason to cut open the deck. Seal off the source of water to stop water entry and help preserve the core.

According to Rob Mazza, an engineer and yacht designer with Alcan Composites (manufacturer of Baltek balsa cores), wood cores in general, including balsa but also plywood, only rot when there is a supply of fresh oxygen available. The wood eating microbes and fungi require food (wood), moisture and oxygen. Cutting off a source of any one of the three prevents the growth of rot. If you catch a leaking fitting early enough and reseal it to prevent further entry of water and air, the balsa core survives and deterioration is prevented. — *NB*

1 "14-Year Sandwich Panel Moisture Permeation Study," by K. Feichtinger et al. Copyright 2001 by Baltek Corporation.
2 "Shear and Compression Properties of End-Grain Balsa as a Function of Moisture Contents," by K. Feichtinger et al. Copyright 2005 by Alcan Composites.

FIGURE 4



Jozef VanVeenen

Potting fasteners in core.

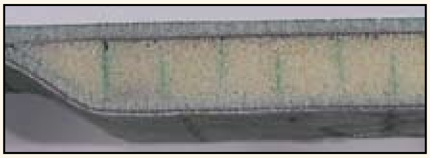
collodial silica (you want a thick syrup).

5 Tape the underside of the hole to prevent drips into the interior and pour the mix into the hole until it's brim full. Use a toothpick or similar probe to work out any trapped air and work the epoxy into the core around the perimeter. Don't knock the tape at the bottom loose. Top up the epoxy if needed and allow it to cure.

6 After fully cured, drill a short distance into the center (from the top) of the epoxy with an undersized pilot bit. Go below and drill the rest of the way up using the fastener hole in the inner skin as a guide. If all goes well your pilot holes will meet nicely. Bore the fastener hole to full size and proceed with hardware installation using the bedding techniques recommended above.

Eliminating all core at the hardware locations is absolutely the best installation method. The most impervious hardware installations take place on decks where there have been major core repairs and there is an opportunity to re-engineer the deck by replacing core in the hardware locations with solid chopped fiber and resin (**Figure 5**). This method totally supports the "better than new" standard for the installation. It adds some weight but it's non-compressible and never allows water into the core. Unfortunately, this is not usually a practical option unless major deck repairs are already ongoing.

Many builders are taking pains during new boat construction to avoid core in areas where there will be hardware installed. If boat builders take steps to reduce

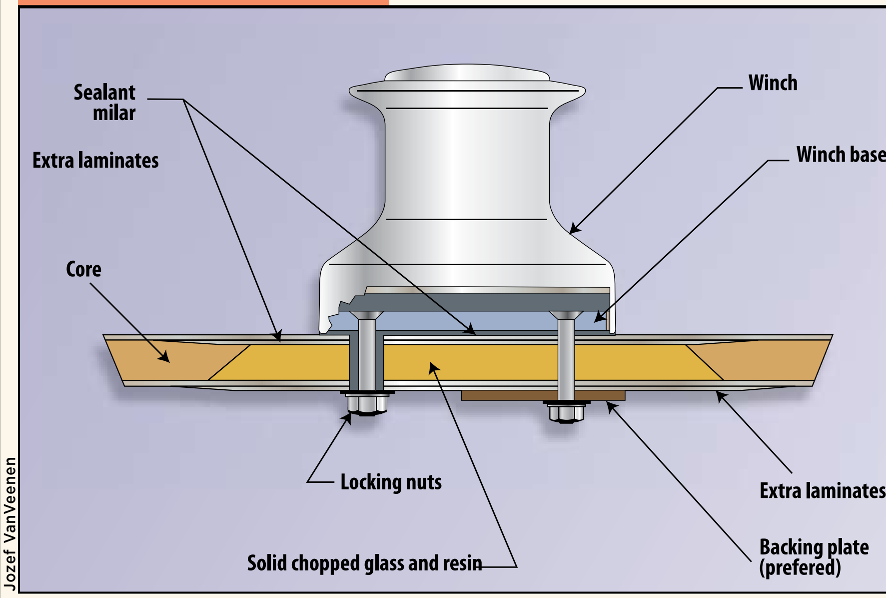


Underneath hardware on C&C and Tartan sailboats, which are constructed of 100% epoxy resin vacuum bagged with E-glass, carbon fiber and cored with CoreCell foam, the core is removed and replaced with a piece of aluminum flatbar.

the risks of poor maintenance, the repair business could lose a revenue source and end the rending of garments, wailing and gnashing of teeth that takes place in front of my desk.

About the author: Nick Bailey is DIY Magazine's repair specialist and has spent 26 years in the boat repair business. He is the service manager at Bristol Marine in Mississauga, Ontario. He crews for his skipper wife on their Thunderbird, "Looney Tunes," which doubles as their club's float in the local Easter parade with both of them in the cockpit entertaining the crowd.

FIGURE 5



Jozef VanVeenen

High load hardware is best mounted on solid glass or on high-density core.

NICK'S TOP 10 CORE KILLERS

1 The aftermarket thru-hulls. Damage is most common where the cored hull construction is iffy to begin with or has no single skin location designed to accommodate additional thru-hulls.

2 The ubiquitous never stay sealed shroud chainplate. If the deck core is exposed at the chainplate cutout, water will enter the core here and migrate along the side decks.

3 The one-design sailboat crew. An oft told tale of the elderly one-design racing sailboat mortally wounded by overzealous crewmembers forever rearranging the deck layout to copy last year's winning boat. Of course, properly fixing the old holes or properly sealing the new ones may not be the crew's highest priority.

4 Death by cover clips at those screw holes for snaps and turnbuttons. These fittings leak into the core for years without symptoms because the holes may not even penetrate the inner skin. Deterioration requires a moisture meter to spot.

5 The amazing back-to-back blind fastened cabintop handrails can leak for decades because most people can't figure out how to remove and reseal them.

6 The truly remarkable deck breaker, otherwise known as the deck-mounted lifeline stanchion. The result of much brilliant R & D, this destructive pry bar is particularly effective in the hands of the aforementioned one-design sailboat crew where the entire group throws themselves violently against the lifelines while roll tacking and jibing. This tool's specialty is structural delamination; moisture entry is merely an added side effect.

7 Why do waste, water and fuel deck plates leak? Here, water is immediately absorbed by the exposed edge of the core. Solar vents, window and opening port cutouts all utilize the same sneaky water invitation into the core without conspicuous dripping technique. Nasty stuff that can't escape detection with a moisture meter.

8 That legendary foredeck killer, the unsealed anchor chain hawsehole. It sometimes lurks unseen and inaccessible beneath the anchor platform. Unless you are prepared to remove the windlass and anchor platform, it can only checked from the underside of the deck.

9 The tiny but vicious interior screw. This seemingly insignificant fastener penetrates the inner hull skin in a wet part of the bilge that just happens to be cored.

10 Last but not least are the dreaded trim-tab mounting screws. These overstressed and leaky little nasties, together with their other fastener brethren have saturated powerboat transoms and created an entire specialist repair industry.

— NB

A Calculated Approach to Proper Gear Ratios

Many modern diesels available for displacement powerboats and sailboats are offered with transmission and gear ratio options and matching the transmission, gear ratio and the propeller size is an important part of getting the best performance from the power package you select. Follow these steps to determine the proper engine power rating, transmission gear ratio, propeller diameter and shaft diameter for your boat.

By Robert Hess

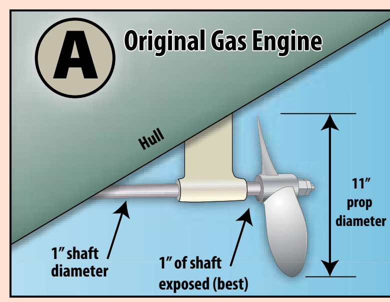
Inboard marine engine manufacturers usually list several optional transmission reduction gear ratios for each engine model. "Ratio" in this context is the number of revolutions (rpm) the engine crankshaft must turn to rotate the shaft and propeller a specified number of revolutions. In other words, the engine gearbox acts as a reducer to convert the engine crankshaft rpm to a lower or higher number of shaft rpm. Common ratios include 2:1 (a standard for many applications), 3:1 and 1.5:1. The familiar 2:1 ratio is not always the best choice but is often recommended because it's an easy way, albeit often not the best way, to get on with the task of putting the engine, transmission (gearbox), shaft and prop package together. The boat owner, the power products' salesperson and even the installing technician may not have a full understanding of the factors that come into play in this mating of the equipment components in the power train.

Why are engines offered with different gear ratios? The Universal M3-20B, for example, is available with five ratios: 2.05:1 (standard), 2.13:1 (V drive), 1.48:1, 2.5:1 and 3:1. Which one is going to fit your Catalina 30 when you buy a new M3-20B to replace the original Atomic Four? Do you just purchase the engine with the standard transmission gear ratio?

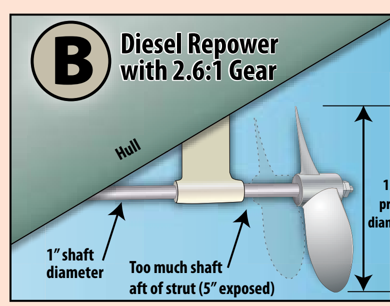
Many older sailboats (Alberg, Catalina, C&C, etc.) were designed for small, low-power auxiliary engines coupled with small propellers. Boat designers allowed only enough space for small propellers to clear the bottom of the boat hull or, for sailboats with a full keel, the propeller aperture in the keel and/or the rudder. This design limitation can be a problem when installing a replacement engine that drives a larger diameter propeller required for a diesel engine with a reduction gear. It's also the main reason manufacturers offer several options for transmission gear ratios since higher ratios use smaller diameter propellers, lower ratios use larger

GEAR RATIO PROPORTIONS

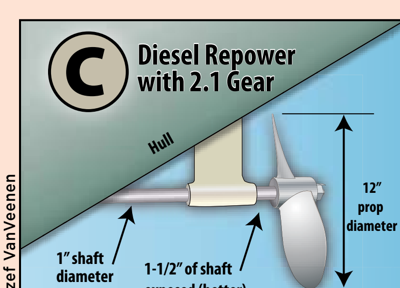
Given the same approximate engine power, the recommended diameter of the propeller is governed by how fast the motor is designed to spin the propeller. Most sailboat engines put out their maximum power between 3,000 rpm to 3,600 rpm. The speed the prop turns is determined by what transmission is fitted to the engine. It may be a direct drive with a reverse gear only or it may have a gear reduction ratio. Direct drive spins the prop at the same speed as the engine crankshaft. A 2:1 reduction gear transmission spins the propshaft at half the engine speed. The faster a prop is rotated the smaller the prop diameter must be to avoid overloading and bogging down the engine prior to achieving its rated rpm. If everything else is equal, the larger the gear reduction, the slower the shaft speed and the bigger the required prop. This can present problems with hull clearance if repowering from a small, high-speed propeller (as are many direct-drive Atomic 4 installations) to a modern diesel, which invariably come equipped with reduction gears in several sizes. Many modern diesels offer a variety of different gear ratios so it's important to choose a transmission ratio for the new engine that causes the least headaches with prop size. — *Nick Bailey*



Example A: For an original direct drive (1:1) gas engine, such as an Atomic 4, producing 30 hp at 3,000 rpm and with a shaft rpm of also 3,000 rpm, the correct prop size is 11" diameter.



Example B: A new diesel engine rated for 27 hp at 3,400 rpm with a 2.62:1 transmission reduction gear means a lower shaft rpm of 1,300 rpm and requires a larger prop to utilize the engine power at low shaft rpm. Unless the shaft is abnormally long, the larger prop will not clear the hull.



Jozef VanVeenen

Example C: Same diesel but with a smaller 2:1 gear ratio outputs 1,700 shaft rpm, which allows a smaller prop and a more appropriate shaft overhang aft of the strut.

Note: All figures are estimated and represent typical cases. Use the formulas contained in this article for actual calculations.

diameter propellers. If the correct diameter propeller cannot be fitted and a smaller diameter propeller is substituted, the new engine never performs properly.

In some cases, the correct diameter propeller can be fitted but, because the propeller shaft was sized to match the original small auxiliary engine, it may not be sufficient to handle the extra power of the new engine. Because propeller shaft diameter is related to propeller diameter, which is related to gear ratio and engine power, it must also be considered when selecting the gear ratio for a new engine. Changing propeller shaft diameter is best avoided for it may involve replacing several expensive components such the stern tube, packing gland, strut, cutlass bearing, engine coupling, prop, etc.

Selecting the proper engine power rating, transmission gear ratio, propeller diameter and shaft diameter for your displacement powerboat or sailboat begins by first computing the specifications as shown in **Table 1** (on page 28). Determining the optimum shaft horsepower is the next step. There are many methods and formulae used to calculate the optimum horsepower of engines as outlined in **Table 2**. The figures these methods produce vary between estimates of the power necessary only to get the sailboat away from the dock so the sails can be raised, the power required to reach boat hull speed in flat water and the power needed to allow long periods of running near hull speed in the open ocean in heavy weather conditions.

Once you have calculated the recommended new engine horsepower rating, it's time to contact dealers for the engine brands you are considering and request brochures for the models with horsepower ratings close to your calculations. Create a paper or computer spreadsheet to record your data and calculations. Note the gear ratio options for each engine. Now you'll need to calculate the shaft rpm for each of the available gear ratio options per **Table 3** (on page 29).

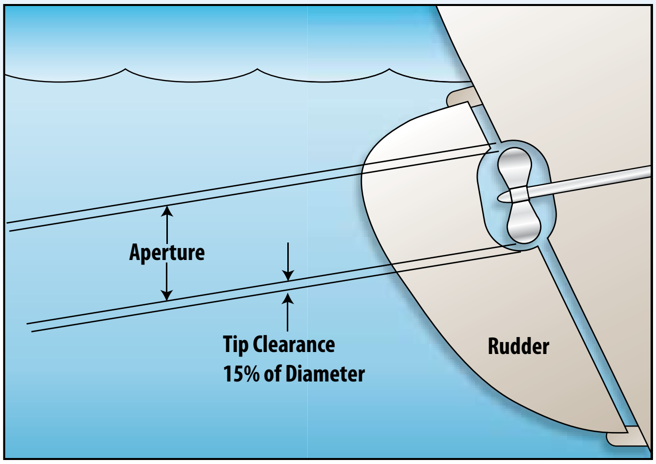
The next step is to calculate the propeller diameter for the maximum shaft rpm available from each gear ratio. The shaft horsepower remains the same for each engine. The formula for this is 632.7 x shaft hp^0.2)/shaft rpm^0.6 + 2" for a 2 blade prop. To simplify, I usually use the Bomon propeller diameter chart available at www.bomon.com/jprop/images/prdiadet.gif. Since chart recommendations are for three blade props, add 2" to convert the specs for two

Sacha

blades. These diameters are about 1" less than calculated propeller diameters but the specs seem to work very well with low-drag sailboat props. Consider this example using a gear ratio of 1.5:1, shaft horsepower of 20 hp and shaft rpm of 2,400 rpm. Plug these numbers into the formula above and you arrive at a 12.8" diameter, two blade prop (Bomon chart specifies a 12.5" two blade). Changing the gear ratio to 2.5:1, same horsepower and shaft rpm of 1,440, computes to 16.67" two blade prop (Bomon chart is 15.5"). You can see that the results are tolerably close.

Standard sailboat propellers have either two or three blades. Fixed two-blade propellers typically have slightly less drag under sail and so are fitted on racing boats, while three blade props have slightly better thrust, better performance in reverse and less vibration and they're often fitted on boats used for cruising.

Albeit you plan to fit a three-blade propeller, the engine



Jozef VanVeenen

Details of aperture and tip clearance on vee-bottom boats.

power and transmission ratio are selected based on a two blade propeller fitting the aperture since this prop is normally larger than a three blade mounted on the same shaft. In other words, by preparing for the installation of a two-blade propeller, we're simultaneously ensuring a three-blade prop fits too, and thus allowing for a future changeover. Where no space exists for a two-blade prop of the correct diameter and you can not (or will not) change the engine transmission specification, then fit the correct three blade. Should you decide to upgrade to a low-drag prop you'll have to fit a feathering type. [Ed: A discussion on feathering versus folding propellers and the performance differences of two-blade versus three-blade props appears in the next issue.]

Before determining the optimum propeller diameter, you need to calculate the minimum tip clearance. This is the distance from the end of the propeller blade to the closest surface, such as the bottom of the hull or, for boats with a keel and/or rudder aperture, the edges of that opening. For vee-bottomed boats, the tip clearance is 12% of propeller diameter, 15% for flat-bottomed boats. Most displacement hull powerboats have vee bottoms, as do many sailboats, though many sailboats and some motoryachts have a flat

TABLE 1

Step 1 Measure Boat and Record Data or Use Manufacturer's Data

Overall length in feet: LOA
The overall length of the boat as measured in a straight line from bow to stern at the longest points.
Example: LOA = 32'

Length at the waterline in feet: LWL
The length of the boat in a straight line from bow to stern at the surface of the water with a normal load.
Example: LWL = 24'

Displacement (weight) in pounds: D
The weight of water displaced by the boat when resting in the water with a normal load.
Example: D = 9,100lb

Propeller aperture in inches
2 x the distance from the propeller shaft centerline to the bottom of the hull directly overhead at the propeller hub forward position, which is located 1.5 x shaft diameter behind the cutlass bearing or the total diameter of the propeller cutaway in the rudder, keel or hull.
Example: Prop Aperture = 16"

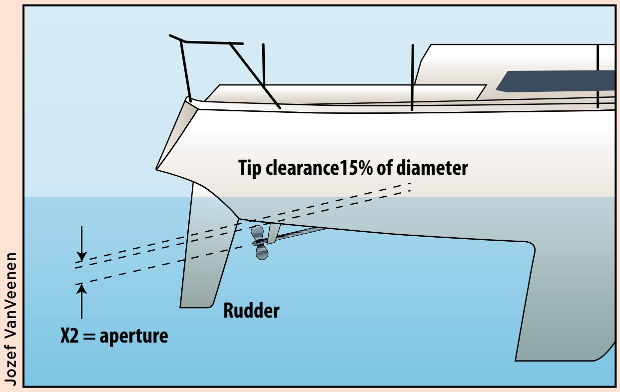


Diagram shows proper measuring of aperture.

Step 2 Calculate Critical Parameters Using the Boat Data

Calculated Displacement in long tons
Formula: Displacement/2,240
Example: Sailboat with displacement of 9,100lb = 9,100/2,240
Displacement = 4.06 long tons

Calculated maximum hull speed
Formula: (1.34) x (LWL)0.5
Example: Sailboat with waterline length of 24' = 1.34 x (24)0.5
Maximum Hull Speed = 6.56 knots

TABLE 2

Step 3 Estimate of Engine Power Based on Rules of Thumb

To estimate engine power using the boat specifications garnered from Table 1 and one of the following formulas:

Method 1
1 hp for each foot of boat length overall (LOA)
Engine power estimate (32' LOA) = 32 hp

Method 2
1 hp for each foot of boat length at the waterline (LWL)
Engine power estimate (24' LWL) = 24 hp

Method 3
2.5 hp per 1,000lb of displacement for offshore
Engine power estimate (2.5 x 9,100/1,000) = 22.75 hp

Method 4
5 hp per long ton of displacement
Engine power estimate (5 x 4.06) = 20.3 hp

Method 5
2 hp for every 1,000lb of displacement for coastal cruising
Engine power estimate (2 x 9,100/1,000) = 18.2 hp

Method 6
3 hp per long ton of boat displacement
Engine power estimate (3 x 4.06) = 12.18 hp

Use this formula to calculate base engine horsepower
Formula: Base hp = Displacement /([150]2 / [Hull Speed]2)
Example: Sailboat with displacement of 9,100 lb 9,100/(22,500)/ 6.56 2) = 17.4 hp base hp

Add Duty Cycle Upsize
Base horsepower upsized for typical engine duty cycle horsepower rating "gross intermittent" to allow continuous use near hull speed
Formula: hp/80%
Example: 17.4 hp/80% =21.75 hp with duty cycle upsizing

Add Transmission Loss Upsize
Horsepower upsized for transmission power losses
Formula: hp + 5%
Example: 21.75 + (21.75 X 5%) = 22.84 hp with transmission loss upsizing

Add Alternator Loss Upsize
Horsepower upsized for typical 100-amp alternator power requirements
Formula: hp + 3 hp
Example:22.84 + 3 hp = 25.84 hp alternator loss upsizing

Total Horsepower Recommendation
Horsepower rounded off to obtain round number for specification
Formula: 25.84 HP -> 26 HP
Recommended new engine hp rating = 26 hp

bottom above the prop. A flat-bottom boat swinging a 14" propeller requires 15% of prop blade tip clearance from bottom of flat hull measured in inches, or 2.1". The total distance from prop shaft center to bottom of hull must be 14"/2 = 7" + 2.1" = 9.1". In most cases, propellers are supplied in even inches, say 12", 13", 14", etc., although they can usually be ordered in 1/2" increments. Assuming your propeller is a standard size; calculate the largest prop diameter that allows for the correct tip clearance.

Prior to making your final selection, you need to verify that the shaft diameter is rated for the chosen propeller. To approximate the minimum shaft diameter, divide the propeller diameter by 14 for bronze and stainless-steel shafts, and by 15 for Monel or Aquamet shafts to calculate the minimum

TABLE 3

Step 4 Calculate Shaft rpm for Each Gear Ratio Option

Using an engine rated power of 20 hp based on Method 4 in Table 3, at 3,600 rpm consider these examples:

Gear ratio = 1.5:1
Shaft rpm at 20 hp = 3,600/1.5 = 2,400 rpm

Gear ratio = 2:1 (often advertised as standard ratio)
Shaft rpm at 20 hp = 3,600/2 = 1,800 rpm

Gear ratio = 2.5:1
Shaft rpm at 20 hp = 3,600/2.5 = 1,440 rpm

Gear ratio = 3:1
Shaft rpm at 20 hp = 3,600/3 = 1,200 rpm

shaft diameter. Note that, if necessary, it's often possible to increase a 7/8" shaft diameter to 1" without changing the strut. Special thinwall cutlass bearings are available that have the same OD, but with a 1" ID instead of the original 7/8". Now that you have all the calculations for the various engines and gear ratios, build a matrix (on paper or use a computer spreadsheet program) to analyze the results and determine the optimum gear ratio. For each engine make, model, horsepower, gear ratio and the shaft rpm at the rated horsepower, record the two-blade propeller diameter based on the Bomon chart, the calculated minimum propeller shaft diameter, the calculated minimum tip clearance (15% plus Bomon chart diameter), the calculated minimum aperture and the measured aperture.

More than likely, your results will provide more than one gear ratio option. Ideally, you want to choose the gear ratio that involves the least amount of additional alterations: retaining the existing propeller shaft and no modifications to the shaft angle or strut to increase the aperture size.

About the author: Robert Hess operates Atomic Four Engine Service Ltd., in Delta, British Columbia, and specializes in sales and rebuilding of Universal, Vetus and Westerbeke gas and diesel inboard engines for sailboats (parts@atomicfourengineservice.ca).

SELF-GUIDED BOAT INSPECTION AVAILABLE ONLINE

Today's Internet technology and digital photography have combined with expert marine surveyor skills to offer boat buyers or sellers and boat owners a complete self-guided inspection of any boat. *Here's how the program works*. You select a full inspection, afloat or out of the water, or a system or group of system inspections, all available in program modules. You are directed on what to look at, where to find it and what you should see and are asked to take digital photographs of certain scenes. Once you order your inspection, you log on to the Marine Recreational Experts Group (MREG) website and download the inspection questionnaire. When you submit your answers and photos, they are reviewed by a certified marine surveyor who emails you a report, complete with observations and recommendations. For a quick tour of the MREG self-guided boat inspection, visit http://survey.marinexperts.com.

ELECTRICAL

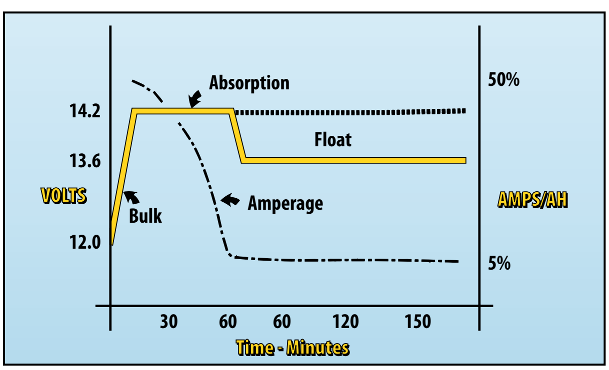
Batteries and Charging FAQ

John Payne, DIY's electrical advisor provides solutions to questions submitted to DIY's Technical Helpline concerning batteries, battery switches and charging systems.

Is 24/7 Charging Okay?

Q: Should I charge the batteries on my boat all the time with the onboard charger while the boat isn't in use?
Doug Alderman, "Southern Breeze," Paris Landing, Tennessee

A: Most batteries can be directly connected to a charger all the time providing the charger is a smart unit with multi-stage charging that automatically shuts off when batteries are fully charged. It's important that the charge rate be a float charge level only, not a full charge rate, such as 14-volts, or your batteries will gas up and boil dry.



Three stages of smart battery charging.

Two Leads Versus Three

Q: I plan to replace the battery charger on my Catalina 36. The boat has one stand alone start battery and two deep-cycle batteries wired in parallel. Is there any advantage to a three-wire charger and connecting one charger wire to each battery? How will the charging be affected in the parallel bank?
Edward Nappi, "Polaris," Douglaston, New York

A: A two lead charger is essentially replacing what you have now. Using a dual output, three-lead charger allows each battery bank to charge simultaneously. This normally requires switching between batteries with a negative lead that is common to both batteries and two output charging leads. Each charging circuit operates independently, so you should have no problems but I suggest you read the charger specification sheet to confirm this. Fishermen with trailerable boats often have this type of battery charger, particularly if they have trolling motor batteries.

Fix for Drowned Batteries

Q: Recently my start and house batteries were completely submerged in freshwater for about two days. How might this submersion impact my batteries?
Jerry Perry, Ahousaht, British Columbia

A: Generally the first thing you should do is to check the battery electrolyte density with a hydrometer. This will determine whether water entered and diluted the acid to a degree where the battery cannot work. If it has and it's a top quality battery, take the battery to a service shop and have it refilled with acid. This option works as long as the actual battery plates are okay.

Check battery electrolyte density with a hydrometer.

Redistributing Power

Q: I have recently purchased a 1989 3288 Bayliner. The factory wiring separates the single start and house battery banks. The port alternator charges the house batteries through a wire run to a four-pole solenoid mounted on the engine starter and the starboard alternator charges the start battery. This solenoid has cables running to both the start and house batteries. Both alternators are wired through an on-off battery switch but there's no switch to join the battery banks in case of a start battery failure. Batteries need replacing as they don't hold much charge and so does the charger, an old transformer type that makes a buzzing sound when on. In addition, the boat is very stern heavy due to optional equipment that has added weight to the boat, making it difficult to get on plane even with 100% trim tabs. I can't easily access the engine compartment because the house batteries fill up the access area under the hatches. To resolve all this, I'm considering buying 400 amp hours of AGM batteries and installing them in the bow along with a new charger. This will give me a 600lb (272kg) weight shift. I would prefer to utilize the power from both alternators more effectively to charge the house bank but I don't know the best way to do this.
George Cartwright, "Pacific," Vancouver, British Columbia

A: My recommendation is to have a set of jumper leads ready. It's normal to have all negative terminals between start and house batteries connected so you only need emergency jumper cables with clips. Maintenance free AGM batteries generally require a more precise output charger than the one you have and transformer-based chargers that buzz or hum isn't a reason to change as they run forever and a hum is quite common. Moving the batteries forward is an uncommon arrangement and does have drawbacks. Because of the distance back to the alternators, you'll need to use heavier gauge battery cables, which adds weight. Battery capacity seems excessive and I suggest you analyze exactly how much capacity is needed. The best solution is to find a midship location for the batteries. This, coupled with fewer batteries will assist with trim problems. Be sure to connect to the alternator with heavy capacity positive and negative cables to eliminate voltage drop. Why a battery switch is used is hard to determine without seeing a circuit diagram and it does not appear to be serving any purpose. I'm unsure why a solenoid unit is there if it doesn't distribute charge between both batteries. A single alternator with a suitable smart regulator will maximize charging and the AGM batteries have a much higher charge acceptance rate than ordinary lead-acid units. It's common to have two alternator arrangements with one feeding the start battery exclusive of the other. I suggest you leave the starboard alternator feeding the start battery as this gives you some charging redundancy. Install a suitable fast charge regulator on the port engine so the alternator can maximize charging of the house bank. [Ed: A boat that is not properly trimmed adversely affects the boat's safety, stability and performance. See "Is your Boat in Trim," in DIY 2004-#1 issue for more on this topic.]

AGM and Outboard Chargers

Q: I'm having a boat built and have ordered twin Yamaha F150 four-stroke outboards. I have been unable to determine whether the outboard alternators reduce their current output as the batteries charge. I'm considering going with AGM batteries for starting and house bank and understand that overcharging could kill them. I called Yamaha and they could not provide an answer. Sadly, they have a policy not to provide technical assistance like this to the consumer. Yamaha says to get answers from my local dealer, which has given me poor information several times in the past.
John Holcomb, "Tough Enough," Anchorage, Alaska

A: All modern outboards have fully regulated charging systems but are designed to charge one battery at a time. In order to protect AGM batteries from overcharging damage, I would advise you to install a battery isolator. This directs the current only to a battery that is discharged and will not overcharge any that are already fully charged. [Ed: For details on selecting and installing a battery isolator refer to DIY 2004-#4.]

Wiring the Negatives

Q: I'm wiring a Xantrex 20-amp battery charger to my two battery banks; namely, one start battery and a house bank that consists of two Group 31 lead-acid batteries wired in parallel. All batteries connect with one ground (two positive leads, one to each bank) to the engine. The Xantrex unit has only one ground that the instructions specify wiring to the battery negative bus bar, which I do not have. Is it okay to wire the negative into one of the two battery banks?
Mark Hoesman, "Mystic Pleasure," Cheboygan, Michigan

A: You have the correct arrangement with negatives wired to each other and the Xantrex negative output can connect to either battery negative point. A negative bus is not that common and often a generic term to mean the negative polarity part of a circuit. In actuality, you usually have a negative bus at the main switch panel for house loads with a single cable going up from the house battery negative terminal. The negative to the engine point goes from the engine battery negative terminal, often called the ground, and this polarizes the power supply.

Blending Charging Voltages

Q: I have a two-bank battery system in my 36' (11m) S-2 sailboat. Bank one consists of two 6-volt batteries in series. Bank two is a single 12-volt battery. When charging these banks, should I set my battery charger to 6 volt or 12 volt for bank one? Where should I connect the battery charger connectors? I also have a "1-2-Both" battery switch. Does it matter what position the switch is set during charging and is there a way to charge all three batteries at once?
David Saunders, "Ursa Major," Cranston, Rhode Island

A: As the two 6-volt batteries are in series to make 12 volts, this should be seen as one 12-volt bank. Set the battery charger at 12 volts for bank one and connect the charger leads across the positive and negative of the combined 6-volt batteries. As the battery switch combines both battery banks, the best option and one I use is to connect the charger across any of the two battery banks and then set the switch to both. This then charges both banks simultaneously.

Voltage Swap

Q: I'm paranoid about discharging my start battery while at anchor. Currently, all loads come off the same feed via fuses and connect to a "1-2-Both" switch with the single start battery at "1" position and two 6-volt golf cart batteries as the house bank at "2." If I forget to switch to "2" position while at anchor, I stand a chance of draining my start battery. I'm inclined to rewire the boat so that the start battery only supplies the engine and the house bank supplies everything else and charge both batteries while running via a battery isolator. What are the current trends in how battery banks are connected? *Geoff Brown, "Nexus," Turkey Point, Ontario*

A: Remembering to switch from one battery bank to another is a common problem yet your configuration is the one that I personally prefer in a boat. Complete separation of house and start battery banks as you describe is best and a very reliable arrangement. The main trend changes have occurred with charging isolators that have gone more hi-tech with smart battery isolators. Otherwise separation via a "1-2-Both" switch remains the most popular.

ELECTRONICS

Illustrations: Jozef VanVeenen

All About Transducers

Here's what you need to know about the construction, selection, installation, routine maintenance and troubleshooting tips of depth, speed, windspeed and wind direction transducers to get the best signal performance.

By John Payne

The transducer and its information input is an essential component of electronic equipment and without them most instruments and systems would not function. A typical boat actually has many transducers, the most prominent ones being the speedometer and log or knotmeter, depthsounder or fishfinder, rudder position feedback on the autopilot, compass input to the autopilot, float switch on a bilge pump, pressure switch on the water system, refrigerator system with pressure transducers and of course, the engine with its temperature and pressure transducers. A sailboat may also have masthead windspeed and direction transducers. Even a GPS is a position transducer to an electronic chart system.

Essentially the transducer converts one value, such as temperature or pressure, which might be a resistance value, into an electrical signal that can be input to a monitoring or control circuit. Signal outputs from transducers are usually classified as digital or analog. In most instrument systems, the analog signal requires conversion into a digital signal for processing.

Temperature sensors monitor coolant and oil temperature. These sensors usually have two wires and are resistance devices. This means that a resistance value is changing and being input to a gauge. Pressure sensors generally have three wires and operate on 5 volts DC to provide a variable DC signal output. The typical operating range is 0.5 to 4.45 volts although some also generate a 4 to 20mA output. Tachometers and speedometers employ a transducer type that produces pulsed outputs from alternators or flywheel sensors or a voltage in generator types. The humble float switch and limit switch is also another form of transducer that gives a simple on or off digital status.

How a Depth Transducer Works

Transducers for depthsounders or sonar are the most common and the ones that cause the most problems. An electrical signal to energize the transducer crystal is generated by an amplifier and then sent by the instrument processor or control circuit to the depth transducer. The energized crystal then reverberates at a predefined frequency and this emits from the transducer as an acoustic output or sound energy. This energy or sound wave creates oscillation of the water molecules through which the sound travels and this radiates in a wave pattern within a set beam radius. The acoustic pulse or wave travels through the water at a rate of around 4,800' (1,463m) per second in saltwater and 4,920' (1500m) per second in freshwater. When the acoustic energy strikes an object within that radiated beam, such as a fish, the sea floor or some other submerged structure, a proportion of that energy is reflected or echoed back to the transducer. The transducer then processes this returned energy back into an electrical signal to compute range and depth.

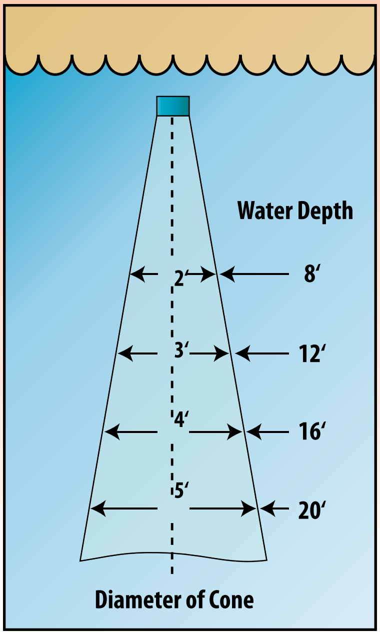
The transducer is constructed of a crystal that is made up of several elements including lead zirconate or barium titanate and some conductive coatings. When the depth transducer transmits the acoustic signal, it undergoes expansion to form a cone-shaped characteristic. The physical shape, thickness and diameter of a transducer crystal directly determine the cone angle and the frequency. Most depthsounder and sonar systems use circular crystals. The thickness defines the frequency and the diameter defines the cone angle.

There are also two primary methods for converting electrical to acoustic energy. They are the magnetostrictive and the piezoelectric methods. The magnetostrictive transducer utilizes the principle of magnetostriction. This is based on the effect that occurs when certain materials tend to either expand or contract when they are located within an alternating magnetic field. This conversion takes place when the material is magnetized, causing it to strain and this is a bidirectional transmit and receive process. The ceramic piezoelectric transducer element works differently.

The piezo effect is based on the change of dimension certain materials undergo when an electrical charge is applied and, conversely, they also produce a voltage when subjected to mechanical stress. An electrical signal is applied to the piezoelectric element in the transducer to cause vibration, which is amplified by the resonant transducer masses and then directed into the water

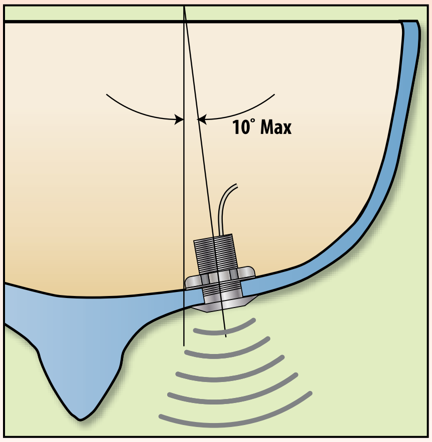
ESTIMATING BOTTOM COVERAGE

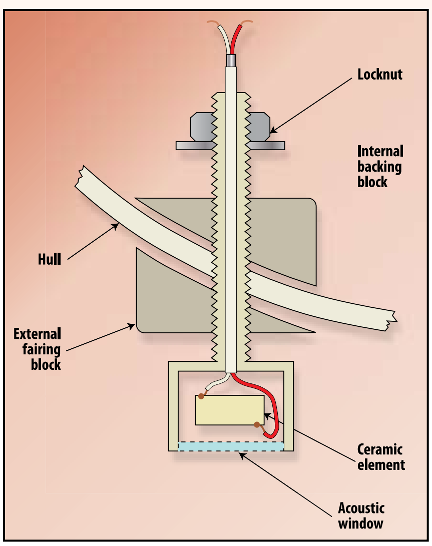
The deeper the water, the greater the diameter of the signal angle sent by the transducer. As a rule of thumb, the water depth divided by four equals the diameter of the bottom coverage.
— JM



through a radiating plate as sound waves. The first practical application of this effect was to sonar in 1917.

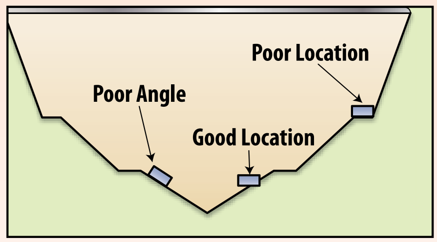
Turbulence Rules Performance





A depthsounder transducer must be within 10˚ of vertical. If not, installation requires a fairing block outside to direct the beam angle as straight down, as possible.

Cavitation significantly affects depthsounder and fishfinder transducer performance. This is caused by turbulence as water flows across the transducer head. At slow speeds, the laminar flow is relatively smooth without any interference. Once boat speed increases, air bubbles are created over the transducer face and this affects acoustic signal transmission and reception. This results in the transmitted acoustic signals reflecting off air bubbles, creating noise, inaccurate return signals and masking real signal returns. Many factors cause turbulence, including the hull form or obstructions, water flow over the transducer and propeller wash. Transom-mounted transducers must be mounted with care to avoid turbulence created by outboard motors or the water flow breaking off the transom trailing edge. The higher the boat speed, the greater the turbulence created. Riveted alloy boats also have some turbulence created off each rivet head.



To prevent cavitation interference with the propeller on a powerboat, mount thru-hull transducers as deep in the water as possible, away from trailer bunks and rollers and at least 1' (30cm) beyond the drive unit.

Thru-hull Installation

Traditionally, the depth transducer is mounted through the hull using a threaded shaft and nut. It must be correctly aligned in the fore and aft position. Be very careful not to bump the transducer and possibly damage the crystal element. In motorboats, the transducer must be at least 12" (30cm) forward of the outboard engine and have smooth, cavitation and turbulent-free water flow over it at all times. In a keel sailboat, the transducer mounts some distance from the keel to avoid false echoes. Any hull with a deadrise angle (angle from the horizontal keel to the hull sides) greater than 10° requires a fairing block. These are made of plastic or wood and shaped so that the transducer mounts vertically with the transducer face pointing directly downwards. When mounting in an aluminum hull, select plastic transducers to avoid any galvanic corrosion problems. Route the transducer cable as far as practicable from other electrical cables to avoid interference.

Inside-the-Hull Mounting

For fiberglass boats, the shoot-through-the-hull-type transducers are

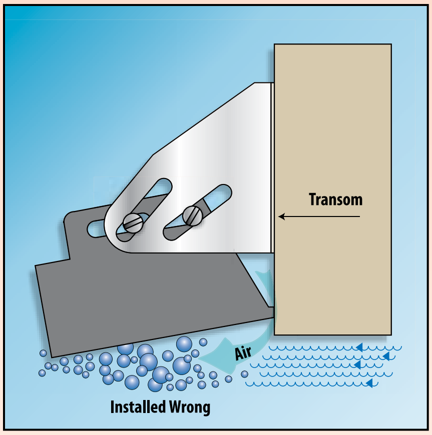
Airmar “smart” in-hull transducer adjusts to any hull’s deadrise angle to create a vertical sound beam.

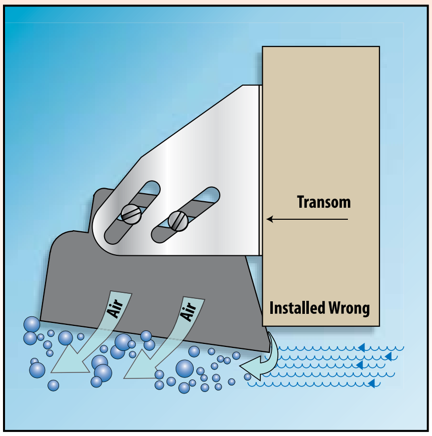
becoming popular. Sound is transmitted and received through the hull. This type of mounting eliminates water turbulence problems and the risks of mechanical damage, so is favored by trailerable boat owners. No hole is needed through the hull and it can be installed on larger boats without having to haul out.

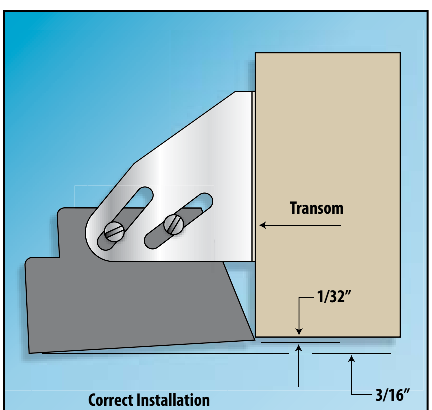
There can be significant reductions in signal strength and therefore depth ranges if the inside-the-hull transducer is not installed properly. The transducer mounts inside the hull towards the transom where possible, clear of any stringers and frames and as close to the centerline as possible in an area of solid fiberglass (where there is no core). The transducer fastens to the hull using epoxy resin. Never use silicone sealant for this task. Water then surrounds the transducer and this facilitates sound conduction through the hull. If performance is poor, there may be air trapped under the transducer head or there may be wood, foam, an air chamber or other “air” in the laminate that breaks the solid path the sound waves travel through the hull. An alternative method is to create an oil bath rather than a water one. Installing inboard transducers on aluminum or foam sandwich core construction hulls often causes problems. In foam sandwich cored hulls, it’s often necessary to remove the inner glass layer and mount the transducer against the outer layer.

Off the Transom

Transom mounted transducers are most commonly used on many small trailerable boats, runabouts and some







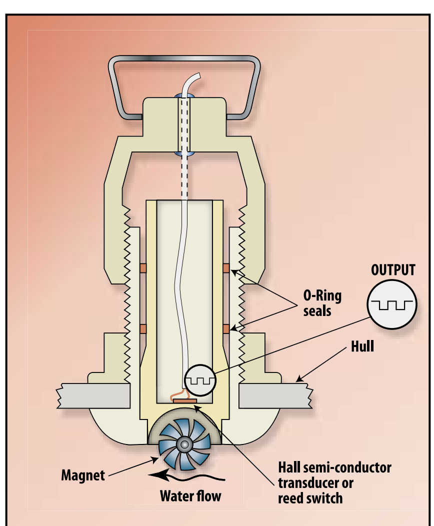
When the bottom is lost at high speed or if noise appears on the display, the likely cause is an improperly mounted transducer. The transducer must be mounted tight against the transom to prevent water surging up between the transducer and the transom. If necessary, fill the gap with epoxy resin.

larger power cruisers. These are often installed on retractable brackets with most designs now swinging up to protect the transducer if there is an accidental contact with and object in the water. This type of installation makes the transducer susceptible to turbulence from propeller wash as well as the laminar water flow breaking away from the hull often affects operation. These transducers are most effective on boats that operate at relatively low boat speeds.

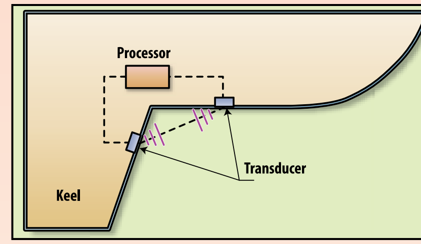
When mounting on a riveted aluminum boat, it's best to locate the transducer between the rows of rivets as water flow and turbulence over the rivets may affect accuracy. There also should be a minimum of 1" (25mm) between the transducer and transom. The transducer should also be located as deep in the water as possible. After mounting, adjust the bracket so that the rear trailing edge is slightly lower than the forward pointed end, the ideal angle being about 2° to 5° down. This depends on how your boat rides when underway. Always use caution when moving the boat on and off a trailer as I have seen many transducers damaged during launch and retrieval.

Speed Readout

The common paddle wheel speed log has magnets imbedded in the paddle wheel or impeller blades and a detector



Common paddle wheel speed transducer registers pulses that are seen as a voltage change, such as 0 and 5 volts, which delivers a stepped signal that is counted and processed.

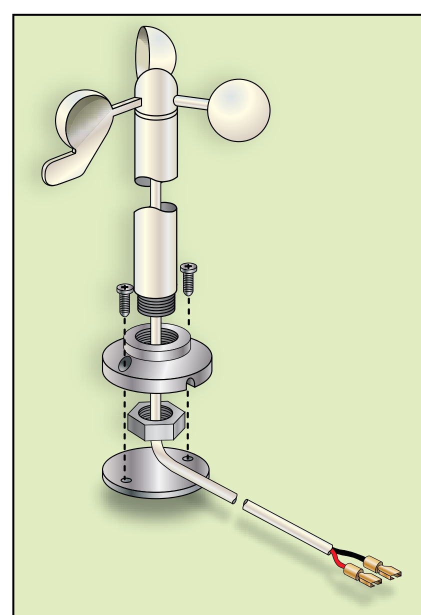


Sonic logs measure transmission time of sound signals between two transducers and because signals are clear of turbulent layer, readings are accurate to .001 knot.

that outputs a pulse that is counted and processed. Some units have a glass reed switch and some newer units have a Hall Effect device. The output signal pulses are essentially digital and are seen as a voltage change, such as 0 and 5 volts, to give a stepped characteristic. The output is directly proportional to the speed and distance traveled.

Install the speed log transducer in the forward third of the hull and within an area of minimal turbulence. Never route depthsounder and log cables together as interference often occurs. Install impellers so that they are properly aligned in a forward and aft direction to ensure a water flow that turns the paddle wheel properly.

There are relatively few maintenance



Maximum performance is achieved when the transducer is mounted vertically (use a wedge if necessary) to a horizontal surface, either the masthead, stern post or rail.

requirements for speed logs. Routinely remove and check the impeller for both smooth and frictionless rotation and apply some light oil to the spindle. If they start seizing, the pulse becomes inaccurate and speed reading errors occur. If your log isn't functioning and you need to test whether the paddle wheel transducer or the instrument head is faulty, disconnect the log input cables to the instrument head or processor. Using a small piece of wire, rapidly short out the input terminals and observe whether a reading is indicated. If there is a detectable pulse, then the transducer is faulty. If there is no reading, the instrument head is probably at fault. These transducers are commonly fouled with weeds and must be kept clean.

Ultra sonic speed transducers use what is called echo correlation. The transducer consists of two 2 MHz piezo electric crystals that transmit short pulse acoustic signals simultaneously and reflect the signals off water particles approximately 6" (15cm) away, which is clear of the turbulent boundary layer. The water particles pass through the forward then the aft beam, and transmission time of the acoustic sound signal between the two crystals is then measured. The time delay is then used to determine precise speed based on the known distance between the two transducers.

Sounding the Wind

Many sailboats install wind speed and direction measurement systems at their masthead. The typical wind system comprises an integral windspeed and direction unit along with an instrument head. The anemometer is the windspeed transducer and is essentially a rotating pulse counter similar to the speed log. The pulses are counted and processed to give a speed value. The wind direction masthead transducer consists of a simple windvane. Several methods are used to measure the angle and transmit the signals to the instrument head or processor. Some systems utilize an electromagnetic sensing system, while others have an optical sensing system that references coded markings that relate to the windvane direction. It's very important that the transducer unit is securely installed as the masthead is affected by vibration. For accurate readings, the fore and aft alignment accuracy is essential.

Transducers require relatively little maintenance, though it's rarely done for it involves going up the mast. Routinely check securing bolts and frame and tighten as required. Ensure that the cable connector is securely fastened and locked in. Check for ingress of moisture and water, as well as for signs of corrosion on the pins. Smear a small amount of petroleum jelly or silicon grease around connector threads when reattaching to minimize seizing and wrap with self-amalgamating tape. Ensure that the cable is not chafing at any access point and that the anemometer rotates freely without binding or making any noises that indicate bearing seizure or failure, which is common as the unit is continually rotating. Also check that the cups are not split or damaged by birds. Older units tend to become brittle as UV breaks down the plastic. Apply a few drops of light oil into the lubrication hole if it has one and rotate freely to ensure that it penetrates the bearing.

TIP: SCREEN INTERFERENCE

Route transducer cable away from all other wiring, especially engine and bilge pump wiring, which produces electrical noise that can be displayed on the display screen.
— JM

About the author: John Payne, DIY's electrical consultant, lives in Mons, Belgium, on a 65.6' (20m) canal boat, shown on the right in the photo, built in the U.K. in 1896. He is author of "The Marine Electrical and Electronics Bible" and "Motorboat Electrical and Electronics Manual," (Sheridan House).

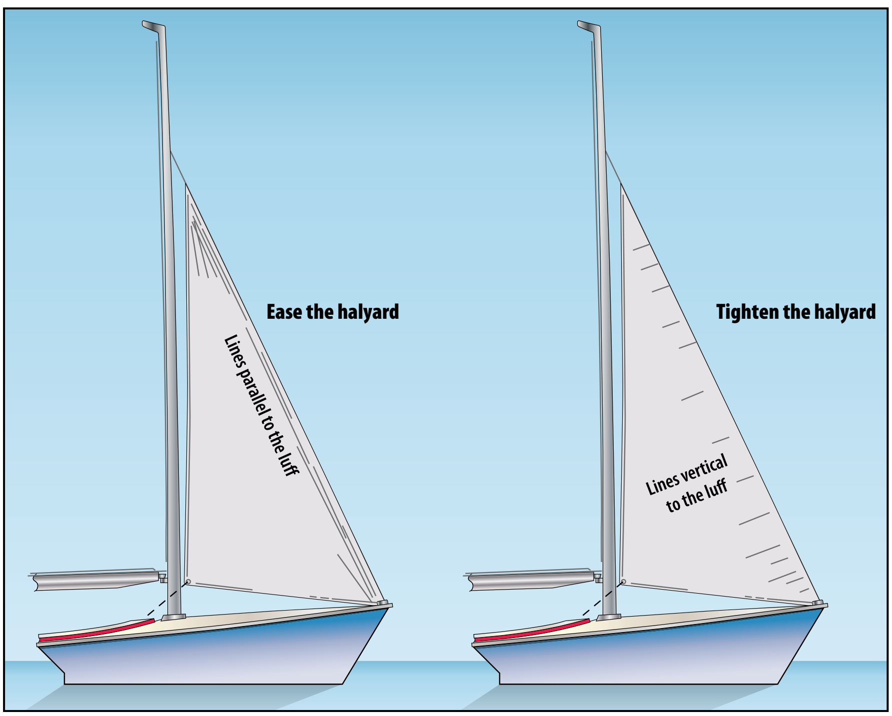
ADDITIONAL READING
Installing Logs and Depthsounders DIY 1998-#3 issue available on DIY Hands-On Boater 1995-2004 CD-ROM

SAILBOAT RIGGING

The Shape of Speed

Whether you're a novice or veteran sailor, you're sure to gain some useful information about how your genoa or jib and mainsail should look in various wind conditions and how you can achieve these ideal shapes on your boat.

By Roger Marshall



Roger Marshall

Effect of halyard tension on luff of headsails.

If your jib leech flaps like pigeon wings or your mainsail sags off to leeward, you might pay some attention here. Sails don't last forever and worn, baggy sails can slow your boat, diminish your control and set you on your ear when you're homeward bound in nasty weather.

Depending on the quality of the cloth and construction and the way you use them, your sails can lose their shape sooner than later. Presuming you know your sails are still in reasonably good shape and do not need replacement, take the time to properly set them up on the rig. [Ed: Step-by-step inspection of your sail inventory is the topic of a future issue.] Assuming that your sails are in reasonable condition, the next step is to learn how to properly set the main and genoa and jib on the rig.

Headsail Trim

Let's look at the genoa first. A well-designed sail, properly set, combines the elements of an optimum leading edge angle, depth and draft position. Critical controls to change shape are the halyard, jib sheet, sheet lead block position, adjustable backstay, barber hauler, foot line (optional) and leech line.

With the boat sitting at the dock on a windless day or at anchor with head to wind, hoist each sail to its maximum with the luff fully tensioned. If you see lines radiating up and down the luff, the halyard is too tight. The best way to set up halyard tension is to tighten the luff until lines appear then ease it until they just disappear. If you ease it too much and horizontal lines form, you've gone too far the other way.

Next, turn your attention to the clew of the sail. The old way of determining where to position the genoa track car was to bisect the angle at the clew. Today, sails have a much higher aspect ratio; the leech and luff tend to be about two to three times the length of the foot. Consequently, the track car angle should bisect the leech and luff proportionately, typically about one-third of the angle instead of half (see illustration on page 38).

It's now time to go sailing. Ideally, pick a day when the wind is blowing about 10 knots. Hoist your sails as per the notes above and, when the jib is sheeted in and the boat is sailing to windward, check the tension on the luff. If it looks like tension lines are radiating horizontally, you'll need to let the sheet out and tension the halyard until the sail looks good when you are under sail under these wind conditions. This often means that there are vertical lines in the luff of the sail until you have pulled the sheet in. That's okay. Now look carefully at the sail. Mentally compare the curvature of the foot and the leech.

TIP: HALYARD TENSIONER

When the wind increases, sails tend to get baggier and the draft (maximum fullness) moves aft, which tends to trap air and heel the boat more. To improve performance and gain control, you need to move the draft forward. To do this, increase halyard tension but this is difficult to do, especially on large sails, when sailing to windward. I've bent winch handles trying to crank up a halyard. If your headsail and mainsail don't have a Cunningham, consider adding one. It's a line that passes through a cringle (eye) about 12" to 18" (30cm to 46cm) above the tack and runs to a cam cleat or sheet stopper. When you can't tighten the halyard any more, you simply crank down on the Cunningham line to move the sail's draft forward. This device is named after Briggs Cunningham who invented the idea.

— RM

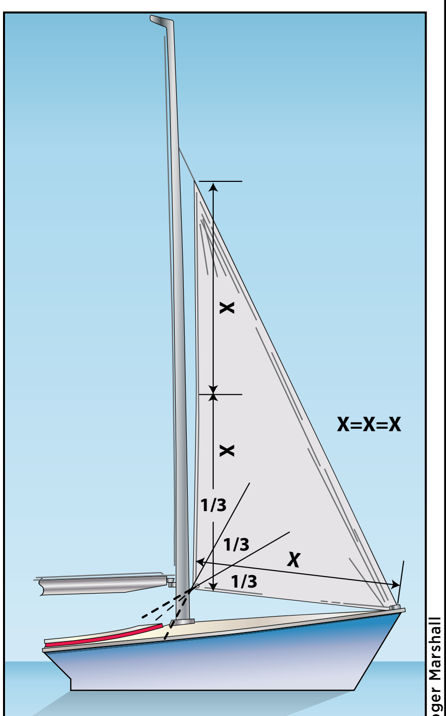
Do they look like they have the same amount of tension on them or does the foot curve roundly while the leech looks stretched? If the sail looks rounded at the foot, you need to slide the track car aft so that the leech and foot look like they have similar tension and the curves are equal. If the leech is bowed outwards and the foot looks stretched, move the track car forward.

The leech should be flat and gutterless. Note that these settings are for winds of 10 knots. Lighter air generally requires a fuller sail; heavier winds a flatter sail.

Sight up from the foot and note the sail's draft or curves. Draft position is affected by luff tension. Tensioning the luff, either with the halyard or a Cunningham, moves the draft or maximum fullness forward and rounds the leading edge. Tightening the sheet and moving the track car aft flattens and depowers the sail when sailing in a freshening breeze. Easing luff tension moves the draft aft and increases the depth to provide more speed in lighter winds. Easing the sheet also moves the draft aft but adds unwanted twist unless the sheet lead car is moved forward slightly. Note that adjusting halyard tension normally requires a change in sheet car position.

Another factor to consider for masthead rigs is headstay sag. This has a negative affect on sail shape. Though it's nearly impossible to remove all sag, it is adjustable using three controls. As wind speed increases, counteract sag by tightening the backstay and then increase luff tension to hold the draft forward and sheet in to flatten the sail. Conversely, ease the backstay to increase headstay sag when sailing in light air.

As you're sailing, keep a watch on the sail's telltales. A telltale fluttering to leeward indicates stalling and you'll need to either ease sheets or head the bow into the wind. When telltales flutter on the windward side, you're either sailing too close to the wind or you need to tighten the sheets. If your headsails don't have telltales installed, you can add them by sewing lengths of yarn on every third panel or so, about 15" (38cm) back from the luff.



When locating the track car, try to bisect the angle of the clew in proportion to the length of the foot and leech. Then look carefully at the sail. If the leech is very rounded and the foot shows stretch lines the sheet is led too far aft. To correct this move the car forward. If the foot is rounded and the leech is tight, the sheet is pulling downwards on the leech. Moving the track car aft opens up the leech.

SAIL TERMS

Angle of Incidence: Angle of the mast to the airflow or apparent wind.

Apparent wind: Total value of true wind speed and direction and a boat's speed and direction or the wind that passes over the boat when underway.

Babystay: Pulls middle of mast forward.

Backstay, adjustable: Controls mast bend by either pulling masthead aft to reduce draft, flatten sails and increase headstay tension to reduce headsail sag or reduce mast bend to increase draft.

Barber Hauler: Short line that attaches to the headsail clew that moves the sheet angle outboard.

Cunningham: Multipurchase block and tackle fitted to an eye on the sail just above the tack, which is used to fine tune luff tension and draft location.

Draft: Amount of curvature (fullness) in a sail.

Flattening reef: Flattens the foot of a mainsail to depower in strong winds.

Foot line: Stops flapping of sail foot.

Halyard: Hoists a mainsail or headsail, controls luff tension and draft placement.

Heel: When a boat hull tips or moves to the side away from vertical.

Jib sheet: Attaches to clew and trims headsail to adjust draft, twist and leading edge angle.

Lead car: Controls sail leech twist and more indirectly, foot and luff tension by either flattening the headsail or increasing the draft, depending on placement.

Leech line: Stops flapping of sail leech.

Leeward: Opposite side from the direction of the wind.

Mainsheet: Affects leech tension and twist when sailing upwind. Off the wind, it controls boom angle.

Outhaul: Controls tension on foot of mainsail and is increased to flatten and reduce draft or eased to increase draft.

Reef: Device or system to shorten sail area.

Traveler: Controls angle of boom relative to a boat's centerline.

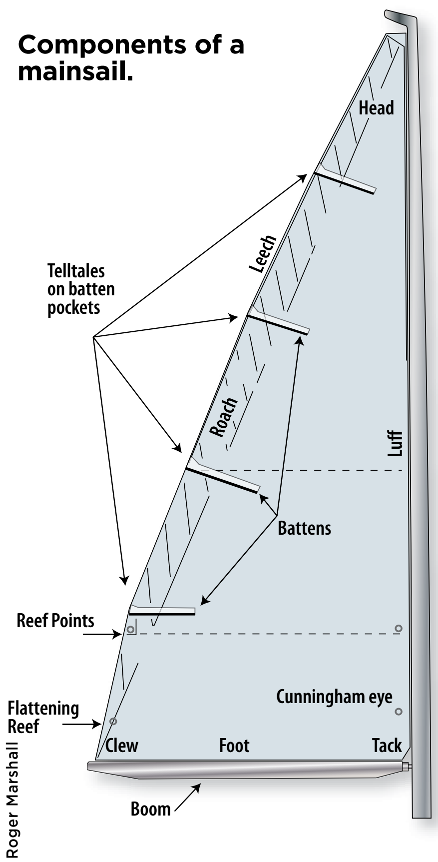
Twist: Curvature of the leech of a sail.

Vang: Controls leech tension and twist and when tensioned flattens mainsail.

Windward: Side the wind is coming from or the part of the boat or land that is facing the wind direction. — *JM*

What about Roller Furling Sails?

Roller furling sails have special needs. They require the same attention to



initial setup, as explained above but special considerations take hold if you reef this sail. Roller-furling gear twists the foot and head before the middle portion of the sail furls in the rotation and that condition is aggravated when the sail is reefed. The stress on the sail causes it to stretch in normal furling but the problem is enhanced when the sail is regularly reefed with the furler. The effect increases bagginess considerably in the middle of the sail, a shape that increases heel angle in stronger winds. Sailmakers build in a luff tape, often reinforced with foam to provide some rigidity to the luff that resists the twist and prevents the fullness from developing in the middle of the sail. The idea is that the foam builds up the luff to remove the fullness. This modification helps prevent sail distortion (bagginess) and the reefed sail will help keep the boat from being overpowered in terms of heel but it can also compromise the amount of sail area you want for best performance.

Mainsail Shaping

Mainsail shape is controlled by the halyard, mainsheet, traveler car position, adjustable backstay, boom outhaul, Cunningham, flattening reef, leech line, vang and on some boats, a baby stay tensioner. Just like your headsails, telltales help you to obtain a good mainsail shape. Attach a 6" to 8" (15cm to 20cm) long piece of yarn to the end of each batten pocket, making sure that the yarn streams aft from the pocket when underway.

Sailing in about 10 knots of wind, hoist the mainsail and trim it as you would normally. If you see vertical lines in the luff, ease the halyard slightly. Sail close hauled (upwind) and check the location of the main boom. It should be either on the centerline or a few degrees to leeward. Adjust the traveler as needed to properly position the boom. From beneath the boom, look up the leech of the mainsail. The top and bottom battens should be nearly parallel to the boom. If they are not, you'll need to tighten the mainsheet. Of course, this pulls the boom to windward so you'll need to ease the traveler

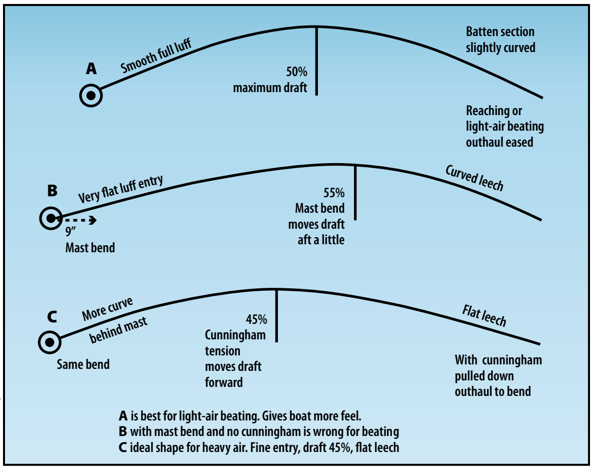
PICTURES TELL-ALL

Taking photos of your sails is a great way to capture sail trim settings. To get the best headsail shots, lie down on deck on the windward side, positioning yourself directly under the foot and halfway from tack to clew. Be sure the light is such that all seams are visible. For mainsails, look at the sail from directly under the boom for the best photos of shape and batten angles and from the end of the boom to capture the twist. Use a wide-angle lens (28mm is even better if you have or can get one as it avoids the "fish eye" effect of the standard 24mm wide-angle lens) and aim for as much of the sail as possible from luff to leech. Take photos under different wind conditions and make a note for each photo taken the sail photographed, the wind speed and all control settings; namely, jib car lead position or mainsail traveler setting, backstay tension, luff tension, sheet and Cunningham positions, etc.

This photo of a 150% drifter was taken in 4 knots of wind with the genoa car set at five position and sheet barber hauled, halyard at preset plus 1-1/2" (38mm) and 20% backstay. With a draft at 40%, as noted by the seams, this is the ideal setting for this sail and wind condition. Rounded entry is powerful when sailing upwind in slop but may produce premature luffing under normal conditions. (2) Photo of a 150% genoa in 10 knots of wind with car at five position, preset halyard, 30% backstay. Maximum draft is at 50% and is much too far aft for the wind. Flatten by increasing luff tension and increase backstay tension to bend the mast and move the draft forward to 40%. Sharp leading edge makes a better close-hauled sail. (3) Too much headstay sag for a masthead rig. Need to tighten the backstay. (4) Mainsail photo taken in 10 knots of wind shows a very flat, tightly trimmed sail, which is slow for these conditions but fast in heavier winds. Easing the mainsheet should open up the top battens and add needed twist. Leech nicely curved and draft set at about 50%. — *JM*

slightly to move it back on centerline. Watch the telltales as you tension the mainsheet. They should be steaming aft, parallel to the sail foot. If the bottom ones are flying and the top ones aren't, ease the mainsheet slightly. If none of them are streaming aft, ease the traveler slightly. When you get the telltales streaming aft nicely, the main is working efficiently.

How do you know what controls to use? Think of the mainsail as a wing. You shape the wing using certain controls (the halyard and sheet at this stage) but the wing has to be at the



Courtesy North Sails

Effect of mast bend on mainsail shape.

right angle of incidence to the airflow, so you use other controls (the traveler) to set the mainsail at the right angle of incidence. If you ease the mainsheet, you change the shape of your wing. If you ease the traveler, you adjust the angle of incidence while the shape of the wing remains the same. So, in gusty weather you ease the traveler first to maintain the shape of the sail and, only when the boat heels farther, do you ease the mainsheet.

When wind speed increases and you want to reduce heel angle you'll need to flatten the sail using the outhaul and the vang. The outhaul controls the bottom third of the sail. In light winds, ease it to increase the draft so the greatest fullness is in the middle of the sail but it's not so baggy that lines appear vertically along the foot. As the wind increases, increase outhaul tension to flatten the bottom of the sail. Racing boats may also have a flattening reef on the mainsail, which flattens it even more as winds increase. Increasing backstay and/or baby stay tension further flattens the main. Tightening the outhaul or flattening reef to flatten the sail also moves the draft to the center of the mainsail. As wind speed increases, you'll need to increase luff tension, sheeting in to maintain correct twist, adjusting the traveler car and increasing mast bend as necessary.

To depower a mainsail on boats with non-adjustable backstays, ease the sheet and/or vang. This increases twist and flattens the upper two-thirds of the sail. When sighted from the beneath the boom, the greatest twist should be two-thirds of the way up. In light air, reduce luff tension and ease the outhaul to increase the draft and tighten the leech. Just like on a headsail, increasing luff tension with the halyard or Cunningham moves the draft forward and rounds the leading edge (a.k.a. entry); easing luff tension moves the draft aft and flattens the leading edge.

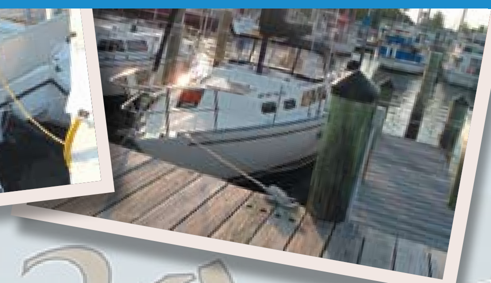
The vang does a job similar to the mainsheet in that it controls the tension on the leech of the sail. It also helps to stop uncontrolled jibes, but that's a topic for another day. Once you have the mainsail leech tension set using the leech cord, tighten the vang. That's about all you need to do. Of course, if you were racing, you could crank on the vang to get the boom to bend downwards and flatten the bottom of the sail more.

Mast Controls

Your boat's mast also helps to control the sail shape. First, it provides the platform on which sails are set and, by bending the mast, you can improve the shape of your sails. Tightening an adjustable backstay countertensions the headstay to improve windward speed and bending the masthead aft also opens the mainsail leech, which is a good thing as it allows cleaner airflow off the edge. It also allows the middle of the mast to bow slightly forward, which is good news for the mainsail, because as the wind increases the draft increases in the sail's middle and you need to flatten it. Racing boats might have a baby stay to pull the mast midsection forward and flatten the middle of the mainsail. Sounds complicated but it really isn't.

Proper sail trim demands your attention if you want to get the best out of your boat. You don't have to sail fast, just like you don't have to drive your car fast, but applying these sail trim tricks will reward you with the best possible performance your boat can give.

About the author: Roger Marshall is a boat designer and author of 12 books on sailing and yacht design. He has a boat design company in Rhode Island and is the president of Boating Writers International.



Boat Owner's Guide To Used Boats

If you're going to invest in a boat that needs renovating, you will recover more of your investment, in both dollars and pleasure, if the subject boat is a "blue chip" issue. Though it's impossible to cover the full range of the minimum, good, better and best of the used boats you'll find for sale, this primer will put you on the right course in the selection process.

By Patrica Kearns

We don't know how long a fiberglass boat will last. We don't have the relative scale of boat years to people years, dog years, horse years, etc. What we do know is that repair technologies get better and better and older boats, the senior citizens of the production line editions of some of our sentimental favorites, are in demand because they appear to be viable alternatives to the purchase of a new boat.

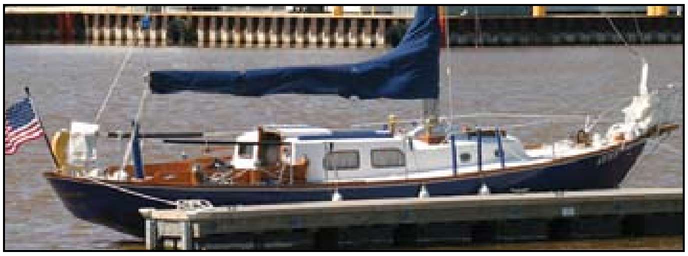
Owners and brokers describe these boats as "experienced," "used," "preowned," "second hand," "older" or by whatever dressed up synonym makes such a boat more palatable to consider its purchase. Such boats are often sought out because, in our mind's eye, they are "classics" that we believe are worth preserving. There are also the old boats that have an intrinsic value as "classic" and that are prized in the same way as a classic automobile. Do they represent good value? Compared to the price for a new boat, they do, if you're very careful to cull the inventory.

Fred Horton describes his 1985 Pearson 38 as "A wonderful boat to sail and is about as roomy and well appointed as any boat in its size."

The familiar automotive analogy here is the Ford Mustang of the 60s, the '55 Chevy and early Corvettes, to cite only a few examples. The difference is that most of us know which cars are worthy of a restoration effort and which ones are "beaters." The parallel continues on the point of the safety developments found in newer automobiles. Boats have evolved there as well. The other factor is that old cars eventually rust away and there is an entire industry devoted to scrapping them for profit, while fiberglass appears to have no finite life. It doesn't matter whether your dreamboat is a sailboat or a powerboat. The hull and attached structure may seem capable of eternal life but everything else must be considered as having a limited service life.

I've been at my practice long enough to see beginnings and ends and the middle ages of most of the kinds of boats DIYers know and enjoy. In that lifetime of "messing about" in boats, vocationally and avocationally, I've seen a few very worthy projects that produced faithful renovations and/or restorations of elderly production boats. An aging marine surveyor is the boating equivalent to the priest in the confessional. That surveyor has heard (and seen) just about everything over the years. I speak from my personal experience with several boats that have been given over to loving and realistic owners who have brought these boats back from states of

Sean and Rachel Burlingham's purchase of a 1987 Bertram 33 Sportfish in 2004 was decided on the Bertram's reputation for superior construction and seakeeping abilities. Though this boat was in good cosmetic condition, mechanical systems needed a lot of TLC. "Every time I stuck my head in a hatch or bilge space to plan an upgrade it lead to many other side projects to correct existing problems," says Sean.



1965 Pearson Vangard, hull #237, affectionately maintained by DIY reader Dave Heilman.

perceived worthlessness to cherished and valuable examples of what can be accomplished with modern repair and refit technology. It's truly a labor of love. It's also a fine line of discernment to accept that, at some point in a life of deferred maintenance, a boat will have to be considered a total write-off and knowing when to pull that plug is still something of a dilemma since fiberglass does not fade away like a wood boat that eventually can go to the retired boat bonfire.

Presuming that your plan to purchase a preowned boat is not restricted by the vision, energy and resources needed to bring the boat up to par, let's explore some ways to pick a boat that will be worth the effort and that, when the job is done, will be something that turns heads in admiration and "thumbs up" approvals when and wherever it's seen.

A Classic or a Beater

The first rule of order here is to find a boat that has the pedigree that is worth your time, effort and investment.

Learn the facts you need to know to be able to access quality, that which is deserving of resurrection. Even among the worthy there are factors that dictate which is the best of the best.

It's critical to find out everything you can about the history of a particular heartthrob and the builder's reputation. What characteristics make for a good choice? For starters, these boats usually have the classic look (how's that for subjective?). Such sailboats are often described as having breathtaking lines, a gorgeous sheer and a graceful counter, whereas for powerboats, it's the rugged, "this boat can really take it" look or the "my dad (granddad) had one of these" sentiment. Read on for more objective criteria.

This whole concept came to life with a client of mine who yearned for a well worn, badly neglected Bertram 35 convertible with diesel engines that he saw as his opportunity to own a yacht with all the potential for classic status. He was right about the boat's potential and he engaged me to survey the boat and to help establish the course toward his goal of bringing the old boat back. He wasn't kidding himself. He knew what he faced. He had overcome most of his illusions about having the boat of his dreams and he knew he could be facing a nightmare.

The first Bertram 35 was launched in 1967. This one was a 1977 model that needed everything except engines and generator and even that machinery needed long overdue maintenance. Everything else was kaput or obsolete but the boat was in running condition. Once the hard work of the prospective buyer, a very patient and realistic yacht broker and a heartsick seller was done and a comprehensive sur-

INSURANCE RULES

The ability to insure a boat at the point of acquisition is key to protecting your initial investment and that means the boat has to be structurally uncompromised and capable of safe conduct afloat or be restricted to "port risk" coverage, which means the boat isn't used at all. The insurance company does not care about the rest. Its only concern is that the boat not be a hazard to life, limb or property, including itself. For this, you'll need a marine survey that assures the potential insurer that the boat is a good candidate for refit, fundamentally well engineered and structurally viable and you'll need to keep meticulous records so that you can increase the insurance coverage as the refit progresses and the boat's value improves. There are insurance companies that understand these special dynamics and some that have special programs for restored classics. [Ed: For the complete insurance "rules of the road" refer to "Insurance: Don't Go Aground in Coverage" in DIY 2004-#3 issue.]

Three examples of well-bred fiberglass boats, according to the author: (left to right) the 1968 Morgan 34, Hallberg-Rassy Rasmus 35 and 1988 Trojan12M.

vey report was in hand, the boat was made ready for the trip from Naples, Florida to the Georgia coast where, at his private dock, the owner immersed himself in a refit that includes just about every topic covered in DIY's Hands-On Boater CD-ROM or the MRT CD-ROM collection.

There are a few other powerboats that I can nominate for the same TLC. We're not talking antiques here or the eclectic or rare editions. Rather boats that are timeless designs, of good breeding, often have historical reference readily accessible and are generally recognized as having classic potential in much the same way that the mid-60s Mustang is appreciated and coveted. Boat builders will not likely bring these boats back into production, as they would be prohibitively expensive to replicate.

Candidates for Best

The nominees for the better and best used boats are cited because I have had professional experience with them and can vouch for their continued viability. Surely, there is a market for more ordinary 15- to 20-year-old (and older) production boats but the payback, on all counts, will be far less than if you are smitten with one of these. Of course, there's a big inventory of stock boats from high volume manufacturers of the '70s and '80s. Pick from that and your experience will be the equivalent of buying a used Ford or Pontiac or Dodge from the same era. These boats can serve you quite well from a strictly practical standpoint but they won't impart that touch of class of a Mercedes 240D or a Volvo 940 or a Jag.

Powerboats

- 34 Hatteras; 41' (12.5m) Hatteras double cabin motoryacht. Virtually any elder Hatteras is worth the effort.
- Hatteras 42 and 48 LRC (long range cruiser). These were definitely ahead of their time yachts now held in high regard, bringing prices that come close to their cost when new.
- 23' (7m) Chris-Craft Lancer. Easy on the eye and great for the Sunday drive on the lake.

This classic 1967 Hatteras 34.4 awaits the new boat owner who is willing to invest the effort to restore the boat to its original pedigree.

- Bertram 28 and 31. There is an entire specialty industry growing up in the business of restoring Bertram 31s, which are now so beloved that they invite incredible investment that, in turn, often brings incredible resale value for the real thing. Another Bertram gem is the 36' (11m) Moppie.
- Trojan 12M (40'/12m) convertible sportfisherman, built when Whittaker Corporation/Bertram owned Trojan. This boat is a sleeper.
- Chris-Craft fiberglass Commander series, the 31' (9.4m) express, 35' (10.6m) and 38' (11.5m) convertibles, 42' (12.8m) motoryacht.

Sailboats

- Hinckley is a no brainer. An obvious candidate but expensive even when worn out.
- Hallberg Rassey 35 center-cockpit sloop/motorsailer. Rugged cruiser with a Swedish heritage and somewhat cramped and dark European interior. Very respectable and comfortable boat.
- Ericson Independence Cruising 31 was way ahead of its time. Lovely to look at, delightful at sea.
- Any sailboat built by Bristol Yachts of Rhode Island. All sail well, were superbly engineered and built. You can do the upgrades a little at a time while you enjoy the sailing. Once you get to the later designs (27.7, 29.9, 31.1, 35.5, 38.8, et al), you are going to pay more but the cost plus of upgrading or a complete refit will be offset by devoted service and a decent resale value.
- Countess 44 and Invicta, Vanguard, Rhodes 41, all early Pearson built. These are true classics but should be considered only if your passion for classical glass is accompanied by devotion to being true to the designs.
- Morgan 45 (Charley Morgan design/ Morgan Yachts), fairly rare but is also seen in kit finished editions, the Brewer designed Morgan 32 and 38 and some of the oldies but goodies like the Morgan 30 and 34.
- Cape Dory (any of them, including the 30'/9.1m motorsailers).
- Westsail 32, 42 and 43. Husky by any definition. Walter Cronkite once owned a 43 that is still a head turner in any harbor.
- Cal 40 is a boat that conjures up the fantasies of fast women in black lace. This Bill Tripp design is fast and sleek but also strong and handsome.
- Whitby 42 was one of the first big, handsome, center-cockpit cruising boats that could be sailed by a couple. Even the oldest ones (over 30 years old) are good values. These hulls defy the doubts of balsa coring (deck delamination problems) and have stood the test of time.
- Pearson 30s still have a dedicated following for club racing and/or cruising and they are compliments to simplicity and good building practices. The same can be said for the 36, 365, 424, 39 and even the somewhat awkward looking, albeit with standing headroom, 26.
- Island Packet, especially the 27, which is no longer built. Same goes for a Shannon 28.
- Sabre 28, 30 and 34. First editions are now at late middle age in boat years.
- A rarity, the Chris-Craft Caribbean 35' (10.6m) center-cockpit sloop or ketch. It's a Sparkman and Stephens design built very stoutly and sails amazingly well. Chris-Craft also produced the Apache, a 38' (11.6m) sloop, and the Commanche, a 42' (12.8m) sloop.

Above are a few of the classy models in preowned boats, mostly in the medium and large sizes. This is by no means a complete list. I'm sure DIY readers can add to this list.

Some boats are languishing in boatyards and backyards, pitifully abandoned beneath the overgrowth of foliage, dirt and mold, for sale or giveaway. Some are tied up at docks with multiple bilge pumps keeping them afloat, with bottoms fouled with years of marine growth. Don't try to make a silk purse of a cow's ear. You can do the work to restore function but you can't change the genetic makeup.

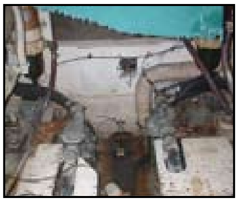
Heart, Back and Bank Account Breakers

Stay away from one-offs, sometimes branded as "custom" boats unless you know that the boat was built by a famous yard and you can track the pedigree. Also, avoid the custom boat built in the owner's backyard (basement, garage, etc.) and the kit boat. By now, it should be obvious but, in case it isn't, these boats can be the mutts of the boat genre. Some have performed well at sea and are the apple of the eye of their owners but, at some point, when you need to sell the boat, you'll have a tough time assuring a prospect of the value added of the boat's lineage.

Don't take pity on a lost puppy. You found it in a field where it's been blocked up on 55-gallon (46L) drums for 20 years. No one knows who built the boat, how old it is or where the owner lives. Even if it's free, it might be plastered with a lien or a mortgage that has not been satisfied. Not all old, tired, "nice" boats make for a good project for refit.

No early Far East. This is a tough caution to swallow because the allure of these boats, both power and sail, is in the teak interior and the low price and those are powerful siren calls. If you can't resist, you should know that you are possibly facing the wrath of the bargain gods and the deepest pit of the can of worms and the worst that a Pandora's Box can hold. The hulls leave little to be desired as they are mostly

Sacha



Don't expect to make money on a quick "flip" where you buy cheap, give the boat a facelift and sell for big bucks. The buyer of this 1980 Bertram 35 Convertible had no illusions about the boat's condition but knew he had a quality built boat.

overbuilt but the problems with the decks, superstructure and systems' engineering will be daunting to overcome. Spend a little more and go newer in this category. These early boats really were "a lot for the money" but their shortcomings have come back to haunt them in their senior citizen days.

No Bargains Here

After the hurricanes there is a buzzing on the airwaves of all the damaged boat deals just waiting for buyers. Be careful here. These boats have been "totaled" for a good reason and that decision was based on the opinion of an expert for the insurance company. Unless you own a boatyard, don't even think about it. These purchases are made under great pressure in an auction like environment. Not a good environment for making any big ticket purchase unless you are fully informed of all the facts, which is not often the case with a total constructive loss.

Old racing boats and charter fishing boats and boats retiring from bareboat charter fleets are the most stressed and strained examples of perceived bargains. They have lived lives of being pushed to the edge as they surge to the finish line, land the big fish or are operated by a different crew every week and in the most extreme climates. If you succumb to the scent of a bargain here, you'd better double the boat's age when you calculate its service life potential. You are looking at the equivalent of a fully depreciated rental car coming out of the fleet. "Rode hard and put up wet" is the expression used for horses treated this way and assuredly describes commercial and racing boats.

Don't fall in love with "potential." If the boat you are eyeing doesn't already have a proven attractiveness, you'll be disappointed on all counts.

FURTHER READING

"Buying a Used Boat," in DIY 2002-#2 issue, written by Susan Canfield, another highly regarded certified marine surveyor and protege of Pat's, provides details on how to evaluate a boat's systems and performance, including a pre-purchase checklist, before making a purchase offer.

"A Systematic Approach to Engine Diagnostics," in DIY 2002-#4 issue outlines the service procedures to help you determine engine health without disassembly before purchasing a used boat.

Self-Guided Boat Inspection: An online survey program that directs you on what to look at, where to find it and what you should see. http://survey.marinexperts.com

NICK'S 10 LAWS OF USED BOAT BUYING

DIY's boat repair expert, author of our Pro Series column and curmudgeon of the boat reconstruction business, Nick Bailey offers his tell-it-like-it-is advice for would-be used boat buyers.

1. There are no guarantees. Buy it if the price reflects the condition of the boat and you are personally and emotionally equipped to handle the challenges of owning an older boat.
2. The only opinions that matter are the ones you pay for. Even they can be inadequate as they are based solely on what can be seen. If there is doubt, ask for further investigation.
3. If it looks bad it usually is bad. Beauty may be only skin deep but ugly has a knack of seeping out from the inside. If the owner was diligent about the boat's appearance, it's more likely that he/she looked after the mechanical maintenance as well.
4. All old boats are trouble. Be prepared. Everything is negotiable.
5. All new boats are trouble. If you're lucky, the dealer will fix it under warranty.
6. No two boats are alike. Don't make generalizations based on a sistership. Look in detail at the condition of that particular boat.
7. Everything will cost more than you think. It's an old boat. What would you expect of a 14-year-old car?
8. You get what you pay for. There are very good reasons why boats from some manufacturers are more expensive than others.
9. Never buy a boat without a survey.
10. Never close before a sea trial (with your mechanic onboard).

Just Ask

No matter how you chose to proceed, you'll still need preliminary expert input to help you moderate your passion with some objectivity. An experienced marine surveyor who is generous with telephone or email consultations is a precious commodity and readily available. That surveyor's experience can give you a leg up on many a boat's well-known Achilles heels, the ones observed, time and again, in routine survey practice. For example, if you ask me about a certain semi-displacement motoryacht built in the mid-'70s, I can tell you, without looking at that specific boat, what areas are likely to be found wanting. The DIY helpline

DIY reader Denis Hosking cruises in this 1970 Bristol 42.

Says DIY reader Richard Dowd of his 1982 Bristol 29.9: "One of the things that attracted us to this Bristol was its underbody and prop aperture as we live in an area with many lobster pot buoys."

1977 Formula 233 repowered by DIY reader David Avedesian now runs at a top speed of 55 mph.

1985 Cape Dory 26 sold last summer by DIY reader Mark Hoopes. "They are beautiful boats," says Mark.

1961 Betram still in use for marine search and rescue on Lake Ontario. Photo sent by one of the boat's captains, DIY reader Mel Smith.

(info@diy-boat.com) is another terrific resource (a free service to all subscribers). The web is a fantastic resource. At sites such as www.yachtworld.com you can review data on brokered sales of previously listed boats. A collection of opinions that affirm each other is a consensus and, with that, you should be able to moderate your passion with objectivity. Once you're past this point, you're ready for the price negotiations and a thorough survey.

Of course, none of the foregoing advice precludes you from rescuing an ordinary boat from the jaws of neglect, fixing it up and enjoying it with little or no expectation of recovering any part of your investment, except for the personal pleasure. Making any dream come true is a worthwhile investment and playing by any set of rules for being sensible about it should never deter you from your pursuit of a life filled with time messing about with boats. It's hard to put a value on the pleasure of that.

About the author: Patricia Kearns has earned a reputation as a punctilious surveyor and some brokers and sellers have been known to groan on learning that she's on the job for a prospective purchaser. She prefers being described as thorough. If you're buying a used boat, she's one of the best in the trade. You can reach Pat at pkearns@marinexperts.com.

Sacha

ASK THE EXPERTS

Below is a sampling of questions recently submitted to DIY's Technical Helpline and answered by our experts.

Q: I had sent an email a number of months ago asking for some information on a boat that I was looking at purchasing. Your team of professionals provided me with some excellent feedback. I've now narrowed down a couple of different boats and I'm hoping that you can provide me with an unbiased opinion on the strengths and weaknesses of the 1990 372 Chris-Craft Catalina. There doesn't seem to be as many around as their popular cousin's the 350 and 381. Obviously if I decide to purchase this boat, I'll have a professional survey completed prior. My biggest concern is that the reputation of Chris-Crafts built since the late 80s. I know of a couple of owners that bought their Chris-Crafts new in the late 80s and treated them very well yet still they suffered from blisters. I don't know if the 372 model is prone to this kind of concern. Also, there appears to be some slight oil leaks from the closed-cooled 454 Crusaders. What kind of problems could I experience? What type of mechanical testing would you recommend to ensure that I'm not running into an expensive refit after I purchase the boat?
Doug Richardson via email

A: By the early 80s, a faltering economy and poor management had reduced Chris-Craft to a shell of its former self. The company's Catalina series are basically lightweight budget boats. As such, they haven't aged well unless meticulously maintained by knowledgeable owners. Fifteen years after construction the boat will have enough of its own history of use and abuse to make the original construction quality less of a factor. With respect to blisters, we don't consider Chris-Crafts of the late 80s any worse (or better) than any other builder of production line polyester boats. Good cosmetic and even mechanical maintenance will not prevent blistering of a hull built using polyester resin. If such boats were properly barrier coated (using vinylester or epoxy resin) early on, the outlook normally would be better. By "properly," we mean over 10 mil dry film thickness. Two coats of VC Tar won't do it. If prone to blistering, the process is typically accelerated on a boat that is afloat year-round, rather than hauled out and dry-stored for the off-season. If blister repairs have been done more than once before, the hull likely will often blister again. You've seen far more Catalina 350s and 381s (an enlarged version of the 350) listed for sale because those models had relatively long production runs, from 1974 to 1987 for the 350 and from 1980 to 1989 for the 381. The 372 was built for only three years from 1988 to 1990.

With regard to the apparent oil leaks from the Crusader 454's, I would advise the buyer of any boat of this age to have an engine survey performed by a factory-trained marine mechanic. [Ed: For step-by-step procedures on how-to evaluate a boat's systems and performance before making a purchase refer to DIY 2004-#2 issue.] You should also ask to review the owner's engine (and other boat) maintenance records at the time of the pre-purchase survey. Any gas engine with over 1000 hours on the clock does not owe anybody a dime. Get a mechanic to do compression tests and take oil samples and a thorough visual inspection. Make sure that the technician is onboard for the seatrial, running the engine at wide open throttle (WOT). If the engines pull their rated rpm (4,200 to 4,600 at WOT), you know they aren't severely worn and are in good tune. You can also discover troublesome vibration and see that the boat is propped correctly (it should not rev above 4,600 rpm if correctly propped). Any problems identified now give you the leverage to negotiate a better price or have repairs done before you sign on the dotted line. Regardless of the current condition of these Crusaders or any other gas engine, a realist would have to budget a reserve for eventually rebuilding them. After a rebuild, you can expect at least another 500 hours of service.

It pays to shop for boats that exhibit quality construction and conscientious maintenance. It's easier/better to compromise where size or age are concerned. That said, the 372 may still have appeal due to its spacious double-cabin layout (for a boat of its size) and affordable price. The hidden costs that typically come with a 15-year old lightly-built budget boat include higher annual maintenance expenses and accelerated depreciation of the boat's market value (relative to better built boats of the same age). Ask a surveyor for his opinion and pay him to look. Ask a mechanic and pay him to look. This is where the answers are. Bear in mind that sometimes the answer will be "I don't know" and will involve further investigation at further cost.

Q: Any evaluation or critique available for a 1980s Albin 36 trawler?
J. E. Hartwell via email

A: The 1980s-era Albin 36 is a fairly typical Taiwan-built trawler. The hulls are solid fiberglass, decks cored with end-grain balsa. It can be a great boat if it has been maintained. Given all the exterior teak and the literally hundreds of fasteners securing it on deck and elsewhere, water intrusion into the deck core and leaks into the boat's interior can be a big problem. These boats require a good deal of conscientious and knowledgeable maintenance if they are to remain in good condition. Many hulls of the period also have a history of osmotic blistering (not unusual for a polyester resin built boat), so ask about the boat's history of hull bottom repairs, barrier coating, etc.

If water leaks into the boat's interior are/have been a problem, it will be evidenced by damaged veneers, wet bilge, corroded metals (including tanks), mildew, etc. It's possible to find an Albin 36 from the 1980s in good condition but they're fairly rare. Original hose, if any, on a boat this age likely needs to be replaced. The electrical system is another potential problem, particularly if subject to high humidity (due to deck/window leaks) and aftermarket add-ons.

Engine wise there is little worry provided oil analysis is done on both engine and transmission. Some of the later 36's had the Warner CR2 transmission instead of the in-line unit that was originally supplied on the engine. Any boat of this type purchased is only as good as it surveys.

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POWERBOAT RIGGING

Is There A Sterndrive Repower In Your Future?

Replacing the power plants in an older boat may just be the better option than purchasing a new boat, particularly if you like your boat. This article discusses the costs and steps to repower a cruiser with new sterndrives from take out to start up.

By Steve Auger

You have had your boat for 10 years or more and the old boat runs okay but the engines are tired and the performance and creature comforts of a new package are quite attractive. Maybe it's time for a new boat but the price of one makes for a major investment decision. Do you cough up the money for a new boat or stick with your oldie? There's a third option to consider: repower your existing boat with a modern electronic fuel injection (EFI) sterndrive package.

The owner of a 1988 Sea Ray Amberjack, powered with a pair of 3.7 liter Mercruisers equipped with Alpha drives, wanted to improve performance and get the superior driveability of EFI engines. When repowering, the first step is to determine what engines to purchase. As the Amberjack's engines are in-line, four-cylinder, 170-hp sterndrives, the most economical option and one that poses the least amount of fabrication is to replace with 2005 3.0 liter in-line Mercruisers with Alpha One drives. These four-cylinder sterndrive packages cost around $10,000 each. The catch is that they are not going to improve the performance of the boat and are carbureted motors. (Mercury is not releasing its EFI 3.0 liter until 2006.) The next option is a 4.3 liter V-6 multi-port fuel injected (MPI) package. The Mercruiser 4.3 MPI with Alpha drive produces 220 hp and retails for around $15,000. The owner was considering a pair of Mercruiser 350 Magnum MPI engines rated at 300 hp with Alpha drives for $18,000 each but we felt this was overkill. So the decision was made to go with twin 250 hp, 5.0 liter MPI Mercruisers coupled to Alpha One sterndrives at a cost of $16,500 per power plant. Once the engine arrived, the work began.

Transom Prep

We removed the original engines, transom assemblies and sterndrives from the boat. Next, the original transom assembly cutout holes in the transom were filled with laminated layers of marine plywood then covered with fiberglass and finished with color-matched gelcoat. Deciding to go from in-line to vee cylinder configured engines meant we had to recalculate the "X" dimension for both transom assemblies to accept the wider V-8 engines. These engines use a 36" (91cm) centerline versus the 30" (76cm) centerline of the original in-line 3.7 liter engine. Deep-V hulls

Installing transom cut out fixture.

Transom assembly matched to "X" dimensions and the fastener holes drilled.

Epoxy resin was brushed on to seal exposed wood around cutout.

Mercury transom cutout fixture, part number 91-55852A2, was used to maintain tight tolerances that will eliminate water leaks.

CONTENTS/ PREVIOUS/ NEXT/

repowering with wider engines also require raising the cutout as shown in the photos. This process is outlined in the included instruction CD-ROM with a chart that indicates what the "X" dimension will be based on transom angle and application. For example, a standard 20' (6m) runabout with a 12° transom would have an X dimension of 14-1/16" (35.7cm) from the bottom of the boat. Once the new "X" dimension is determined, each transom assembly was mounted and fastener holes drilled. The access hole was cutout using a large sawsall and the exposed wood around the hole perimeter sealed with multiple coats of epoxy resin.

Instead of using a very heavy complete transom assembly to determine the new front motor mount location with the H bar, we used a lighter stripped-down version of the transom assembly.

Determining Mount Locations

Working in the engine compartment, the next step was to remove all old fasteners, clips, brackets and any old junk systems not required in the new setup. In this case, we installed new bilge blowers and bilge pumps and fabricated and installed new front motor mounts. This later job was a fairly simple process as we used Mercury Marine's engine bed H bar, part number 91-806794a1, and a stripped-down transom assembly (or gimbal housing) to set up the mount location. Final mount location often requires removing and installing the transom assembly several times, a task made easier with the lighter stripped-down version. The H bar predetermines the location of the front engine mounts. We then simply installed new square

H-bar ensures correct engine to transom assembly and drive unit alignment, eliminating vibration while underway.

metal tubes under the front mounts and attached them to the existing in-line motor mount pedestal at the correct height and location with 1/2" by 3" (12mm by 7.6cm) stainless-steel bolts, nuts and washers.

Compartment Prep

After locating the front mounts, the engine compartment was thoroughly cleaned, degreased then sealed with a few coats of epoxy resin and painted light grey. We now removed the used transom assembly, installed the two new transom assemblies and torqued to spec. Trim limit and trim position indicator wires and hydraulic hoses were then routed correctly and fastened to the transom using J-clamps. A steering tie bar installs between the

Freshly painted engine compartment readied for transom assembly and engine installation.

New front engine mount location.

Starboard transom assembly installed on new mount.

Transom assemblies mounted and torqued to spec.

Engine transom assemblies installed. Note the black and chrome tie-bar that connects to each of the two tiller steering arms.

two transom assembly tiller arms and is set to dead straight ahead (no toe in or out).

Placing New Engines

The engine compartment is now ready to accept the new engines. We used the existing 1988 vintage instrument harnesses and remote controls as these are compatible with the new engines. This repower foresight by Mercruiser means less cost for the owner and a much faster process for the installer. New power trim pumps were installed in the engine compartment complete with electrical and hydraulic lines prior to the new engines installed. Engines were prerigged with new battery cables and fuel lines. Once positioned on the mounts, engines were bolted down and alignment nuts set just hand tight. Engine alignment is checked and adjusted using a Mercury Marine alignment tool, part number 91805475A1. Once set, the motor mount adjustment nuts are tightened and nut lock tabs bent over locking the nuts in place.

Final Fitting

Sterndrive units are now installed being certain to install the counter-rotating drive unit on the port engine. These weigh just 75lb (34kg), so no special tools are required; however, drives must be torqued to spec as part of the predelivery inspection process outlined on the next page.

It's pretty tight in the engine compartment so both motors are preinstalled as singles to ensure that everything drops into place and facilitate inspection of the installed single motor.

The starboard motor runs the power steering system so it makes sense to install it as a single unit to verify there are no leaks, etc., prior to final installation of both motors.

Once both drives are installed we can verify that both are aligned correctly.

Drop the hatch and let's go boating!

We're now ready to connect the wiring and remote controls and make the necessary adjustments per the supplied installation CD-ROM "manual." Connecting the engine supply hoses to the fuel tank and double clamping the fittings, installing correctly pitched propellers, topping up all fluids, installing new bilge pumps and blowers and remounting engine compartment hatches completes the job.

Each power package from Mercury Marine comes with a CD-ROM that details the entire installation procedure. There's also a predelivery inspection document that requires completion prior to and during the installation and after sea trials. Sea trials ensure that the steering, remote controls and other systems are functioning correctly before giving the keys to the owner.

Total cost of this repower was $40,000. The owner now has a boat that he is familiar with and has all the user-friendly, high-tech features of new Smartcraft Mercruiser EFI engines at significantly less money than a new 30' (91.m) express cruiser. It should be stated that many of the minor steps involved in this engine repower have not been identified in this article and a sterndrive engine repower is not a typical DIY project. That being said, some of the work, such as engine compartment clean up, bilge pump and blower replacements, are all easy DIY tasks that would reduce the overall labor cost of an engine repower.

About the author: Steve Auger has more than 35 years experience servicing marine engines. He is DIY's engine technical advisor and service training instructor/ Mercruiser product support specialist at Mercury Marine.

PROJECTS

Indicates the degree of difficulty with 10 being the hardest and 1 being the easiest.

HOT AND RAW

9

Installing a water heater is a straightforward procedure. This project looks at the less well known method of setting up a hot water system with a raw-water cooled engine.

Story and Photos by Peter Caplen

Water heaters (a.k.a. calorifiers) work best when heated from a freshwater cooled engine (heat exchanger) as the proper running temperature of the engine is around 185F (85C). Raw-water cooled engines run cooler to prevent the build-up of corrosive salts and sediment inside the water passages of the block. The normal recommended temperature for a raw-water cooled engine is around 125F (52C). While a lot cooler than a freshwater cooled engine, it's still hot enough to provide for a boat's domestic hot water needs.

As the majority of cruising today is from marina to marina, the addition of an immersion element into the water heater means that the temperature can be "topped-up" whenever a shorepower connection is available. Heating water by a raw-water or freshwater engine heat exchanger is a safe form of supplying hot water for many smaller boats, especially those with gasoline engines.

Installing the water heater and its various connections is identical to that for a freshwater cooled engine. It's only the heating system from the engine that is different with a raw-water cooled engine. Freshwater-cooled engines have an internal water circulating pump installed on the front of the engine, which is usually driven by the alternator belt. This assists the natural flow of water around the engine and provides sufficient flow to also pass water through the water heater heating coil. In most cases, the take-offs for the water heater are the same as those used for cab heating in the motor vehicle equivalent of the engine. On raw-water cooled engines, this circulating pump is omitted and water flows through the engine under pressure from the external raw-water (Jabsco type) pump. As the flow is designed to pass right through the engine, it's not usually possible to simply connect the water heater in the same way as with a freshwater-cooled engine because the hot water will bypass this external diversion. What is needed is an external pump to draw some of the hot cooling water from the engine and pass it through the water heater coil and back into the engine before being discharged overboard. This flow must be sufficient to heat the water heater but controlled so as not to adversely effect proper engine cooling.

The easiest method of pumping is to use a constantly running electric pump that operates as soon as engine ignition is activated. Jabsco makes a suitable constant running pump that is simply mounted in the engine compartment adjacent to the engine.

On my boat, hot water is now provided by a C-Warm water heater from Cleghorn Waring. This was installed alongside the engine to minimize the flexible pipework required between the engine and water heater heating coil. Being in a warm area also helps to maintain the water temperature. The engine is a gas Volvo-Penta AQ130 from the late '60s but it has plenty of life remaining and it maintains a steady 125F (52C) when running.

Before beginning this job, I spoke first with Cleghorn Waring to find out if there were any particular problems to be expected from heating a water heater from a raw-water cooled engine and was told that there was no reason not to use raw-water cooling for heating water. However, Cleghorn did suggest that I speak to a local dealer for a detailed explanation of what is required for this particular engine. After a short discussion, I decided to install a tee fitting into the water temperature sender orifice as a feed to the water heater with the return into the engine block drain tap. With the temperature sender and drain tap removed, it was a good opportunity to flush the engine with freshwater to clear as much muck as possible from the block before piping it to the heating coil.

I took the two removed parts to my local hydraulics' engineers to have them check the thread sizes and was able to get the necessary adapters for piping to the cylinder. Apart from the constant running circulating pump, this was all that I needed to begin the installation.

The water heater installation demands special attention to ensure the mountings are strong enough to take the weight of the storage tank when full, especially when subjected to the dynamic motion of the boat underway in rough conditions. Although this one is only 10gal (41L) capacity, the total weight when full is close to 120lb (54kg). I used some heavy scrap timber left over from another job to make up two mounting beds on which the water heater sits. To keep the heater as low as possible and beneath the height of the engine cover seat, I cut shallow slots into the main longitudinal stringers to allow the beds to sit lower and to provide additional support. These cut-outs were glassed in with three layers of mat and polyester resin to maintain the watertight integrity of the stringers. The beds themselves were sealed with a coat of resin prior to being screwed into place. Once the supports were securely fitted into position, I installed the strap kit, which includes stainless-steel brackets and webbing straps that are available from water

Strap kit fastened to custom mounting beds ready to install the heater.

Marine grade double insulated immersion element fits inside tank.

A combined pressure and temperature relief valve installs in the bottom of the water tank.

heater suppliers. The brackets are screwed to the supports using screws at least 1" (25mm) long to ensure a firm hold. The webbing straps are then threaded through the brackets, ready to accept the water heater.

Before installing the water heater, the pipe fittings and immersion heater element are fitted. This is the same for any water heater installation. On an installation involving a raw-water cooled engine, the immersion element provides a boost to heat the water in the water heater when the boat is plugged into shorepower before leaving the dock. For small boats, this initial tank of hot water will probably be enough to last a weekend even if the engine cooling water is not particularly hot. However, the water will be sufficiently hot if the engine is running at its proper temperature of about 125F (52C). It's essential to use a proper double insulated immersion element designed for marine use as ordinary domestic elements suffer from earth leakage and will constantly trip the boat or marina circuit breakers.

The body of the pressure relief valve was installed in the bottom of the water heater and screwed firmly into place with the thread sealed using Loctite or other thread seal tape. The hose end was then screwed into the relief valve, ready to accept a hose leading in to the bilge to safely carry away any hot water released under pressure. These valves consist of a combined pressure and temperature relief valve, which gives twice the protection. The rest of the fittings were then installed into the water heater.

Ideally, to avoid the possibility of airlocks, the water heater should be installed so that the heating coil inside is vertical. In this case, the fittings on top of the unit wouldn't fit under the cockpit seat cover so I tilted the cylinder slightly to get the needed clearance but, since the water is circulated from the raw-water cooled engine by the constant running pump, there won't be airlock problems. Had the system relied on natural circulation, as is generally the case with freshwater-cooled engines, I would have had to ensure the correct vertical orientation of the heating coil cylinder and therefore the heating coil were mounted in the correct way.

The inlet and outlet fittings to and from the heating coil and engine were made up with standard 5/8" (15mm) plumbing fittings using solder ring elbows. These are not only easy to solder due to the raised ring that contains the solder, they are also ideal for use with the flexible heater hoses that connect them to the engine.

The water feed from the engine to the water heater heating coil was via the modified temperature sender fitting. Initially, I installed the sender in the end of fitting but later I modified the arrangement with the water feed straight through the sender in the tee.

The constant running circulating pump was bolted to the bulkhead inside the engine compartment and later wired to a connection on the starter key switch

Solder ring elbow fittings ensure the hose is held firmly in place when the hose clip is tightened.

This was the Mark One layout with the sender in the end of fitting, which was later modified.

so that it ran whenever the ignition was activated. An in-line fuse was also fitted to protect the pump.

All the pipework and wiring connections were finalized. The system was tested with the engine running and showed no problems. I assure you that the temperature is quite warm enough for all my domestic water requirements.

There is very little difference in the method for installing a water heater using a freshwater or raw-water-cooled engine heat exchanger. However, the differences are important if the system

Circulating pump bolts to the bulkhead inside the engine compartment.

Note the inclined attitude of the water heater to allow the fittings to clear the seat and the final layout of the water outlet from the engine.

is to work. This installation took two days, including fabrication and bonding the water heater base in place and used standard tools plus soldering equipment.

About the author: UK-based Peter Caplen is a mechanical engineer and technical writer with nearly 30 years experience in building, maintaining and renovating mainly powerboats.

Ease Up on Your Starter

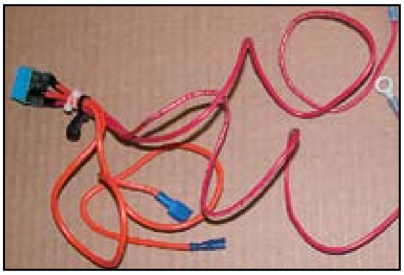
5

One and two-cylinder diesel engines often found on small (30' /9.1m or less) sailboats increasingly have been sporting large alternators to power the myriad creature comforts onboard. A 35-amp alternator was common on these engines once but 55 or 60 amps seems to be the minimum now, with 90 amps not uncommon.

This is fine once the engine is up to cruising speed but consider what happens during starting, especially if the batteries aren't fully charged. When the starter turns the engine, it draws a lot of electricity. The alternator regulator, which comes to life when you turn on the key, senses this battery drain and applies full field current to the alternator to replace the charge. The poor starter now has to not only spin the engine but also spin the alternator at full output load. Typically, it takes a couple of horsepower to turn the alternator, stressing the starter, using more electricity to run the starter and, if the batteries are in extremis, maybe not turning the engine fast enough to start. In the long term, this is not good for the starter and puts extra wear on electrical parts.

If you find yourself between a rock and a hard place with dead batteries and a non-starting engine, you can sometimes get started by disconnecting the lead to the alternator field coil or, with an internally regulated alternator, the lead from the engine "on" switch. Good luck hooking it up again with the engine running. It's usually close to the alternator and all those spinning belts are very hazardous to fingers. If you don't reconnect the alternator, there is no charging for the batteries.

A better idea, for not much money, is the device shown in the photo. It's simply a normally "on" relay with some wires soldered on and then potted in epoxy to make it marine durable. The actuating circuit, red wires in this case, connect between the starter solenoid and ground, so it's powered "on" when you crank the starter. The orange wires go between the lead from the ignition "on" switch and the alternator. Alternatively, the orange wires could go in series with the field wire as described above on externally regulated alternators. Cranking the starter actuates the relay, which interrupts the alternator until the starter stops and the engine is running.



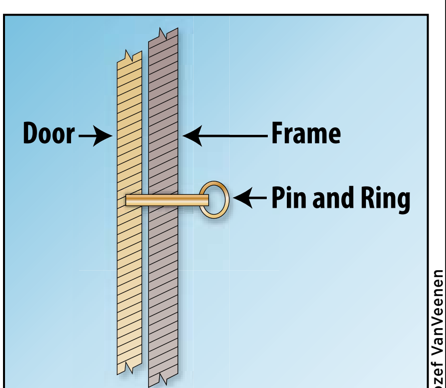
Buy the relay at any Radio Shack or other electrical supply store. The rest is just a few lengths of marine grade wire, some crimp-on connectors to fit, solder and epoxy. Total cost is about US$5.

– Quentin Kinderman has more than 40 years sailing experience and has restored and repaired fiberglass cruising sailboats from 25' (7.6m) to 42' (12.8m).

Sliding Door or Window Lock

4

Many boats have inadequate locks or none at all on sliding doors and windows. To prevent unauthorized entry into your sliding door, purchase 5/16" (7mm) wide by 3" (7.6cm) long, stainless-steel fast pins from your marine supply store for, about $15. You can make your own pins. For each "lock," you'll need a length of 5/16" (7mm) diameter brass rod and one stainless-steel key ring, 1" (25mm) in diameter. Actually, rod length is determined by the door or window construction as described below.



Drill a 1/8" (3mm) hole near one end of the brass rod and insert the key ring. The ring becomes the handle to extract the rod and makes a handy hanger when placed on a convenient, nearby hook. Measure the thickness of the outside door (or window) frame plus about half the thickness of the frame containing the door or window assembly. Select a drill bit slightly larger than the brass rod and mark the total thickness on the drill bit by applying a piece of tape or use a drill stop. With the door (or window) fully closed, drill a hole at a right angle through the frame and into the frame up to the mark on the drill bit. Insert the rod into the hole to insure that the door (or window) cannot be opened from the outside.

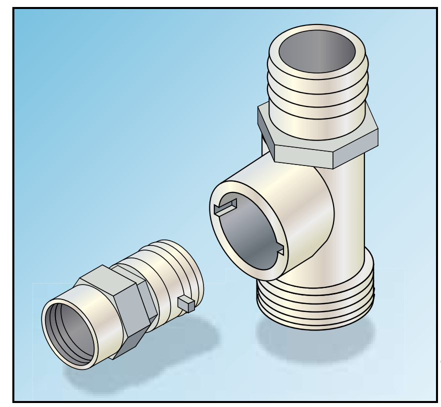
– George and Sheilah Van Nostrand have owned both wood and fiberglass cruisers for 36 years and cruise inland waterways in their 1975 Tollycraft, "Dream Catcher."

Gentleman (and Ladies) Flush Your Engines

7

Your mechanic's report that your sterndrive or inboard engine has a major problem is never good news. What's worse is that the news invariably comes during the boating season that, in the northern climates, is already too short. By far the most common "big ticket" engine repair results from corrosion that destroys key components of your cooling system, causing damage to running parts. Responding to the need, engine manufacturers developed the closed-loop cooling system. Engine damage still remains a problem because most saltwater boaters don't understand how the system works and, falsely so, feel they are protected.

Some saltwater boaters opt for the upgrade to freshwater-cooled engines when buying a new boat. If you've migrated from a raw-water system or you're new to boating, it's easy to think that a water/antifreeze mix circulating in the engine will prevent engine damage from salt. The error in this logic is that all of that heat in the engine has to go someplace and I've never seen a boat with a radiator and fan. The engine relies on a heat exchanger to mitigate the heat and that device is cooled by, you know what — saltwater. Lift the hatch and find thru-hull fittings in the hull or the engine intake hose on a sterndrive. You'll see that the hose runs to the seawater intake pump, through the heat exchanger and risers, on its way to the exhaust hoses. The saltwater also travels through the transmission oil coolers in most engines. Both the heat exchanger and the risers are very vulnerable to corrosion. If they deteriorate and corrode through, saltwater



(top) Groco Engine Flush Kit shown with service adaptor. (bottom) Sea Safe automative Aqua Purge kit for twin engine installations.

can enter your engine and cause serious damage and in some cases, very quickly.

The engine manufacturer's manual cautions that engines operated in saltwater should have the saltwater side of the cooling system flushed as often as possible. Flushing with freshwater from a dockside hose rinses the harmful salts from the system, drastically slowing the corrosion process. In the past, the only way to flush an inboard engine was to disconnect the inlet hose from the thru-hull fitting, find a way to connect it to the dock hose and flush the system. I can't tell you how many times I've flushed an engine by immersing both hoses into a bucket of water. These methods work but, if the bucket runs dry or worse, tips over, you better hope you have your fingers on the ignition key for an immediate engine shutdown. Who wants to perform this messy, hot bilge ritual after a nice summer cruise?

New products have emerged that make it easier to keep your engine(s) clean and healthy. They can be divided into two basic categories. The first is simply a fitting that attaches to your thru-hull so a hose can be attached quickly and easily. In this case, bring the dock hose into the bilge, close the engine raw-water intake seacock and attach the hose to the flush adaptor, turn on the engine and flush. Inexpensive to buy and easy to install, manual flushing systems for inboards only are offered by Thoro Flush, (www.thoroflush.com) costing US$80 to US$100 per engine and US$80 for the Engine Flush Kit from Groco (www.groco.net). These work only if you have a thru-hull fitting for the raw water intake, which means they won't work on most sterndrives. Another product offers the convenience of on-deck automatic flushing but at a higher price and is a bit more complicated. These systems have a deck fitting for the dock hose and are plumbed into the engine's water system. They can be used with both inboard and sterndrive setups. You attach the dock hose to the deck-mounted hose fitting and flush your engine. Prepare for a more complex installation that is more costly than the simpler systems. The Aqua Purge System kit (US$339 to US$625) from Seasafe (www.seasafeinstruments.com) includes a deck plate for connection access and flushes the engine using key operated automatic valves. This system eliminates the need to enter the engine space to hook up the hose every time you want to flush your engine.

An experienced DIYer can install any of these systems but plan for spending a good part of a day on an installation, which usually can be done with the boat afloat. The deck fitting systems require you to install the hoses and deck plate along with other items that make the system work.

Which system fits your needs? Just ask yourself how much it's worth to you to regularly flush your engines. By regularly, I mean ensuring that, before you leave your boat at the dock or load it onto the trailer after running the engine in saltwater, the engine is freshwater flushed every time. If you can get to the thru-hull fitting easily and quickly, then save some money and consider installing the adaptors. On larger boats with twin inboards and on any sterndrive, the better choice is probably the plumbed-in system with the deck plate.

– Barry Essig is an avid boater and president of SeaSafe Instruments and can be reached at bhiggins@seasafeinstruments.com.

Redesigning Trader Galley

Reconfiguring the galley of this 25-year-old trawler to improve efficiency and function grew from a simple modification into a full-scale project.

8

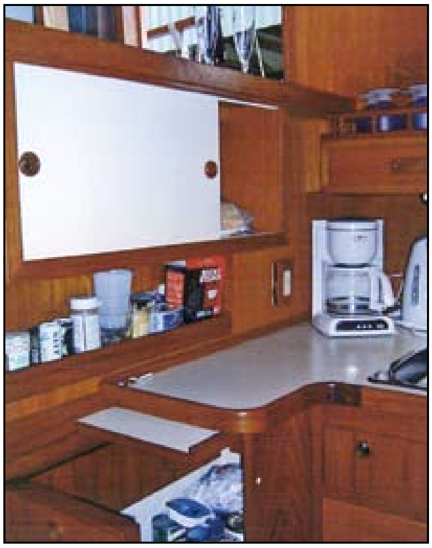
Before: (bottom) View facing port bulkhead shows propane stove with hinged stovetop cover. To the left can be seen the peninsula under which is the blank wall holding a paper towel rack. Beneath the counter are storage cupboards. Note depth of the counter and the small teak holder for glasses. (top) View from above the peninsula facing the forward bulkhead. The depth of the counter made it difficult to access the farthest sink or open the far drawer. The small counter over the refrigerator was the main working area.

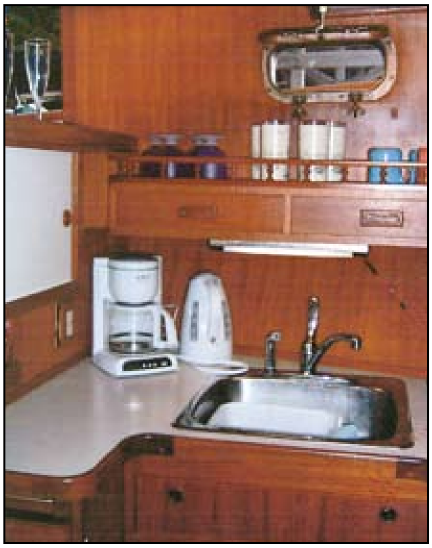
When my husband Wilf and me purchased a 1980 40' Marine Trader we were impressed with the quality of design and craftsmanship throughout the boat. From the beginning, however, we were aware that the galley needed some changes if we were to enjoy the efficiency and amenities that makes on-the-water cooking a joy.

Although galley down is not the standard layout in this boat, it was our preference. This model has the galley separated from the salon by a peninsula running from the portside door across to a three-step companionway leading down to the galley and forward berth. The peninsula is topped with a counter 4' (1.2m) long and 1' (30cm) wide. This is an important step-saving feature when transferring things from one level to the other.

A bank of cupboards with a countertop was situated under the peninsula. Across from the port bulkhead was a three-burner propane stove with a full-size oven. Along the vee-berth bulkhead was a double sink and a refrigerator with cupboards and drawers above.

We lived with the original galley for a season in order to determine precisely what needed changing. To begin, the footprint area was extremely cramped. There was scarcely room to open doors and no place to put a garbage container. Workable counter space was also limited as the stove and sinks and a full-sized microwave oven placed beside the stove took up much of the counter. Because of the depth of the stove and the deep flare of the hull, a large portion of counter space along the entire portside was inaccessible. To reach the farthest sink, you had to lean across the stove making it very awkward and potentially hazardous.





After: (top) Single sink installed with drawer and storage cupboards underneath replaces original stove. Bank of drawers and dish rack replace the original were moved from the forward bulkhead. (bottom) To the left are the new sliding doors and pullout cupboard. Note how cutaway in the counter makes entire counter accessible.

Storage was another problem. Three cupboards beneath the peninsula held the everyday staples and provisions. Less frequently used supplies were stored in various places throughout the boat. Plumbing under the sink took up most of the lower space of the vee-berth bulkhead. Dishes and some small appliances were stowed in the upper drawers and cupboards. Again, the farthest cupboard was all but unreachable. Pots and pans were stored inside the oven when not in use. Other small appliances were juggled from place to place as needed.

Planning

In a nut shell, the problems revolved around: use of both floor and counter space; lack of or poorly assigned storage; and choice of appliances. Did we need a full-sized stove and conventional oven?

Obviously, others had lived with these short-comings but since it's our dream to spend extended time aboard this boat and since cooking is one of my personal passions, we decided to make the necessary changes. We based decisions on what we must have and what we would like to have if space and budget allowed. The first to go was the propane stove and free-standing microwave. The double sink was next. Although a nice convenience, it didn't justify the space it took. Because the refrigerator was a new, top of the line, Norcold, we tried supplementing the refrigeration by using a Koolatron and coolers filled with ice. After a summer of boating with a refrigerator that did not hold enough food for an extended weekend we knew we had to install a larger one.

One thing that was very important to us was to retain the boat's integrity. All changes must be in keeping with the original materials and design. Although my husband has excellent building skills, he did not have the time nor experience to tackle the job by himself. With this in mind, we called in Eric Seepa of Classic Boat Restorations, an expert with many years experience. Eric is amazingly imaginative in the use of space on a boat. We knew him to be a fine cabinet maker whose finished work had enhanced the beauty of our former classic Chris-Craft tri-cabin.

Construction Details

Come spring, Wilf and Eric began the renovation with removal of the propane stove and fittings. They removed the refrigerator next. After researching the options, we purchased a 53" (134cm) Norcold 12-volt DC/110-volt AC refrigerator. The only viable place to locate the refrigerator was in its original place against the vee-berth bulkhead. This meant eliminating the countertop and removing the bank of drawers but there was room to leave the upper cupboards.

Sinks and plumbing were then removed. The upper cupboards on the vee-berth bulkhead were left but everything else was removed. Dismantling the cupboards and drawers proved challenging since Marine Trader used ring nails for fasteners, which were also glued in and covered with veneer. Thus the purchase of a sawsall became a necessity. As the dismantling took place, everything that could be salvaged was put aside for reuse. This included louvered cupboard doors and pin rails. Once the cupboards and stove were out, Eric discovered that the teak floor underneath had been painted white. Sanding with 80-grit sandpaper restored this section of the floor to match the original.

With the refrigerator in place, Eric prepared a full-size mock-up of the proposed counter, complete with a template for a single sink. This allowed us to explore how best to utilize the space. The portside counter was moved back approximately 10" (25cm). This still left a significant amount of space across the back unusable. By cutting out an additional 6" (15cm) across the front of this counter, the entire area

The entire galley was dismantled and reconfigured. Note how the hull flares inward. This was why, in the original design, the stove jutted out so far making a significant amount of space inaccessible.

became accessible. The difference these few inches made to the floor area was incredible.

After considering several options, we replaced the propane stove with a smaller, more efficient, combined convection/microwave oven that runs off either shorepower or generator. To free up counter space, the oven was mounted on a shelf under the vee-berth bulkhead cupboard, approximately 10" (25cm) above the counter. Initially, I thought that the space under this shelf would be used only for storage but, in time, I came to see how useful it was when taking items in and out of the oven, as well as for food preparation. The cooktop remained a problem but given the other appliances we use, including a portable propane two-burner stove, a portable electric cook top would suffice. [Ed: ABYC standard A-1 contains very specific requirements for propane (LPG) stoves and their fuel supply storage and delivery systems. "Camp" stoves that have attached LPG cylinders with a fuel capacity larger than 16oz (473ml) are not permitted on boats. Only the portable stoves that meet ABYC standard A-30 are permitted to be used.]

Sink placement was dictated by the existing plumbing but it could no longer

View from the salon down into the galley shows refrigerator, microwave oven and counter. Drawers and rack were removed to accommodate the larger refrigerator and the shelf for the oven. The counter underneath proves quite useful during food preparation. The refrigerator was faced with leftover arborite to brighten the galley. Note the slats on top of the refrigerator to ensure air circulation.

be placed on the vee-berth side because of the oven shelf. After considering the options, the sink was mounted in the center of the portside counter where the stovetop had been. This greatly reduced the working surface but a custom made cutting board for the sink helped recover some of it.

With the major appliances in place, the next step was to design the storage. We needed space for cookware, dishes, utensils, food stuffs and small appliances. There was now generous space under the port bulkhead counter where the oven had been. Although the flared shape of the hull reduced the space, two large shelves were installed that wrapped around toward the vee-berth bulkhead. This blind area provides an ideal place to stow seldom used, bulky cookware, such as the Crockpot.

Reinstalling the original bank of cupboards against the peninsula would have taken up precious floor space. To avoid this, Eric designed a pull-out cupboard making use of dead space under the port counter. This cupboard was mounted on a heavy sliding frame and contained two moveable shelves. It was fitted with a toggle to prevent it from sliding forward during rough seas. In a 3" (7.6cm) space above this cupboard, Eric built a pull-out counter that could be hidden away when not in use.

We now had considerably more storage and floor space and more efficient appliances in terms of both space and function. The next problem was what to do with small appliances, such as the toaster and pantry items that are part of meal preparation. Once again, Eric came through with an ingenious idea. Making use of dead space under the peninsula, Eric cut an opening into the salon area and built a curved wall faced with teak. Two 5-1/2" (14cm) shelves deep were built into this area. These are ideal as an appliance caddy and storage area for condiments and other frequently used food stuff. Drawers removed from the bulkhead wall were modified and reinstalled on the port wall above the sink.

A deep, 8" (20cm) wide space beside the refrigerator remained unusable until Eric inserted a bank of three deep drawers measuring 6" x 6" x 20" (15cm x 15cm x 51cm). These were fitted with catches to ensure that they would be secure in rough water. These drawers are long enough to hold over-sized barbecue utensils, aluminum foil and other awkward items.

The last problem was what to do with kitchen garbage. With the increased floor space, a container could be placed on the floor, but it would make for clutter. By cutting into the bulkhead beside the companionway, Eric was able to scavenge space from the bilge. Working within the limits imposed by a hot water tank, he built an 8" x 10" (20cm x 25cm) sealed box with a sliding steel frame.

PROJECTS WANTED

If you would like to share one of your own boat-tested projects, send your articles to DIY PROJECTS via mail or e-mail. Include a brief explanation and photos and/or sketches (don't worry, we'll redraw the art). Also, please include your mailing address and a daytime phone number or email address. If we publish your project, we'll send you between $25 and $150, depending on the published length.

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Finally, the countertop and additional lighting were installed. To brighten up the galley, a panel of ream-colored arborite matching the countertop was made for the front of the refrigerator. Finally, a shelf was built over the top of the refrigerator. Slots faced with teak slats were added to ensure ventilation and increase air circulation. This area houses large trays and other more awkward items.

As we had hoped, the new galley is completed true to the original interior of the trawler. The use of teak trim, original pin rails and attention to every small detail all ensure that this renovation does not detract from the original decor but rather adds value both economic and aesthetic.

We have now used the galley for three seasons. It never ceases to amaze me how functional and accessible everything is. I cannot help wondering why when so much time and energy goes into designing a boat, so little though goes into planning the galley. We invested a good deal of time and money in planning and executing this renovation but I would not change a thing.

— Wilf and Susanne Eden have shared their love of the water for nearly 30 years.

DIY BILL

Three types of plywood were used: maple plywood for interior surfaces that were sealed with arborite and epoxy resin glue; and mahogany and teak plywood for finished surfaces. This was a significant savings over using marine grade plywood. Prices below are in Canadian funds. To convert to U.S. dollars divide by 1.20 (approximate rate).

Building Materials	
2 1/2" (12mm) sheets maple plywood	$126
8 sq. ft. 1/2" (12mm) mahogany plywood	$20
16 sq.ft. 1/8" teak plywood	$52
13 sq.ft. 1/2" (12mm) teak plywood	$60
6 sq.ft. 1/4" (6mm) teak plywood $20	
14 sq.ft. teak veneer	$53
6 board feet solid teak trim	$158
6 teak finger holes (finishing rings)	$10
3 sheets arborite	$150
3 teak drawers (set)	$90
Total	**$739**
Hardware and Consumables	
(heavy duty sliders, contact cement, etc)	$194
Labor	
Approximately 75 hours at $50	$3,750
Appliances and Fixtures	
Norcold refrigerator (6.3 cu.ft.)	$875
Convection/microwave oven	$650
Sinks and plumbing	$150
Lighting	$75
Subtotal	$1,750
Total cost of the renovation	**$6,433**

Note: Recycling cupboard doors, hardware, trim, etc., saved approximately $350. Self-dismantling galley, plumbing, electrical, etc., saved 35 hours of paid labor or $1,750. Sale of existing appliances netted $500.

View from the Stern

Finding Volumes

Do you know your boat's tank capacities? Here's help for our math-challenged readers. These formulas will help you calculate the volume of fuel, waste and water tanks on your boat.

By Roger Marshall

Suppose you have a rectangular water tank onboard and you need to determine its volume (capacity)? You probably practiced solving this problem using a formula you learned in elementary school math class. That formula is length times width times height (L x W x H). The catch for using that formula on boat tanks is that the tank shapes are often dictated by the irregular shaped interior spaces into which the tanks must fit. Here you'll find some useful equations for calculating the volume of cylindrical and other odd-shaped tanks.

Let's say you have a water tank shaped as shown in **Figure 1**. It's 3' (91cm) long and one end measures 2' (61cm) across the top, with an inside

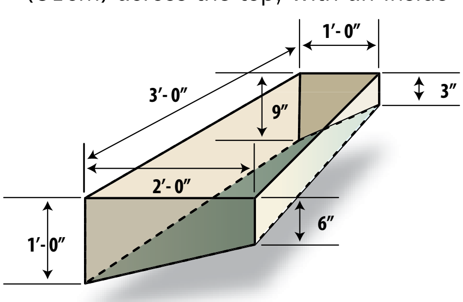

Figure 1

depth of 1' (30cm), while the outside depth is only 6" (15cm). At the front end, where the boat gets narrower, the tank tapers. Here it's only 1' (30cm) across at the top, 3" (7.6cm) deep on the outside and 9" (23cm) deep on the inside. How do you figure the volume?

It's easier than it looks. First, find the area of each end. In order to do that, average the height (shown in feet for clarity). This equates to 1' + 0.5' = 1.5' ÷ 2 = 0.75'. Now the end area becomes 2' x 0.75' = 1.5 sq. ft. Now do the same for the other end: 0.75' + 0.25' = 1.0' ÷ 2 = 0.5'. The end area measures 1' x .5' = 0.5 sq. ft.

The two ends of the tank are sized at 1.5 sq. ft and 0.5 sq. ft. If we add them together and divide by two, we get an average end area equal to 1' (1.5 + 0.5 ÷ 2 = 1). If the average end area is 1 sq. ft. and the tank is 3' long, the

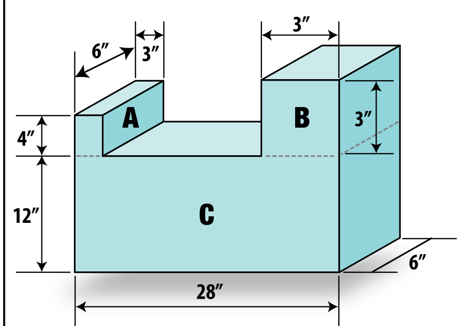

Figure 2

volume must be 3 x 1 = 3 cu. ft.

You want to know how much water a 3 cu. ft. tank will hold? Since freshwater weighs 62.2 pounds per cubic foot, the tank holds 186.6lb (84.6kg) of water (3 cu. ft. x 62.2lb) and since a gallon (3.78L) of water weighs 8lb (3.6kg), the total amount of water the tank holds is 23.3. gallons (88L), which is what you get when you do the arithmetic (186.6 ÷ 8 = 23.3 gal/88L).

The trick is to average the areas of the tank ends and then multiply by the length to find the volume. If the tank is oddly shaped, break it down into smaller tanks. For example, to find the area of a tank shaped like a big "U" as in **Figure 2**, the first step is to break off the end marked A. This measures 6" x 3" x 4". Multiplying all dimensions, converted to feet, results in a volume of .5 x .25 x .334 = 0.04 cu. ft. Now you find the volume of the other end (B) by multiplying 8" x 9" x 6" or .667' x .75' x .5' = 0.25 cu. ft. The last step is to find the volume of the third part (C). This measures 12" x 28" x 6" or 1' x 2.334' x 0.5' = 1.167 cubic feet.

Add all three volumes known to find the total volume and then multiply the tank volume by 62.2 pounds of freshwater per cubic foot and divide by 8 gallons per pound to get a total capacity of 9.1gal (34.4L).

How does this work if you have a round tank such as a water heater? As in the first example, find the area of each end. In the case of **Figure 3**, the diameter is 18" and the tank is 30" long. The calculation for the area of the ends is πr2 or π x 0.752 = 3.142 x .752 = 1.767 sq. ft. All we need to do is multiply that by the length to get the

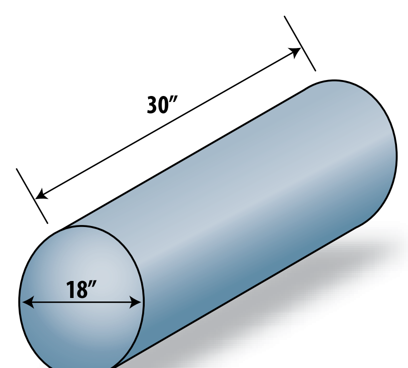

Figure 3

volume 2.5' x 1.77 sq.ft. = 4.42 cu. ft. Finally, multiply by 62.2 to get the poundage the tank can hold and divide that by 8 to get the number of gallons. In this case we get 4.425 x 62.2 ÷ 8 = 34.4 gallons (130L).

That's it. Use these formulas to determine the volume of existing tanks or when you plan to add a tank and need to find a place for it and calculate the volume of the space available.

About the author: Roger Marshall is a boat designer and author of 12 books on sailing and yacht design. He has a boat design company in Rhode Island and is the president of Boating Writers International.