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Edited by Jan Mundy

Positive Feedback

"After running about six hours with hatches open, the sooting is much less and also it's now a dust as opposed to a thin black tar-like stain. I think you have probably solved the mystery. I will continue to run the engine with the hatches open for the short term until sooting diminishes. I'll also check and clean out the elbow and exhaust system if necessary and install proper ventilation. The engine was professionally installed by a Yanmar dealer and two more Yanmar-certified mechanics took more of my money before you diagnosed the problem. I hope to remain forever soot free and forever a subscriber to DIY." *Comments from Bill Shenko, Jr. of Estero Island, Florida, who contacted DIY's Technical Helpline for help with a sooting engine problem and DIY diesel engine advisor Bob Smith provided a solution. For the complete engine analysis see "Talkback," on page 16 in this issue.*

In Search of Window Frames

Do you know of any suppliers of custom-made, add-on frames as described on page 22 of Nick Bailey's article on leak proofing cabin windows in DIY 2004#1 issue? I've had no reply from my email to Beclawat or any luck with Internet searches.
Al Kirk, Salt Spring Island, British Columbia

Nick Bailey answers: *The add-on frame pictured on page 22 was supplied by Engineered Marine Solutions, a small outfit started by a Lake Ontario boat owner who felt there had to be a better way to seal and secure bonded windows. This style of external frame has been successfully installed on many boats. Contact Dan Boisvert at 519/404-0267 or email at dansbeausejour@hotmail.com. He has templates for some models but you may have to provide templates for your boat. Beclawat now only supplies commercial users. It hasn't made small boat windows in many years but replacement gaskets are available from aftermarket suppliers.*

Weather Resources

DIY reader Chip Lohman in Woodbridge, Virginia, sent us this list of Internet marine weather resources. They're just a click away! NOAA: www.nws.noaa.gov/om/marine/marine_map.htm; NOAA buoy reports: www.ndbc.noaa.gov/; Wave watch: //polar.ncep.noaa.gov/waves/main_int.html; Weather models: //weather.unisys.com.

How-to Seminars

I attended Jan Mundy's "How to Repair Fiberglass Boats" seminar and I must tell you, I was not expecting it to be that good. Jan did an excellent job. It was by far the best boat show seminar I have attended. Only wish I had a recorder.
George and Mary Marasco, Wyoming, Delaware

DIY editor Jan Mundy presents seminars on various maintenance topics at boat shows where DIY exhibits. For a complete list of go to www.diy-boat.com and click on "Events/Seminars." FYI: Sorry, but we don't permit recording of our seminars.

Tips from a Skilled Wrapper

In the article titled, "Shrinkwrapping Afloat," in the DIY Projects column in the 2004-#3 issue, the author shows using the torch inside the wrap. This is ill advised due to the potential to set fire to the plastic from the heat retained under the plastic. A heat gun produces about 300,000 BTUs, about five times the output of an average house's furnace, and the heat buildup is very fast. The volume under the plastic is a fraction of the volume of an average house. The heat retention pre-heats the plastic making unintended holes a problem. If shrinking is done inside the plastic, and the flame gets close to the webbing tape, fragments flare off causing holes along the tapeline. Materials, like felt under a pad and carpet, used to pad sharp edges have a flash point far below the plastic and burn far more easily causing holes and increasing potential for fires. Additionally, a by-product of burning propane is water that will condense on the inside of the plastic making repairs very difficult. The adhesive repair tape will not adhere if the shrinkwrap film has any moisture on it at all. I have found that, due to the static charge on the shrinkwrap film, dirt is easily attracted to it. Care needs to be taken not to let the film get dirt on it by touching the ground. The dirt particles absorb the heat and makes pinholes that must be taped over. Don't wait too long to shrink the plastic after laying it over your boat as air born dirt accumulates and makes shrinking a real problem. It may be necessary to wash the film before shrinking if dirt accumulates on the surface of the film.
Rex Miller, Mundelein, Illinois

How best to protect non-skid, the molded-in gelcoat type, from oxidizing?

This is a million dollar question with no definitive answer. To protect gelcoat from oxidation you would apply a wax but wax a deck and you lose the skid-resistant properties. To remove oxidation, compound the non-skid areas with a mild rubbing compound followed by a finishing glaze, such as 3M Finesse-it II. These products don't contain any silicone, wax or UV inhibitors to block the sun's rays that cause the gelcoat to oxidize. Once completed, the non-slip will be glossy but not slippery. Wash the surface with boat soap to remove any residue and the non-slip will still be effective. A skid-resistant deck with a splatter-like pattern is more difficult to maintain due to its irregular surface.
— Nick Bailey

Mike Stenburg of Dr. Shrink replies: *I agree with what this reader says. It's much harder to shrink from the inside and there are greater chances for holes to melt the plastic when heat rises to the top of the cover on the inside. Any direct heat applied to vinyl-covered lifelines and the woven cord strapping used for support structures can easily cause damage. More importantly, the heat tool can use up most of the oxygen under the cover, which is an asphyxiation hazard to the person doing the shrinking or anyone else within the cover. It's safer to shrink from the outside.*

Mandatory Boat Certification by '07

Effective the with 2007 model year, the National Marine Manufacturers Association (NMMA), the leading boating industry advocacy association in the U.S., requires that all NMMA member boat manufacturers have boats NMMA Certified to American Boat and Yacht Council (ABYC) standards. This certification program also requires participants to institute a Customer Satisfaction Index (CSI) program.

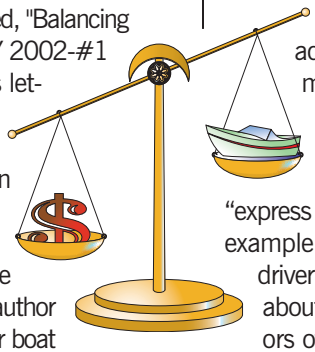
There are currently 140 boat manufacturers participating in the NMMA certification program, representing 75% of all boats produced in the U.S. each year. The goal of NMMA, ABYC and the United States Coast Guard (USCG) is that all boat manufacturers be NMMA certified. (Presently, boat builders can elect to comply with the voluntary ABYC standards.) Only NMMA-certified boats are allowed to display the NMMA Certified label.

What does this mean to new boat buyers? Purchasing a boat that is certified as built and equipped to the accepted ABYC safety standards provides at least a minimum quality confidence level to buyers who are trying to make comparisons in both safety and value. What it does not mean is that a boat builder who is not an NMMA member is automatically not incompliance. There are very conscientious boat builders who are fully compliant with the USCG and ABYC standards but they are not affiliated with NMMA. This can be confusing to the boat buyer so it's important for boat shoppers to be informed about the safety issues at stake. (Ed: For more information on marine certification and what it means to consumers refer to the "Scuttlebutt" column in DIY 2004-#3 issue.)

TIP: Smoking Bad Time

If your diesel engine runs at idle without smoking but then blows out lots of blue smoke and soot at cruising rpm, say 2,000 rpm, guess what? It's time for an injector rebuild!

Boat Warranties: Buyer Beware



Further to the article titled, "Balancing Boat Warranties," in DIY 2002-#1 issue, we received this letter from a DIY reader detailing his experiences and difficulties in receiving warranty coverage. His case contrasts sharply to the guidelines provided by author Nick Bailey. To aid other boat buyers we have published it in its entirety, except to change the actual names of the boatbuilder and boat model.

In Nick Bailey's excellent article on boat warranties he points out how boat manufacturers pass the warranty buck back to the makers of "all the installed equipment, engine, gen-set, steering and control systems…." By making careful notes, doing no repairs oneself, and including the selling boat dealer in the process, Nick suggests new owners can get warranty service. His "it can be fixed if you document and calmly present the claim" approach didn't work for me. Boat owners should be aware that some manufacturers will totally disregard a warranty claim, government regulations are vague and government agencies are of little help.

I purchased a new sportfishing runaboat made by ABC built in North Carolina. The hull is foam covered roplene plastic, which has a feel similar to Tupperware. I decided to buy the boat on the basis of printed advertisements and salesman statements. Little did I realize I was about to receive an education in warranties, Coast Guard Certification and the Florida and North Carolina Consumer Protection business.

When it became clear my boat manufacturer wasn't going to fix the many problems, I did some research to find out how a manufacturer can be made to recall defective products. In the United States there is a Federal law called the Magnuson-Moss Warranty Act, which outlines manufacturer warranty requirements. The law is cited as Title 15 Chapter 50 United States Code Sections 2301-2312.

Warranty words have developed from a long history of merchandise peddling. One such word is "merchantability," meaning the product is marketable, that it will perform the basic task/service/use it is presented and advertised as being able to do. In my case, it means my new boat should float and do everything a regular boat is thought to do. Another warranty word is "express or written warranty." By way of example, the basic purpose of a screwdriver is to turn screws saying nothing about its ability to withstand the rigors of saltwater exposure. A screwdriver claimed by the manufacturer to be "zinc coated for marine use" has an express warranty. Another warranty word is "implied warranty." Warranty law includes a concept attaching legal economic liability on the part of a salespersons and boat dealer when a customer relies on the subject matter knowledge of a salesman in determining which product will meet his/her expressed needs. Manufacturers try to guard themselves against the implied warranty claims of salesperson that would close a deal by claiming that nice new boat not only floats but also indeed flies!

Written and unwritten product marketing claims are all enforceable in the U.S. through civil and sometimes criminal courts. New boatowners can hire lawyers asking a judge to order their boats fixed and for payment of all legal fees. New boatowners can also attempt to interest the various state consumer affair offices for help. Those offices may bring suit to protect against unscrupulous merchants. The state becomes most active in cases

of out and out fraud. The Magnuson-Moss Warranty Act also defines "deceptive warranty" in part as a written warranty which contains an affirmation, promise, description or representation which is either false or fraudulent, or which, in light of all of the circumstances, would mislead a reasonable individual exercising due care. This sentence is most important. It's the legal standard a boat owner must prove in order to prevail in court — that you were a "reasonable individualv who took "due care" to ask questions and look over that boat yet were "mislead."

Numerous problems existed with my boat, the major one being water seeping into and filling up the bilge. The boat was nearly 30% heavier than the advertised weight. Some other problems existed including hinges tearing off and seat lids pulling out the first use, battery box incapable of draining seawater, and trailer that needed rebuilding by its manufacturer (no help from the dealer) so I could tow the boat home. My complaints to the builder were straightforward: a lack of merchantability, as a boat should float and this one did not; deceptive advertising as a boat advertised to weigh 635kg (1,400lb) should not weigh 1,088kg (2,400lb); and the boatbuilder's refusal to comply with the Magnuson-Moss Warranty Act by ignoring my many letters demanding a replacement hull.

Lessons learned include not buying a boat at a boat/sportsman show, hundreds of miles away from home, without first visiting the dealership. I was later to learn that this business was not an authorized outboard dealer and had neither qualified service nor rigging technicians. Unfortunately, at that time I didn't even know what "rigging" meant. The dealer simply provided me with the boat and trailer manufacturers' phone numbers. I didn't even know what a "sea trial" was until I was on one but it's a good thing I went for the ride. The throttle controls had been improperly connected and slipped

Engine Computer Nomenclature

Marine engine technicians use two descriptions for engine computers in electronic fuel injection (EFI) outboards and sterndrive engines; namely ECU and ECM. According to Steve Auger of Mercury Marine, who is also DIY's engine advisor and a regular contributor, the difference is just a technicality. The designations are simply the means for techs to distinguish an outboard from a sterndrive computer. Outboards have an Electronic Control Unit (ECU), as these engines were the first to get EFI and ECU was the common term back in the late 1980s. When Mercruiser engines finally got EFI, five years after outboards, the term had evolved to Engine Control Module (ECM). They both perform the same function of measuring the airflow of the engine and then injecting the correct amount of fuel to achieve an air to fuel ratio of approx 15:1.

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to the point of loss of most power. As DIY has reported, there was no written material provided with the boat to help with further rigging, maintenance or service. This information can be important. For example, hull registration numbers won't stick to the side of the super slick plastic hull without the use of a torch. At least this much information would have been useful.

A generic owner's manual, produced by the National Marine Manufacturers Association (NMMA), was the only documentation provided. This booklet indicates the International Organization for Standardization (ISO) directive 10240 requires specific information be provided and that American Boat and Yacht Council (ABYC) Technical Information Report T-24 recommends additional data to help the new boatowner service and maintain the vessel. This booklet also states, "The manufacturer may also provide a Construction Standards Statement detailing industry standards followed in building your boat." None of that information was provided.

I did receive a one page limited warranty, which states: "ABC will repair or replace, at its sole option, any part found by ABC to be defective." The warranty, as Nick Bailey reported, refers the new owner to the manufacturers of subcomponents to cure problems under the warranty programs yet leaving those manufacturers unidentified. It specifically claims exclusion of eleven concerns including liability for "damage from improper trailer issues, abuse, misuse, use without normal maintenance, use in commercial or rental purposes, weight, speed, or other estimated performance characteristic, owner inconvenience, improper propulsion, canvas, fabric or trim and degradation or other failure of the boat's finished surfaces," and more. Non-warranty declarations are the manufacturers' best-case scenario for defense of legally imposed liability to warranty products. DIY readers should know that just because the boatbuilder says it will not be responsible for problems they created or installed does not necessarily make it so. It just won't happen without a lawsuit.

Winning in court is hard work and while one doesn't plan on having to go this route, you must always consider the possibility. Save all sales brochures. Make notes of everything promised, by whom and when. Having sales personnel put their signatures beside their recorded promises may cause backpedaling that should trigger "Caution, run the other way" warnings. Hopefully, these brochures and notes will become nothing more than sentimental keepsakes. Keep them anyway. They are the best evidence. For instance, one of my brochures had a photo of the firm's chairman with his printed message stating: "Leading-edge design. Unsurpassed quality. New technology. Customer satisfaction." Unfortunately, this wasn't my experience.

It seemed to me that someone in government should care, namely the Coast Guard since each new boat carries U.S. Coast Guard (USCG) certification identifying load limits and compliance to legal standards. [1] The Coast Guard office of Boating Safety web site (www.uscgboating.org/) has fact sheets, including a form for "Boat Owner Reports of Safety Defects." It states: "recreational boats that contain a defect, which creates a substantial risk of personal injury to the public are subject to a recall by the manufacturer." Unfortunately, for consumers and perhaps the USCG, "substantial risk" is a steep legal threshold.

[2] The applicable law is The Federal Boat Safety Act of 1971 that "encourages voluntary cooperation and compliance by man-

ufacturers." I spoke with an officer at the Coast Guard Flotation section in Washington (Tel: 202/267-0986), the unit that enforces those standards. I was told how USCG oversight of a boat manufacture is based on an interpretation that the Act's "intent of Congress to write minimal regulations that are supported by actual accident data." When the law was passed, the USCG reviewed all the actual accident data on file. Most of the accident reports at the time involved inboard-powered boats and improperly stored fuel, fuel fume buildup and the accidental ignition of those trapped fumes due to a failure to ventilate. Therefore rules were enacted mandating requirements concerning closed fuel storage and pre-ignition venting of inboards. Few regulations concern outboard-propelled boats.

[3] I was also informed that it's the manufacturers who specify the load capacity of hulls, the USCG verifies those limits by tank testing a hull to insure any outboard-powered boat less than 20' (6m) floats level when swamped. [4] I filed a USCG safety defect complaint electronically via their website, stating that my boat doesn't float. There has been no response nor apparently any follow up by the USCG. [5] I expended many hours composing complaint letters to Offices of Consumer Affairs in both Florida (where I bought the boat) and North Carolina (where it was built), alerting of false advertising claims and failure to comply with warranty laws. Both offices just sent the manufacturer a copy of my letter, await the response, then send me a form letter indicating "there is a factual dispute" and that the offices are "prohibited by law from acting as a consumer's private attorney." North Carolina office said it needed a court order to prove the dealer or builder "engaged in a pattern of unfair or deceptive acts," suggesting I file a small claims action.

As for the trailer, I was unable to identify a single governmental regulation or organization concerned about whether a boat trailer sold in a package by a boat manufacturer can carry its load safely. [6] The U.S. National Highway Transportation Safety Council and similar organizations address safety concerns about automobiles, big trucks and buses.

In short, no governmental entity was concerned that the boat was unsafe much less wanted to look at any matter. The factory wasn't interested in honoring its legal responsibilities; a certified letter to the builder demanding warranty action remains unanswered. Absent of any "Lemon Laws" to coerce manufacturers into believing "consensual arbitration" is a good thing, advertisements of warranty are just advertisements. I did managed to fix the bilge leak, caused by automatic bailers mounted on the transom but located at or below the waterline preventing the flapper valves from closing, so the boat floats.

Fortunately, a dealer took my "lemon" in on trade and I now have a new boat, a new set of problems and still no warranty or maintenance manuals. And yes, I'm compiling an owner's book as DIY suggested. [Ed: How to create an owner's manual for your boat appears in DIY 2001-#4 issue.]

Editorial Notes:

[1] The USCG doesn't certify recreational boats. The law provides that the boatbuilder self-certifies that the boat is built to USCG standards.

[2] It's very important to understand the rather narrow definition of a manufacturer's "defect" in the context of the law. Defects are normally defined as those problems that arise from noncompliance with the law, e.g., failure to certify boat capacity correctly would be considered a "defect" under the law. A boat that leaked at the hull/deck joint might certainly be considered defective in general terms but would not be specifically considered so under the existing law. The courts usually decide of the impact of those defects.

[3] Accident reporting at the time of the inception of the law led to mandating requirements is much broader than represented by the writer. They include requirements that affect both inboard and outboard powered boats and address issues of capacity, safe loading, safe powering, flotation and start-in-gear as well as those related to fuel and electrical systems. Reporting today still reflects what has always been the most common types of boating accidents and those are capsizes and falls overboard, many of which were totally preventable if the victims had worn PFDs.

[4] The USCG does not test all boats. The testing program is selective and very limited. Boat manufacturers may request that their product be tested.

[5] The "defect" likely does not fall within the definition of "defect" as defined under the law. Many such "defects" are reported and recorded but are not acted upon because they are not within the scope of the law's definition.

[6] NMMA does certify trailers to this effect.

The Magnuson-Moss Warranty Act can be located online at many University Law Schools or the Government Printing Office site: www.access.gpo.gov/uscode/uscmain.html. Various state laws may be more stringent. Don't hesitate to ask your local consumer advocate office for help. BoatU.S. keeps a Consumer Protection Bureau database of consumer complaints on its website (www.boatus.com/consumer). Information can only be accessed by telephone and available only to BoatUS members.

WANTED

DIY reader Al Perkins has taken on the restoration of an "abused" 34' (10.3m) Chris-Craft Constellation, hull 0070, built in Holland, Michigan in 1963. The cabin has been changed to a daysailor configuration and the dining table and sofa area replaced with curved seating on both sides. He is interested in contacting anyone with a similar boat. You can email Al at alsan@xpressamerica.net.

Reader Brian Hall is selling a 1983 33hp Westerbeke 33 with 2,500 hours on it and a Hurth 150 V-drive, 3:1 ratio transmission. Engine has a closed-cooling system and includes the wiring harness and instrument panel. Engine requires a rebuild based on compression tests. He's asking US$2200 for the package. Contact Brian at bh@brianhall.net.

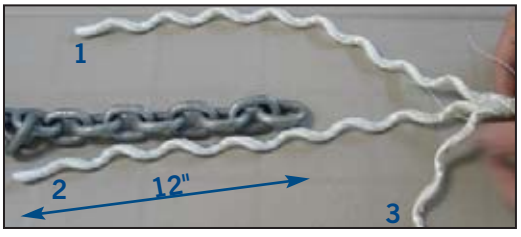
Easy Rope-to-Chain Splice

Follow these 10 steps to splice three-strand rope to chain to make an anchor rode that will pass through a windlass.

All rope-to-chain windlasses require that the anchorline be directly spliced to the chain, eliminating the shackle and thimble. This splice is very strong but over time it can chafe where the line wraps over the chain. Some experts recommend replacing this splice every two years; others suggest every 50 usages. Be sure to add periodic inspection of this splice to your maintenance log and replace as needed.

Three-strand medium lay (not firm, not soft) nylon rope is spliced to chain with a tapered back splice. To splice up to 5/8" (16mm) line, you'll need a hollow 5/8" (16mm) fid, scissors, tape and whipping twine. Mike Paulssen, general manager and in-house rigger of The Store in Mississauga, Ontario (www.thestoremasons.com), demonstrates the steps below. It takes a professional rigger about 30 minutes to do this splice, charging as little as $25, which makes an affordable do-it-for-me job should you have a rigger nearby.

1 Measure 12" (30.4cm) from the bitter end of the line. At this point, tie with whipping twine and knot securely. Tape each end to prevent unraveling. Unlay the strands up to the twine, being careful to maintain the natural twist of the line. Arrange the strands as shown below. You might want to label each strand, one, two and three so that strand two is in the middle.



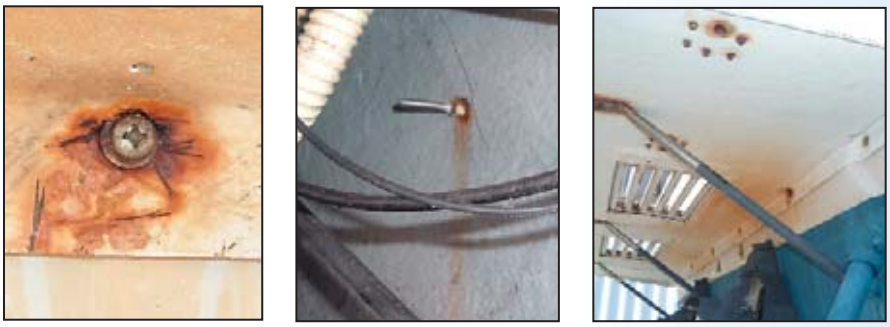
2 Pull the middle strand (two) though the last link of chain. Pass the two outside strands (one and three) through the same link but from the opposite side so they straddle the middle strand. Keep the twist of the line as natural as possible. Pull equally on all strands until the knot (twine) is snug against the chain link but not so tight it bunches the fibers or prevents the chain from moving freely.

(Continues on page 62)

All that Shines is Not Always Stainless

When selecting stainless steel fasteners, knowing which alloy to select for use above and below the waterline can save some maintenance headaches.

By Patricia Kearns



What's with "stainless" steel fasteners that rust and leave a dark amber telltale stain?

We think of steel as strong, very strong, and we think of stainless steel as even more robust with a sparkling finish to complement its resistance to corrosion and rust but all that's shiny is not always the stainless steel you think it is. When it comes to the nuts and bolts of stainless steels used in marine fasteners (screws, nuts, bolts, washers), there are variations on the theme and there are some absolutes for marine applications. Here's the drill (pun intended). Bolts, nuts, washers, screws, hinges, virtually any hardware that can be fastened to a boat or its components is available in several metal compositions, known as alloys.

Alloy steel is defined as steel with modified properties made by combining iron with one or more elements in addition to carbon. Alloys change the properties of the steel making it, for example, harder, more formable or more corrosion resistant, depending on the combination and amounts of alloys used. Stainless steels (alloys) encompass a very broad group of metals. "Stainless steel" is a common term for describing steel alloys that consist of 10.5% or more chromium (Cr) and more than 50% iron (Fe). Although it's called "stainless," a better term for it is "highly stain resistant." The chromium gives the steel its "stainless" properties, essentially corrosion resistance. On the surface of the metal, a very thin chromium-rich oxide layer, which is inert, is formed and prevents the steel from rusting. In general, the higher the proportion of chromium, the stronger the corrosion resistance of the steel. In addition to chromium, other metals are added to give the steel particular properties such as strength and malleability.

Stainless-steel fasteners are widely used in modern boatbuilding and repair because they provide strength and affordable corrosion resistance but only a few grades of stainless steel are suitable for boat fasteners. The 300 series stainless steels are the most popular. Among them are the 18-8 grades that contain very little carbon, about 18% chromium and 8% nickel, which give them good corrosion resistance. 316 series stainless contains molybdenum, which significantly increases corrosion resistance, strength and of course, cost. There are also "super" stainless steel alloys with significant additions of chromium, nickel, molybdenum or copper that should be used where requirements for extra corrosion protection, strength or heat resistance are paramount. Other alloy types, namely 410, 302, 304 (18-8) and 305 stainless, generally provide excellent corrosion protection in most situations. However, in direct saltwater or other high chloride atmospheres these alloys may pit and discolor. This may cause color to bleed through finishes and lead to streaking in the wood surrounding a nail or screw head.

What distinguishes Type 316 from Type 304 (18-8) is the addition of molybdenum up to a maximum of 3%. Molybdenum increases the corrosion resistance of this chromium-nickel alloy. As such, molybdenum is one of the single most useful alloying additives in the fight against corrosion. Type 316 is the main stainless used in the marine environment, with the exception of fasteners. Where strength and wear resistance are needed then Type 304 (18-8) is typically used. Type 316 is recommended in saltwater and other highly corrosive exposures to prevent fastener pitting and/or head discoloration and possible bleeding through finishes.

Stainless-steel fasteners, when used below the waterline, can deteriorate from galvanic corrosion from lack of oxygen. In this case, the corrosion likely developed due to a combination of factors of immersion and the use of a minimum quality stainless steel.

Use stainless-steel fasteners cautiously below the waterline for they cannot survive in an anaerobic (starved of free oxygen) environment. Because oxygen is necessary for the reaction, immersion in water for a prolonged time prevents oxygen contact and promotes corrosion. If the screw is immersed in "still water" with no oxygen, the chromium oxide corrosion-resistant film cannot form. Without this film, fasteners soon suffer from galvanic corrosion and eventual failure.

Not all stainless steel is equal and you definitely get what you pay for. You just need to be sure you know what you need, why you need it and what you're getting.

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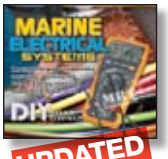

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A guide to expanding, upgrading, surveying and troublshooting your boat's AC and DC electrical system. All articles follow ABYC Standards.

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The complete guide to painting and refinishing hulls, topsides and decks with marine coatings.

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UPDATED

How to prepare your boat for spring launch and winter storage. Includes lay-up checklists, maintenance and lubrication guides, engine servicing, haulout guidelines, easy-to-build storage covers and more.

Marine Equipment Installations

UPDATED

Here's how to choose, install and operate equipment for your boat including: air conditioning and heating systems, audio systems, bow thrusters, davits, lightning protection, propane systems, refrigeration, windlasses and more.

Fiberglass Boat Repair

How to survey, repair and prevent cosmetic and structural damage in fiberglass hulls, decks and transoms. Includes the step-by-step repair of minor cracks and gouges, large holes, water-soaked decks, delaminated hulls and proper installation of hardware.

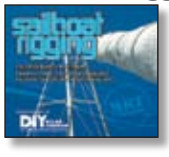
Nautical Necessities

From cleaning to fuel filtering to waterproofing charts, you'll find ideas and inspiration in this compilation of tips to do-it-yourself boat maintenance, repair and troubleshooting. Divided into 20 categories to make look up easy.

Better Boats

More than 200 do-it-yourself projects. Practical solutions to deck and cockpit refitting, interior renovations, rigging upgrades, space-saving equipment storage, safety add-ons and other nifty items to customize your boat.

Sailboat Rigging



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From gauges to propellers to steering systems, here's everything you need to know to maintain and repair your boat and trailer, improve boat handling and performance, and find solutions to common servicing problems.

DIY BOAT OWNER
THE MARINE MAINTENANCE MAGAZINE

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Radar Arch Patch-up

Q: Do you have a reference that would keep me from making any major errors while patching screw holes and repainting an aluminum radar arch that's installed on my boat?
Leo Orenstein, "Brer Boat," Hertford, North Carolina

A: First fill the holes with SeaRepair Aluminox (or QuikAluminum), an epoxy-based putty with aluminum fillers. It's strong enough to repair engine parts and is a permanent fix for sealing holes. It cures steel hard, is solvent-free so it doesn't shrink much and is sandable and paintable. To apply, solvent wipe the repair surface to remove all contaminants. Lightly sand the surface to ensure a good bond. Follow the prep instructions for this material on the label (cut off a piece, knead it, etc.). Apply and then wait a few minutes and slice off excess with a sharp utility knife dipped in water. Before it fully cures, about five to seven minutes, wet sand with 320-grit paper. Check for imperfections, reapply, if needed, and sand again. Degrease the repair with solvent then apply a primer followed by several coats of color-matched high-gloss automotive spray paint. We did this six years ago to fill holes after removing a hydrofoil on an outboard anti-cavitation plate and the plate still looks like new.
— Jan Mundy

A ready mix epoxy putty makes quick and strong hole or patch repairs in aluminum.

Cure for Rusting Metal Water Tanks

Q: We have steel tanks on our trawler. During winterization, I discovered surface rust on the interior of tanks. Is there a DIY solution for this condition?
Jack Wohlgamuth,"Hoist," Cleveland, Ohio

A: Assuming your water tanks are stainless steel and your rust problems are the relatively minor bleeding of iron oxides that often occur on stainless (especially at welds), I suspected the appropriate cure would be some kind of acid cleaner. The dilemma is determining which one is safe for a potable water tank? For help I consulted with Abe Kelly of Captain Phab Marine (www.captphab.com). He spent many years as a professional chemist working in the field of water treatment prior to bringing out his own line of products. Abe recommends flushing the tank with a 3% to 5% solution of food-grade phosphoric acid available from suppliers of cleaning products to the food industry. This is used in the dairy industry as a rust removing cleaner and flushing agent for milk pipes and tankage. It also has the advantage of reacting with steel to form an inert surface layer of calcium phosphate. This pickles or passivates the steel making it more rust resistant. Albeit phosphoric acid is non-toxic (it's in Coca Cola), it's a good idea to rinse the tank with freshwater afterwards. If you discover that phosphoric acid is only available by the car load, use oxalic acid as an alternative. This is another organic acid used as a rust remover in a variety of cleaning products, including Capt. Phab Algae & Rust Stain Remover, Davis FSR, StarBrite Rust Remover and others. Oxalic acid does not passivate the steel, however. You likely won't find food-grade purity and therefore extra flushing is recommended to remove any residual cleaner from the tank. *— Nick Bailey.*

Steering Off-Course

Q: I had the dual rudders and packings replaced on my 1975 Chris Craft. After doing this, the cable steering feels very loose and the boat won't stay on course without holding the steering wheel tightly. The wheel turns to starboard, which results in a high speed U-turn if the helmsman isn't careful. The starboard rudder is mounted straight back from centerline and slightly outside the propshaft; the port rudder is slightly outward of centerline almost directly aft of the propshaft. Some people I've spoken to suggest that the rudders may be misaligned or incorrectly positioned.
Paul Seifert, "Lil Rivet," Cape Haze, Florida

A: You don't want the wheel moving on its own but, without conducting an on-water boat test, it's difficult to ascertain the problem. Rudders are usually installed symmetrically and offset from the shaft. Additionally, the balanced spade rudder could be capsized by prop wash. Is there any vibration? Rudder vibration that increases with engine rpm indicates a rudder that is too close to the propeller. It's an interesting problem and for assistance I contacted Mark Ellis, designer of the Freedom Legacy and Bruckmann motor yachts and Nonsuch and Niagara sailboats. Here's what he thinks. "Rud-ders in a twin installation are mounted with a specified toe-in. Changing the alignment requires disassembling the drawlink. If this was done, then your rudders might need realigning. It's more likely the original packing and stuffing boxes were over tightened, which put a brake on the steering system. This would be evident if there was a load or obvious drag previously on the wheel with the boat at rest (docked) and now the wheel moves freely. Servicing the stuffing box and not repacking it as tight eliminated the brake, causing rudders to move freely. A well-engineered rudder steering system greatly affects the boat tracking, as you've discovered. Hull design plays a major role in a boat that tracks well. See if you can contact owners of similar boats to determine if there is an inherent steering problem. A boat will wander off-course with frequent corrections to the wheel to hold the heading when the longitudinal center of gravity (LCG) is too far forward relative to the hull

design. In this case, you may need to shift the LCG aft or increase the lift of the hull at the bow. In a twin-screw boat, the rudders are installed with different angles." According to an article in Professional Boatbuilder (February/March 1997) written by naval architect Donald Blount on twin-screw boats with outboard turning props, the optimum rudder angle for straight running is with the leading edge near the hull centerline at or about an angle of 1° to 3°. If indeed the rudders are not symmetrically located vis-a-vis the propeller shaft, they will need to be adjusted. Blount also states that the preferred tiller-arm toe-in/toe-out angle is relative to the length of the tiller arm and the tie rod. To tune the rudders, run a straight course using an adjustable length rudder tie rod. Fit a turnbuckle to the tie rod or mount end fittings that allow adjusting of the rudder angle offset. Set the throttles to cruise (or WOT) and measure the speed for each rudder offset angle, noting any observations regarding the force needed to turn the helm and your boat's response in turns. Changing the rudder angles may increase speed, lower steering forces and change the boat's running trim. — *Jan Mundy*

Specs for Trailer Refit

Q: I bought a used Trailrite sailboat trailer for my fin-keel Ranger 26 sailboat. It was originally built for a wing keel Catalina 270. How do I determine where to place the support pads, the best number of supports and where do I set the keel in relationship to the dual axles?
Michael Wiseman, "Witt's End," San Diego, California

A: According to the Marine Cradle Shop, (Tel: 905/294-3507) builders of custom trailers and cradles, you have a few considerations as the trailer wasn't built for your boat. If there is a draft difference between the two boats, you may need to cut down the steel uprights and install new pods for the adjustable pads. On custom-made trailers the upright supports and cross-bars are positioned so they always lay against an interior bulkhead. If pads don't catch a bulkhead, should the boat hit a pothole when trailering, the pressure of the boat bouncing against the pad can punch a hole through the hull. You might want to consider replacing pads with athwartship bunks. A six post trailer would have two pads and two bunks; a four post requires just two bunks. This is a better configuration for a hull when retrofitting a used trailer. Bunks are made of 2x6 pressure treated wood. To provide sufficient tongue weight, position the center of the two axles, 8" (20cm) behind the center of the keel. If using pads, these are placed so they support the boat in column and won't topple over. They are not meant to support any weight. The weight of the boat should be supported at the keel, the same as for a boat that is blocked ashore. Therefore, the pads would be placed on the topsides at the turn of the bilge but not underneath so the boat sits on the pads thus supporting the boat's weight. — *Jan Mundy*

Trailers are tailor-made so upright support pads always lay against an interior bulkhead. Athwartship bunks (not shown) provide best support when retrofitting a trailer not built for your boat.

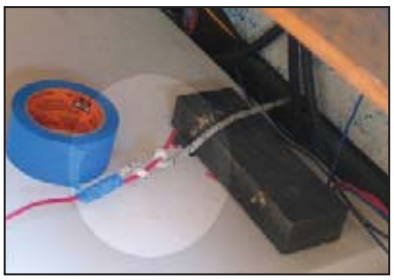
Cooling Alpha One

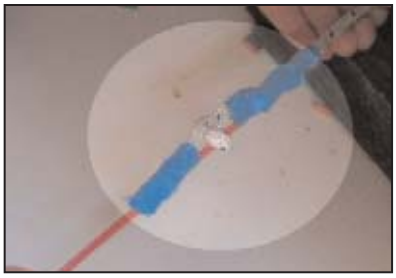
Q: I would like to know how much water a seawater impeller pump puts out on an Alpha One sterndrive? I have an overheating issue with my boat's port engine. This engine, the lower unit, exhaust, all hoses and components are new. I removed the hose from the drive inlet to the heat exchanger and there is no water yet I blew air through the line and it appears clear with no blockage at the drive.
Mark Horn, "Scuba Too," Stockton, California

A: The Mercury V-8 Alpha power package with closed cooling can have two styles of seawater supply to the heat exchanger. If water temperature is below 65F to 70F (18C to 21C), there may be a standard issue seawater pump located in the drive unit. For water temperatures above 70F (21C) there is a higher volume belt-driven pump mounted to the front of the engine. This pump pushes around 18gal (68L) per minute (gpm/Lpm) at 2,000 rpm; the drive style pump moves around 12 gpm (45 Lpm). Both of these pumps should have the rubber impeller changed annually. The impellers don't usually wear out in a year but they can dry out and lose volume from lack of use. You can purchase a water pump repair kit from your dealer. Stick with the original engine manufacturer's (OEM) parts, the extra cost is warranted. During this process, make sure all water hoses are in good shape and replace any that are cracked, delaminated or weak. I also recommend double hose clamping each water inlet hose connection. — *Steve Auger*

Routing New Halyards

Q: I plan to change my genoa halyard from wire to rope without removing the mast (the existing sheaves will work). Is there a trick to attaching a string messenger to the new halyard to get it through the block without having to go up the mast? I tried sewing and taping, but the string seems to fray.
Dick Cooke, "Victor," Fairfield, Connecticut





How to secure a tie-off used when routing a messenger line to pull wires. A more secure method, as described in the text, is needed for halyard messengers.

A: You shouldn't need to go up the mast. To make a strong messenger, purchase twice the length of the mast plus about 15' (4.5m) extra of #4 polyester cord sold at marine stores for whipping. This won't break or fray. Now tie one cord end onto the halyard using four or more half hitches that extend about 6" (15cm) or so onto the bitter end of the halyard, leaving about 1" (25mm) between hitches, so that when you pull the cord it's secured by the hitches. Now tightly wrap duct

or similar tape, over the entire length of bound hitches and halyard. The bitter end of the cord is at the end of the 6" (15cm) wrap. When done properly this won't pull out. — *Jan Mundy*

Sealing Leaky Tank Bolts

Q: I have a slight leak in one of the fiberglass diesel fuel tanks on my Prout Snowgoose catamaran. Fuel seeps down between the tank and the engine. The tank is mounted externally between the hull and center nacelle and I'm guessing that the leak is coming from a mounting bolt that goes through the tank and bolts through the engine nacelle. I plan to cut a hole in the top of the tank to get to the mounting bolt. What is the best way to repair the leak? It has been suggested to use a two-part epoxy paint or epoxy resin and fiberglass and patch the bolt hole from inside the tank.
Elbert B. Hill, "Sundsvalla," Pensacola, Florida

A: If the leak is at a fastener (as you suspect) and the tank is not loose and moving around, it may be possible to simply remove and reseal the bolt using a sealant

Use Gasoila Hard-Set to seal all kinds of threaded fuel fittings.

designed for fuel fittings, such as Gasoila Hard-Set made by Federal Process (www.federal-process.com) of Cleveland, Ohio. It's available through OMC dealers but a good automotive jobber should have it. I doubt painting the inside of the tank with an epoxy will do much to reseal a leaking bolt and it will be much work to debunk the fuel, degrease, prep-sand and clean the tank interior then apply the coatings, all through an opening cut in the tank. If the sealant approach doesn't work, the next best solution would be to apply a substantial fiberglass and epoxy resin patch over top of the offending bolt(s). I'm concerned though, about your boat's fuel tank mounting. Any mounting bolts passing through to the inside of the tank are invitations to trouble. — *Nick Bailey*

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Mariner Tilt/Trim Troubleshooting

Q: I have a mid-80's powerboat with a Mariner 150hp outboard that has perhaps 12 running hours over the past six years. While docking I had a steering issue, so I went under the dash to tighten a nut and the tilt/trim has not worked since. The only wiring I can see that connects to the trim is the dash gauge. I can't find any loose wiring connections and everything else seems to work fine. The tilt drive is a one-piece unit composed of solenoids, an electric motor, pump and small reservoir. It's in a dry area behind the cockpit, sharing space with the battery box and built-in fuel tank. The drive unit is connected to the hydraulic ram by hoses. Some years ago, the up-trim quit but the down-trim and trailer functions worked fine until I went under the dash. Now, when I attempt to activate, the up-trim does nothing and down-trim and trailer simply cause the unit to click. I've removed the unit and would like to bench

test it. Can I do this without frying something if I don't have a wiring diagram? If I just delivered the unit to an industrial small electric motor shop, would they be able to fix it or does this require a marine mechanic?
David Page, "Sea Jay," Pelican Point, Alberta

A: If this type of power trim pump is a remote pump mounted inside the boat with a large single ram between the engine transom brackets, then the pump rotation for up and down is activated by the solenoids mounted on the pump assembly through dedicated wires from the pump motor. In order to supply the pump's electrical requirements, battery power is routed directly to the large terminals on the solenoids via a 10-gauge red wire through a 100-amp fuse. To activate the up mode, the up button in the dash or remote control sends a 12-volt signal to the up solenoid via the blue 16-gauge wire. This energizes the solenoid and allows battery current to flow through the solenoid to the electric motor via the large 10-gauge blue wire that runs from the upper solenoid to the electric motor on the pump. The same process takes place for the down mode except the trigger wire and electric motor wires are colored green. The most common failures on these systems involve fuses: 110 amp on the pump feed and 20 amp on the switch feed. Most auto electric shops can repair these units as they are quite similar to units used on smaller snow plows.
— Steve Auger

Repairing Keel Dings

Q: I ran aground on some rocks last season and took a chunk of metal out of the cast steel keel on my 1997 Hunter 376. I'm considering filling the void with epoxy and building it up to conform to the original shape. It measures about 1" (25mm) in depth and maybe 2" to 3" (5cm to 7.6cm) in width. What would you recommend as a repair?
J. Kenneth Michaelchuck, "Orion," Milwaukee, Wisconsin

(top) Example of grounding damage to the keel tip; (bottom) Same dents shaped, filled and faired.

A: Any repair here is a cosmetic issue, so you are correct in planning to do a simple fill and fair repair. First, make sure you clean off any corrosion with a grinder or wire brush wheel. Next, apply two or three coats of a good epoxy primer like Interlux 2000 or Awlgrip 545. (This provides corrosion resistance). To ensure best adhesion, apply a stiff (peanut butter consistency) epoxy filler as soon as the primer becomes tack free. Once the filler is tack free, but not yet rock hard, shave it to the approximate proper shape with a good paint scraper or bodywork file. To cure properly, most

epoxies require a minimum temperature (of the keel, not just the air) of 50F (10C). During spring in a northern boatyard, this temperature requirement can be achieved by warming the keel for several hours with a heat lamp before beginning any epoxy work and keeping the heat on until the epoxy is fully cured to a rock hard consistency. Finish by sanding smooth with a foam pad feathering sander or a hand sanding board with 40- to 80-grit paper. If you are fussy, do a final fill with a mayonnaise consistency filler to eliminate porosity and small imperfections. Prior to applying antifouling, finish sand with 80- to 120- grit paper. No primer is required over epoxy filler. *— Nick Bailey*

Filling Old Transducer Hole

Q: I'm currently restoring a 1978 Cheoy Lee Offshore 32. I plan to remove the old depthsounder and thru-hull transducer and replace them with a modern sounder where the transducer sits inside the hull. What would be the best way to repair the resultant hole?
Brian McDowell, "Cristina III," Vancouver, British Columbia

A: Assuming you prefer to repair the hole instead of using it for a new thru-hull fitting, the correct procedure for repairing a single skin (uncored) laminate is to replace the full thickness of the fiberglass skin at and around the hole. It's no good mixing up a batch of epoxy filler and gooping it over the hole. This kind of laminate-free plug or patch is brittle and will crack and start leaking eventually. To prep the hole and the adjacent area for new laminates, first degrease with solvent to remove any contaminants and then use a grinder with a flexible 36-grit disc to grind back and bevel the outside surface of the hull, starting at the edge of the hole and working outwards. Grind out a circular dish-shaped depression centered on the hole and tapering at a constant angle outwards to a radius of at least 12 times the thickness of the hull laminate. This makes room for a recessed scarf joint with an adequate bonding surface for the new patch laminates. For example, if the hull is 1/2" (12mm) thick the radius of the scarf ramp should be at least 6" (15cm). If the new glass is only applied to the outside of the hull, the maximum scarf depth at the edge of the hole should be almost the full thickness of the hull. Note, however, that if the inside surface is easily accessible, the ideal repair technique would be to apply a glass patch to both the inside and outside of the hull. If an inside/outside repair is planned, scarf both the inside and outside to half the depth of the hole. Although the inside/outside repair has long been considered the best repair it's not mandatory. Lab tests done by Structural Composites for the US Navy (and presented by Art Wolfe at IBEX 2000 trade show) demonstrated that inside/outside repairs offer only an incremental improvement in tensile strength over the outside-only repair. Once the prep grinding is finished, vacuum the dust and clean the ground surface with an acetone dampened rag. Examine the ground surface and iden-

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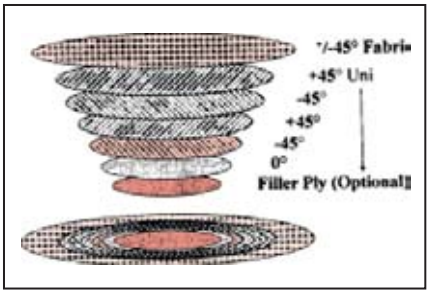

Professional BoatBuilder Magazine

Laminate patches replace original structure and are oriented from small to large.

tify the different layers of laminate. Ideally you should try and put the same number of new layers of glass back into the patch. Most hulls are laminated using alternating layers of 1oz or 1.5oz mat and 12oz to 24oz woven roving. Alternatively, a few layers of 1808 or 1810 Stitchmat (which combines the mat and roving into a single cloth) makes a good substitute for the traditional mat and roving lay-up. Use the outline of the exposed laminate layers as a template to cut the pieces of new cloth you will use. This should ensure the new glass pieces fit the repair recess. Presuming they are stacked from the smallest to the largest, each piece will be in the best position to transfer its load to the corresponding layer in the original hull laminate. If you are doing an outside-only repair, cover the hole on the inside with heavy tape or secure a piece of cardboard in there to act as a molding surface. Carefully follow the mixing instructions and temperature requirements of your chosen laminating resin. Wear protective gloves, Tyvek coveralls, etc. Prewet the exposed surface of the scarf and then wet out each patch piece in turn on a table before applying them to the repair with a roller and plastic squeegee. Most repairs of this type can be laminated in one session. If you are working with epoxy in cold temperatures (anything under 59F/15C), it can take a long time for resin to cure. In the meantime (usually as soon as your back is turned), the patch may fall off. To avoid this, be prepared to come up with some kind of clamping or securing method to hold the wet patch in place until the resin cures. This may be as simple as a cardboard cover held in place with duct tape or as sophisticated as a vacuum bag set-up. After the resin cures, grind off any lumps protruding beyond the hull surface, prep-sand the low spots with 40-grit paper and apply an appropriate underwater filler. Use a large putty knife or batten that can conform to the hull shape to spread and smooth the putty. When the putty is cured, coarse sand with a block or longboard and spot fill again if needed. If perfection is your goal, apply a fine filler to smooth out the sanding marks or apply a high-build epoxy primer or barrier coating. Sand this with 150 grit and apply your antifouling. Any repairs on the inside that may be conspicuous can be sanded a bit and touched up with paint to match the rest of the interior surface. *— Nick Bailey*

Soot's an Air-Starved Diesel

Q: A 27 hp 3GM30F Yanmar was professionally installed by a Yanmar dealer in my Cal 29 five years ago. At that time, we upgraded and installed a new exhaust system with a new muffler, a new propeller (turning 3,550 rpm at full load) and Algae-X. From day one, I have experienced excessive soot at cruising rpm. The dealer is now out of business and the distributor, Mack Boring, runs the other way. The original fuel tank wasn't replaced until after about 50 hours of use and fuel and Racor filter are clean. I've since replaced (all at my expense) the injector pump and all injectors. Besides the Yanmar dealer, two more Yanmar certified mechanics have taken more of my money. I'm now told to put the engine on a diet of Stanadyne three times the normal dose. Some mechanics suggest rechecking the timing and my latest mechanic (who installed the injector pump) says the shims are fine and I should live with the soot. My boat never leaves the dock with a fouled bottom, and the tachometer is within 100 rpm of true. Any truth to the Marvel Mystery Oil claims of cleaning the system? Or should I just paint the transom black and keep a supply of spare exhaust elbows?
Bill Shenko, Jr., "Rampage," Estero Island, Florida

A: You say that the problem existed from day one of the installation. This tells me that there was something missed on the repower. If the engine does not have a good cool supply of air it will soot. If the engine has restriction in the exhaust it will soot. If the valves are too tight it will soot. If the propeller was too large, the engine would not turn the rated rpm and it would soot. These are not likely the problems as you said as the timing, injectors and injection pump are okay, fuel is fresh and all as it was when the engine was new and it sooted. The problem is not with the engine, it's the installation. Run the engine full power underway with the engine room hatch opened. See what happens. Does the exhaust clean up? I like Marvel Mystery Oil, but the Stanadyne should do the same. No magic required here to solve an installation problem. The most overlooked item in your very comprehensive list is air! *— Bob Smith*

Tech TIPS

20 Tips to Help with your Painting Jobs

HOW MANY COATS?: Protect a paint can label by wrapping a piece of wax paper or aluminum foil around the bottom of the paint can and securing it with a rubber band to stop drips from running down the side of the can. When you remove the wrapping, the instructions and coverage specs will be there for the next time you use that paint.

CLEANER HANDS: To reduce paint brush (and hand) cleanup, cover the metal ferrule on the handle with masking tape before you begin to paint.

RIM SHIELD: Shape a protective covering of aluminum foil around the rim to catch paint drips and keep the rim clean so the lid closes tightly.

ROLLER REST: Clip a clothespin to the side of the roller pan keeps the roller from sliding down into the paint while you pause for a break.

FREEZER ANTIDOTE: Don't clean a brush if you're going to use it again the next day. Instead, tightly wrap it in plastic wrap, place it in a plastic bag, seal well and store in the freezer overnight.

BREAK WRAP: When taking a brief rest from painting, no longer than an hour, instead of cleaning the brush each time, wrap it in plastic wrap or put it in a plastic bag and lay it in the shade.

DEW POINT: Avoid painting in the early morning or evening, even on a dry day, as any moisture on the surface from dew can cause blistering of the coating later.

GO HAIRLESS: Always buy good quality natural bristle brushes, the best you can afford, because cheap ones may shed hairs.

SPIN CYCLE: A brush spinner effectively removes excess paint and cleaning solutions. Get a big bucket and spin the brush inside. After washing, spin the brush dry.

TRAY JACKET: Cover a paint tray with aluminum foil or slide the tray into a plastic shopping bag. When you're finished painting, let the paint dry and then wrap the mess up in the foil or the bag and dispose of the whole package.

STORAGE TIP: To stop a skin forming on any unused paint, always stow the tightly sealed can upside down.

QUICK FIX TOOL: When you need to touch up small areas of chipped paint, use a cotton swab or a sponge. Saves cleaning a brush.

BRUSH CLEANING 101: To properly clean a bristle brush, dip it in a can of brush cleaning solution, remove and spin it dry. Use a comb (a metal pet comb works great) to remove any crud. Repeat the process in clean solvent, if needed. Wash the brush with a little dishwashing detergent and warm water working the bristles between your fingers, rinse a few times to remove all soap residue, comb it out again and hang to dry.

BRUSH RESTORER: When you don't get around to cleaning the brush right away and it gets hard, hang it overnight in a can of strong solvent, such as Interlux 202 Fiberglass Solvent Wash, remove, spin dry and then comb it out to remove any hardened crud. Repeat the process in clean solvent, if needed, and finish cleaning as above.

BRUSH SUPPORT: Never place a brush in a can of cleaning solution with the bristles resting on the bottom of the can. Instead, use a specialty brush cleaning container with a lid that grips the brush handle or drill a small hanging hole in the handle just above the ferrule and insert a wire.

MASK REMOVAL: Wait until a coating is tacky before removing the masking tape.

RECYCLE CLEANERS: With expensive brush cleaning solvents, allow sediment to settle at the bottom of the container, pour off the clear liquid into a clean container and reuse.

SHAPE RETAINER: To keep natural bristle brushes in good shape after cleaning thoroughly, wrap an elastic band around the bristles and hang so the bristles face down. Remove band when dry.

AIR FRESHENER: To remove odors from a newly painted cabin, cut an onion in half or pour 1/2 cup of vanilla (the kind used for cooking) in a bowl, let sit overnight and the paint smell will disappear.

FOR FUTURE REFERENCE: Before storing any leftover paint, mark the level of the paint and the date on the label so that you will know how much you have and how old the paint is.

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:

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Alexandria, VA 22304

Or e-mail 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

Bad Vibrations

Vibration is a sure indicator that something is amiss with your boat's running gear. Here's how to diagnose problems and the steps needed to maintain, repair or replace bearings, propellers, shafts and struts.

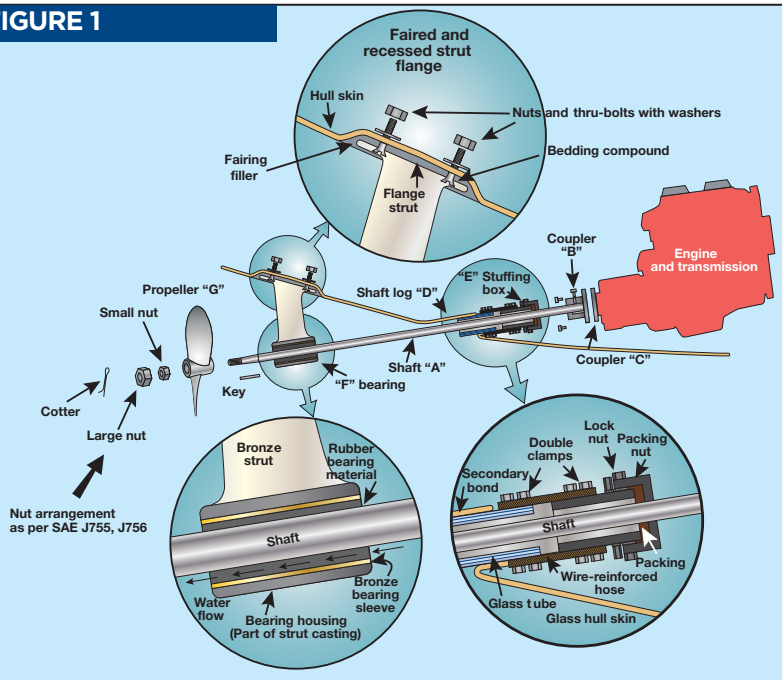
By Nick Bailey

Given the countless submerged hazards on our waterways, the repair of running gear is a mainstay for many boat yards. Accidental damage is just one of the things that can and do go wrong with the typical inboard engine shaft to propeller assembly. Vibration from wear and tear and lack of maintenance are usually your first clues that attention to these vital components is required.

Some boats are more prone to vibration than others. "It's been that way since I bought it" is no excuse for ignoring minor shaft vibration. Unfortunately, the exact cause can be hard to identify. Vibration from engine misalignment, shaft bearing (a.k.a. cutlass bearing), wear or damage due to an unnoticed impact can all feel the same. Continuing to operate a boat with a constant vibration is asking for trouble. Added stresses accelerate wear at the shaft bearing and can cause failures at the transmission, a very expensive end of the shaft. Here transmission oil seals and output shaft bearings are vulnerable to vibration; particularly those caused by shaft coupler misalignment (see **Figure 1**). In the worst case scenario, a misaligned flange coupler works loose from the shaft allowing the prop shaft to suddenly exit the boat. On the way out it fetches up against the rudder and jams the steering while water pours in through the open shaft log. Routine maintenance can avert this sort of disaster. Check and tighten coupler bolts and grub screws at least once a year. If vibration seems to be getting worse, do not delay. Identifying and repairing the problem before there is a catastrophic failure is priority one.

Since vibration is the common denominator for many different shaft problems, a professional technician will follow a step-by-step diagnostic procedure to pinpoint the problem. This process can start at the inboard or outboard end of the shaft, depending on whether or not the boat is afloat or on the hard (land).

FIGURE 1



Major running gear components are the prop shaft (a) with a flange coupler (b) that connects to the engine and transmission coupler (c). Shaft passes out of the hull via the shaft log (d) or stern tube and the opening is sealed by a traditional packing gland, also known as a stuffing box (e) or a dripless shaft seal. One or more bearing (f) supports the shaft and a propeller (g) provides motive force.

Joe VanVeenen

Shaft bearings, also known as cutlass bearings, are water lubricated and designed for underwater use only.

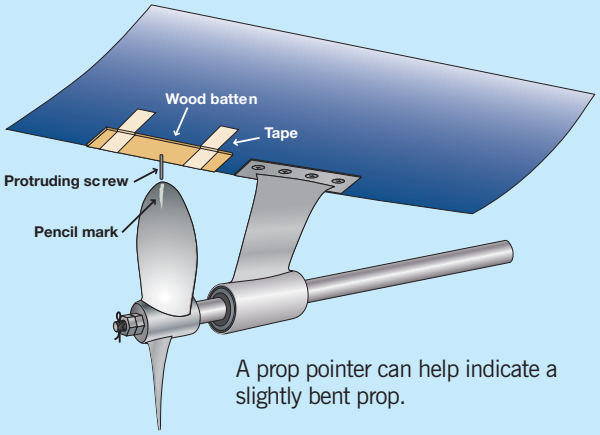
Step 1: Troubleshooting Afloat

Some yards use a periscope or a diver to check for obvious impact damage to submerged hardware but subtle problems are often hard to identify underwater. Always check engine alignment with the boat afloat. At the same time, a preliminary check of the flange coupler also reveals any loose fasteners or an obviously sloppy fit. [Ed: Step-by-step details on aligning engines appear in DIY 2002-#1 issue.] If engine alignment and coupler look good, the next step is to haul the boat to inspect the prop, shaft bearing, shaft taper, etc.

Step 2: Troubleshooting Ashore

First on the list is the propeller. Any hint of impact damage can be considered a smoking gun, likely indicating a bent shaft. A prop that has struck a deadhead or other soft object may not show any obvious damage but it may have distorted the pitch or blade geometry, which can affect balance. Sometimes, a slightly bent blade is visible by attaching a prop pointer to the strut or hull (**Figure 2**). Set the pointer to just touch the tip of one blade and rotate the prop by hand. As each blade passes the pointer any minute bend is clearly obvious. Check folding props for excessive play at the blade hinges. Balance is a moving target on some folding props and some folding props tend to vibrate even when they are in perfect condition and well balanced. If in doubt, check for bearing play first (as outlined below) and if it checks out, pull the prop and check the shaft at the taper with a dial indicator. To remove a prop, extract the cotter pin and lock nuts then pop the prop loose with a wheel puller (not a hammer!) Most yards send the prop out to a specialty shop for inspection and repair as required.

FIGURE 2



A prop pointer can help indicate a slightly bent prop.

Joe VanVeenen

Most props come off easily with a puller.

Next, check the shaft bearing for wear. Firmly grasp the prop and shake vigorously from side to side. Shaft bearings are designed for a snug fit. ABYC standard P-6 appendix, Table V, recommends a clearance of only .003" for shafts between .75" and 1.25"…), so any play detectable by hand indicates a worn bearing requiring replacement in the near future. If the technician actually feels a distinct "bonka-bonka" as the shaft bounces between the bearing sides, bearing wear is severe enough to be an obvious source of vibration and immediate replacement is unavoidable. Not all bearings die naturally, many are murdered. If the bearing is badly worn, it's important to isolate and

repair factors causing premature wear (see "Factors Affecting Bearing Longevity" on page 22).

To check a cutlass bearing, grab the prop with both hands and shake it back and forth. There should be no movement between the shaft and the strut bearing.

When the prop and bearing check out okay, vibration (alone or in combination) involves invisible damage to the prop, the shaft or a problem inboard at the forward end flange coupler. To inspect the most vulnerable part of the shaft, the taper, remove the prop. A dial indicator is then used to check the shaft for straightness. Measurements are taken at both ends of the taper and at the mid-point of any exposed shaft between the strut and the shaft log. "In place" measurements are not as accurate as a bench check, which requires shaft removal, but should identify any significant bends. Acceptable deviation varies according to the size and length of the shaft. For 1" (25mm) diameter shafts, .006" is considered the maximum acceptable bend. If the shaft dials within spec, it's presumed that the problem is inboard and any further investigation requires prop shaft removal. Removal of the shaft has the added advantage of allowing a comprehensive inspection of all running gear components individually. It's also the best way to identify any hidden problems, such as excessive shaft wear at the packing gland.

Troubleshooting vibration can be frustrating and time consuming. Some boats, usually sailboats with heavy folding props on long, skinny shafts powered by rough running diesels that have always vibrated, such vibration continues regardless of a

The ideal way to check a shaft for straightness is on a bench with a dial indicator.

straight shaft, good prop balance, perfect alignment and a new bearing. A common characteristic is a bad harmonic resonance at a specific engine rpm. In some cases, an otherwise perfect but too skinny shaft whips like a skipping rope. If hull clearance is a bit tight at the shaft log, the whipping shaft can bow out far enough to beat against the edge of the hull aperture. This produces a loud drumming noise, impossible to duplicate on shore. It's weird cases like this that make most yards reluctant to quote a vibration repair without a detailed investigation first.

Replacing a Shaft Bearing

Bearing removal and replacement is well within the skill of a do-it-yourselfer with the proper tools. Presuming the prop has already been removed with a wheel puller, the next step is to find and remove the setscrew (or screws) securing the bearing in the strut or stern tube. These are often buried under coats of antifouling paint. What comes next is subject to many variations depending on the individual technician and the characteristics of the particular boat. On rare and wondrous occasions where the bearing is loose, it's possible to easily push out the old bearing and push in a new one without removing the shaft. If more force is required, a screw jack tool can be improvised using a split pusher sleeve or a discarded bearing of the same bearing size. There are also commercially available screw jack tools designed for this job such as Strutpro (www.strutpro.com). In many cases, however, the bearing is firmly seized and the usual method (and best if you also need to check the shaft) is to remove the shaft, slice the old bearing lengthwise in a couple of places with a hacksaw, bend the pieces inward and remove them.

After removing the cutlass bearing, don't discard it. Used with an improvised screw jack tool it could be useful as a pusher sleeve to press the new bearing into place.

The new bearing may simply slide into place but, if not, use a screw jack to press the new bearing into place. Pros don't recommend the Fred Flintstone technique of banging the new bearing into place with a block of wood and a hammer. Reinstall the setscrew(s) with Loctite but don't overtighten them as this can pinch the bearing out of shape. If the new bearing seems too loose, it's often necessary to bond the bearing in place with a thickened epoxy like Chockfast. Using epoxy means the bearing will definitely need to be cut out the next time it's replaced but better that than have it come loose in service.

Shaft Removal: Necessary or Not?

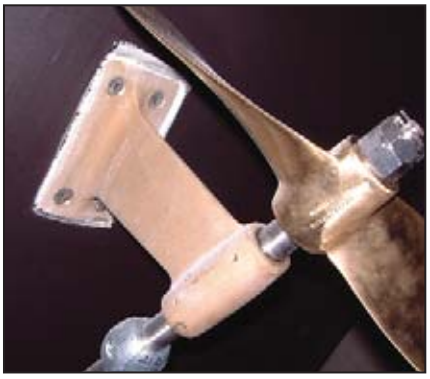
Within the framework of general vibration repair, shaft removal is always desirable and often mandatory. Unfortunately, it's not always easy to do. If a shaft is seized or difficult to access and there is no other pressing reason to remove it, other than simple bearing replacement, it may be worth pursuing alternatives. Review the troubleshooting steps above to help clarify the decision. Meanwhile, check the clearance under and behind the boat to determine if there is enough room to pull the shaft all the way out. If not, the boat may need jacked up or lifted and reblocked. Many boats also appear to have rudders squarely in the way but, on most powerboats, it's possible to squeak the shaft past the rudders without too much bending. Some sailboat rudders, however, are insurmountable and require disconnecting the steering and removing the rudder before removing the shaft.

Shaft removal begins with unbolting the coupler from the transmission output flange by removing the setscrews or clamping bolts in the sides of the coupler and pulling back the coupler, usually with a wheel puller. If the coupler easily slides off the shaft it's much too loose and that gets added to the repair list. Shafts on large motor yachts are a little different, usually being the double taper type. In this case the coupler is secured to a taper on the inboard end of the shaft with locknuts in a manner similar to the method used to secure the prop on the shaft.

It's an unfortunate fact that shaft couplers on many boats (saltwater boats in particular) are often corroded and seized to the shaft. In these circumstances, carefully heat the coupler with a blowtorch or heat gun to assist removal. In extreme cases or a situation where the shaft or coupler is due for replacement anyway, the best method is to sever the shaft or cut the coupler in half lengthwise. The preferred cutting tool for this job is usually a high-speed grinder that's fitted with an abrasive disc designed for cutting steel. Once the coupler and its key are off the shaft, loosen the packing gland, remove any retaining collars or sacrificial anodes and carefully push the shaft back out of the boat. Next stop for the shaft is the workbench for a detailed checkup.

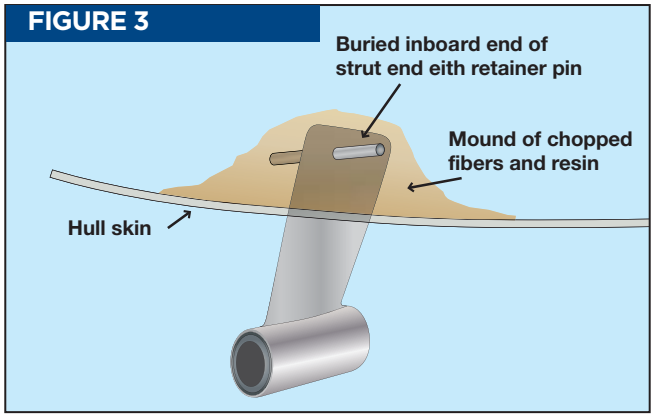
Strut or Stern Tube Removal: An Alternative Technique

If shaft removal is anticipated to be too difficult or expensive and a bearing removal tool is not available, it's often practical to remove a seized bearing by first removing the strut or the stern tube assembly and bringing it back to the shop for further work. All powerboat and many sailboat struts have mounting flanges that are simply thru-bolted to the bottom of the boat and relatively easy to remove, provided they are not completely out of reach under a fuel tank



(continues on page 23)

FIGURE 3



Joe VanVeenen

Cross-section of a glassed-in strut. A strut installed as shown is difficult to remove or repair if it leaks.

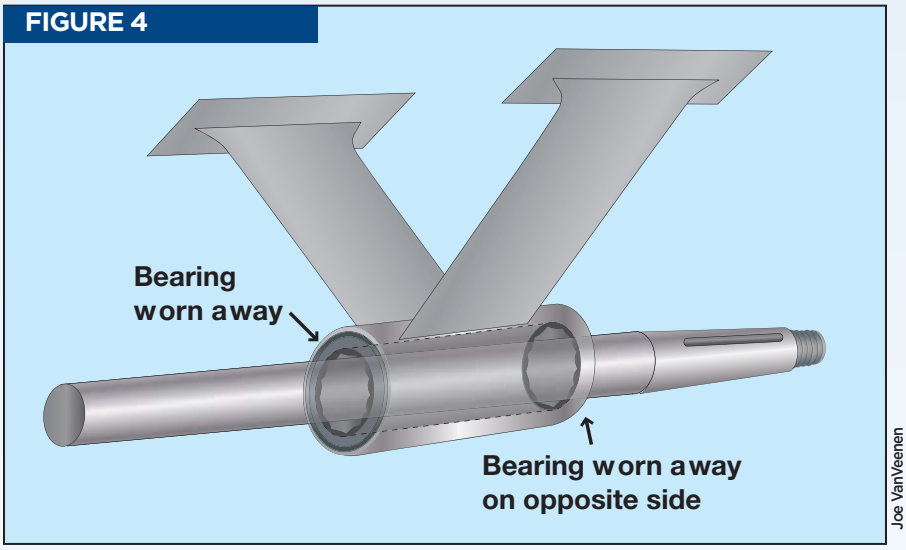
Factors Affecting Bearing Longevity

Propeller shaft bearings manufactured by BF Goodrich, Duramax, Morse, Palmer, Thordon and others are designed for underwater use only. Most are made with a rubber bearing material bonded inside a bronze or composite sleeve but some makes are 100% composite material. In all cases, the inner bearing surface is grooved or fluted (see photo on page 18) to allow water to flow through the bearing as a coolant and lubricant. Without this flow, the rubber overheats and wears out quickly, sometimes in as little as 10 hours of operation. Rubber bearings normally last a minimum of 100 operating hours but many shaft bearings never reach this due to original installation problems. It's important to determine if a worn bearing is just a symptom of a larger problem such as restricted cooling water supply, incorrect prop shaft length, strut misalignment or ozone.

Stern tube configuration with fluted cutlass bearing.

This small opening at the side of a stern tube bearing is an inlet for cooling water. It should never be blocked with caulking or antifouling.

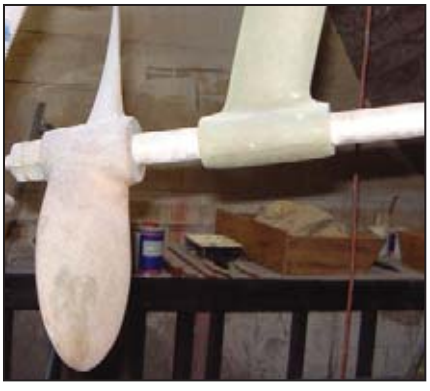
FIGURE 4



Joe VanVeenen

A misaligned strut must be removed, shimmed for correct alignment and reinstalled.

Single engine displacement motorboats and full-keel sailboats usually incorporate the bearing into a stern tube assembly where the shaft exits the hull. This configuration requires some provision to introduce water into the stern tube assembly to cool the bearing. Many stern bearing assemblies have side scoops to supply water to the bearing. If these are fouled or blocked, bearing wear accelerates. Twin engine or planing powerboats and fin-keel sailboats have the bearing in a separate support strut, often described as a "P" or "V" strut, depending on how the strut is configured (single strut mounting or two that form a "V." This arrangement allows water to flow naturally through the bearing provided it's not blocked by a shaft sacrificial anode mounted too close to the strut.

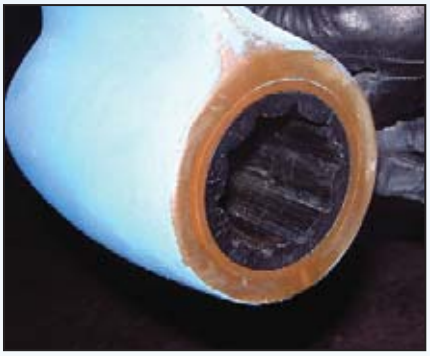


This shaft is about 1" (25mm) longer than ideal and will contribute to premature bearing wear.

If the prop shaft extends too far past the bearing, it's guaranteed to vibrate and quickly beat up the bearing. This is most often seen in a repowered boat where the new engine requires a larger diameter prop that is too big to fit behind the strut. Ideally, the front face of the prop hub should be fitted no more than one prop shaft diameter behind the bearing for best support as well as least wear and vibration. In these cases, the strut should have been relocated further aft during the repower or a transmission fitted with less reduction.

Sometimes, when a boat builder installs running gear components, it's difficult to achieve perfect alignment of the three shaft location elements: the transmission output flange (adjustable within limits), the shaft log (not adjustable but has a narrow tolerance) and the strut assembly (not adjustable without shimming and remounting). Many boats have struts that don't line up with the shaft log let alone the transmission. Boat builders get away with this because the rubber in the strut bearing is compliant enough to allow the shaft to be jammed at an angle through the bear-

ing. This sort of installation consumes bearings fast. The problem is easy to identify by inspecting to see if the shaft is running true in the center of the bearing or whether it's offset in one direction at the front of the strut and the other direction at the back. This problem can be solved but not without removing and remounting the struts on solid fiberglass compensating shims.



The rubber in this bearing has hardened and cracked throughout. Soon chunks will break off. Best to replace now.

Rubber components, including shaft bearings, deteriorate over the years without even seeing much service. Exposure to air pollution (primarily ground level ozone) during extended haul out periods (especially in the industrial Great Lakes and Northeast regions) causes the rubber in shaft bearings to harden and crack. When used in this condition, they tend to crumble and fail prematurely. A careful examination of the exposed end of the rubber will reveal any cracks.

(continued from page 21)

that was installed before the deck was mated to the hull. Some sailboat struts are not bolted but are bonded in place (**Figure 3**) with fiberglass and are best left undisturbed.

This strut is not glassed in yet is very similar to the one shown in Figure 3. The recessed flange has been filled over and faired smooth and hairline cracks trace the outline of the flange. The thru-bolts are buried just under the filler.

Before removing the strut, securely block the shaft to avoid inducing a bend. Now remove the nuts securing the strut on the inside and gently knock out the bolts. The strut flange may require prying away from its bedding compound (or fairing filler) and, once free, slide it off the shaft. On the workbench, use a hydraulic press or screw jack to remove the old bearing and install the new one. To reinstall the strut, slide it over the shaft and mount it with lots of polyurethane bedding compound, e.g. 3M 5200, around the fastener holes in the original location. Where this location is incorrect (see "Factors Affecting Bearing Longevity" on opposite page), the strut is carefully realigned to the shaft's natural position and chocked with a thick mixture of epoxy and chopped glass fibers. Redrill the mounting holes, if necessary, and complete the bedding and fastening.

Once a strut has been removed and is on the work bench, a variety of techniques can be used to remove and reinstall the bearing, such as this improvised screw jack for pressing bearings.

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 of Bristol Marine in Mississauga, Ontario.

Additional Reading: "Drive Train Tune-up" in DIY 2002-#1 issue features step-by-step bearing replacement, tips for matching couplings and checking shafts and techniques for proper engine-to-propeller shaft alignment.

ELECTRICAL

Generating Power with Fuel Cells

MaxPower MFC 100 AHD, one of the first fuel cells packaged for boats, produces electrical energy efficiently, quietly and without combustion.

Imagine having a clean and quiet source of 12-volt power available 24/7 anywhere you choose to cruise. No noisy engine or gen-set, no relying on solar power, no whirling wind generator. Imagine no longer — fuel cell technology has arrived!

By John Payne

Charging technology continues to evolve and the latest development for boats, in common with the powering of automobiles, is the fuel cell. Though NASA has been using fuel cells to power its space craft for more than 40 years, the biggest barrier to more readily available cells has been both the cost and the fuel type and storage. The new fuels cells are commonly called direct methanol fuel cells or DMFCs. The replacement of hydrogen with an alternative fuel such as methanol has allowed an economically viable fuel cell to be manufactured and one that can be used on boats. Such technology was originally invented at General Electric, who in the early 1960s developed a small fuel cell for a program of the U.S. Navy Bureau of Ships (electronics division). Later, fuel cells were developed for use by the British Royal Navy submarine fleet.

The basic fuel cell is an electrochemical energy conversion device also known as reverse electrolysis. The cell converts the chemical energy of a fuel, such as hydrogen, natural gas or hydrogen rich fuel such as methanol, and an oxidant such as air or oxygen into water to produce electricity as a direct electrical output similar to a battery.

In principle, a fuel cell operates somewhat like the lead-acid battery, another electrochemical device. The fundamental difference between them is that where a battery needs recharging, the fuel cell does not discharge or have to be recharged from a charging source. Electrical and heat output, similar to having fuel in the diesel-powered generator or wind for the wind generator or sun for solar panels, will always continue as long as the fuel and an oxidizer are available in adequate quantities. One similarity between batteries and fuel cells is that they both have a positively charged anode and a negatively charged cathode. They also both have an ion-conducting material that is also called an electrolyte. There are a variety of fuel cells and each type utilizes different chemistry. The classification of fuel cells is generally based on the electrolyte material that the fuel cells use. The proton exchange membrane (PEM) fuel cell device has the most common application in powering automobile and boat charging systems.

How's it Work?

Basic construction of a fuel cell comprises a fuel electrode (the anode) and an oxidant electrode (the cathode). The anode and cathode are separated by an ion-conducting membrane. Oxygen continuously passes over one electrode and hydrogen continuously passes over the other electrode. This generates electricity, water and heat. What occurs in fuel cells is that they chemically combine the molecules of the fuel, such as methanol, and the oxidizer without any combustion or burning. As such, they are pollution-free — no toxic or high temperature exhaust emission. The byproduct of a fuel cell is a very small quantity of carbon dioxide, some pure water and a little heat. The carbon dioxide is around the same as a person's breath, so some basic ventilation is required.

The anode is the negative part of the fuel cell. The function of the anode is to conduct electrons that are released from the hydrogen molecules and these electrons can then be used in an external electrical circuit. That is the battery part or motor or other electrical equipment. The anode is constructed with a series of channels that is used to aid in the even dispersal of the hydrogen gas across the catalyst surface so maximizing efficient reactions.

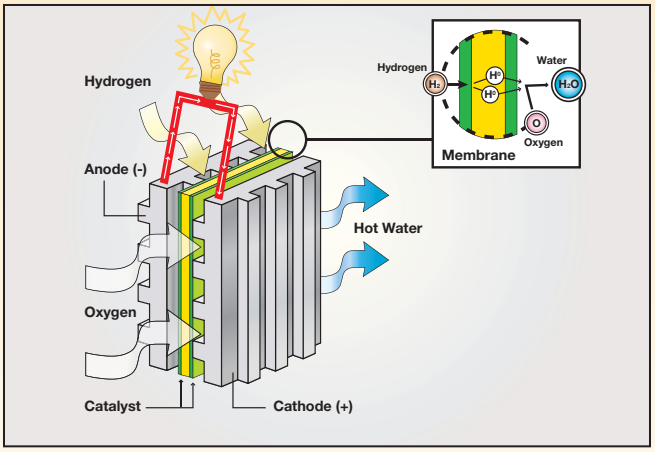
The cathode is the positive part of the fuel cell. It also has a series of channels etched into it to ensure reaction efficiency and to aid in the even distribution of oxygen across the surface of the catalyst. The cathode also conducts the electrons in the external circuit from the catalyst, which then recombine with the hydrogen ions and oxygen to release water.

The electrolyte is the PEM. It consists of a specially treated solid polymer electrolyte material that resembles kitchen plastic wrap. This membrane conducts the positively charged ions through it and blocks the passage of electrons. It works at very low temperatures, about 175F (79.4C).

The catalyst is manufactured from a special material that triggers and speeds up the reaction of the oxygen and hydrogen. Typically, it comprises a thin coating of platinum powder that is layered onto a substrate of carbon paper or cloth. The catalyst is also rough and very porous. This ensures that a maximum surface area of the platinum material is exposed to the hydrogen or oxygen to ensure maximum reaction takes place. The catalyst is always orientated towards the PEM. For this type of fuel cell to work, the PEM electrolyte must allow passage of the hydrogen protons but prevent the passage of electrons and other heavier gases.

Fuel Conversion

While hydrogen was a major component of earlier basic fuel cells, it's not readily available to buy and is inherently dangerous. To overcome this, a device called a reformer is used. This converts hydrocarbon or alcohol fuels (i.e., methanol) into hydrogen and then supplies it to the fuel



Fuel cells are a power "generating" device as they draw fuel from an external source, such as a hydrogen cylinder, and mixes with oxygen to produce water and generate electricity for as long as the fuel is supplied.

cell. Reformers also generate some heat and produce other gases in addition to hydrogen and this tends to lower the overall efficiency of the fuel cell. Methanol is a liquid fuel that has many similar properties to gasoline. Better yet, it's a farmed fuel, a renewable source, processed from sugar cane. It also is less flammable than hydrogen so is ideal for carrying safely on a boat.

Efficiency

If the ideal fuel cell is powered using pure hydrogen, it can be up to 80% efficient, a very high number. Using a reformer to convert methanol to hydrogen drops this efficiency to around 30% to 40%. Converting electrical energy into mechanical work using an electric motor or an inverter, this number falls to around 24% to 32%, still a lot more efficient than solar, wind or generators. The reaction in a single fuel cell produces a fairly low 0.7 volts. However, like a 12-volt battery that consists of six cells, basic fuel cells are built to form a fuel cell stack. To increase power source availability, fuel cells can be connected in parallel, the same as getting more amp-hour (Ah) capacity with a battery. For example, two 100 Ah fuel cells wired in parallel equals 200 Ah.

Here and Now

MaxPower (www.max-power.com) MFC 100 AHD fuel cell units now available require a 10 lb (4.4 kg) fuel cartridge that lasts three days or 72 hours on full power. It produces 340 Ah of 12-volt DC power over a longer period if charging intermittently. The MaxPower unit is made by the Navimo group and utilizes the Navimo distribution network (Scandvik in the U.S.) to distribute fuel cartridges. Fuel cells are not service or maintenance free; however, given there are no moving parts, this is significantly reduced. A fuel cell stack gradually degrades with a slow decrease in performance during its operational life. Stack life typically is a minimum of 1,500 hours up to or exceeding 5,000 hours. Stack replacement is relatively simple and fast. Given that a basic fuel cell unit weighs in at just 16 lbs (7 kg), it's easy to ship replacements to the nearest service center.

MaxPower units are distributed in the U.S. by Scandvik (800/535-6009; www.scandvik.com), which is also handling fuel cartridge recharging and fuel cell replacement. Current retail price for the MFC 100 AHD is US$5,999. Laboratory grade methanol to refill one fuel cartridge is expensive, $40 for 1.3gal (5L), though sales manager Sabastian Blackman expects prices to drop substantially. Replacement fuel cells are available to purchase from Scandvik for US$700.

REAL-TIME USE

DIY asked bluewater cruisers and professional videographers Paul and Sheryl Shard for their opinion on the use of fuel cells. Here's what they had to say.

On our 37' (11.2m) we use 60 to 80 amp-hours (Ah) of electricity per day at anchor (fridge, computer, lights, etc). This is replaced into the battery by our solar panels which generate roughly 30 Ah per day in the Mediteranean. So we have a shortfall of 30 Ah to 50 Ah per day.

The MaxPower unit produces 340 Ah of power on one fuel cell. Therefore, I can get from seven to 11 days of use from one cell before changing it, assuming the solar supplies the rest. So before leaving for a three-week cruise we might need to purchase two to three extra cells from a local fuel cell supplier. As these cells weigh 10lb (4.5kg), that's an extra 30lb (13.6kg) onboard. Finally, after between 1,500 and 5,000 hours of operation we would need to replace the stack. We would need to return the unit to have this replaced.

— Paul and Sheryl Shard have logged more than 40,000 nautical miles aboard "Two-Step" a Classic 37. They have crossed the Atlantic Ocean three times and have sailed to more than 35 countries including the Caribbean, South America, Europe and the Middle East. They are currently in the Mediterranean filming a new season of their sailing adventure TV series, "Distant Shores" (www.distantshores.ca).

Selection Criteria

A fuel cell is designed to run constantly over a 24 hour period. It can be operated in either a standby or in float charge mode for charging batteries; whereas, solar and wind charging systems depend on the elements being available for limited periods. Fuel cell costs equate to a very small 2kW diesel gen-set but without any of the installation and engineering costs or issues, such as seawater plumbing and exhaust systems.

The big savings are realized because, when a fuel cell operates in continuous float mode, the batteries are always topped up, constantly held at between 70% to 85% of their full charge. Battery life is greatly increased when the batteries do not have to go through the discharging and repeated deep cycling that taxes their performance. This also allows you to install a much reduced battery bank size. The battery bank ultimately ends up doing float service and supplying system power surges or higher demands, while the fuel cell supplies the main power. Power transfer is completely automatic. The MFC 100 AHD, for example, automatically monitors the battery voltage, switching on and off as needed. When the engine alternator kicks in, this device switches off.

As technology continues to improve, the fuel cell will become an integral part of an onboard renewable power source to charge batteries.

About the author: John Payne, DIY's electrical consultant, is the commissioning manager for BP Thunderhorse, the world's largest semi-submersible oil platform installed in the Gulf of Mexico.

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DIESEL

Optimizing Fuel Quality

A well-engineered fuel system involves the onboard cleaning, filtration and transfer of fuel. Improve your boat's fuel system and keep your diesel engine humming without skipping a beat with these simple do-it-yourself upgrades.

By Peter Pisciotta

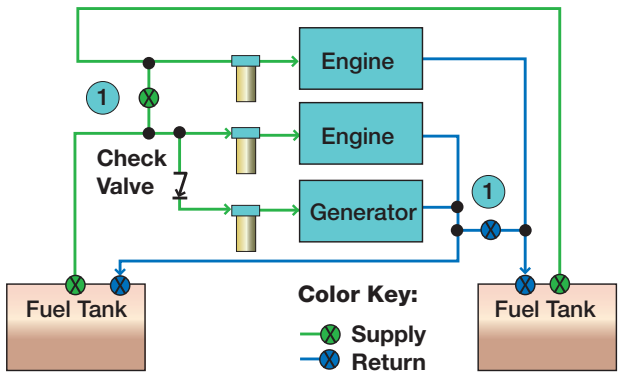
The skies are crystal clear and the view of the coastline is gorgeous but an offshore high-pressure system has been grinding against a deepening inshore low-pressure cell for the last two days. The resulting pressure gradient has generated 25-knot winds and whipped up steep chop off the port bow. The motion is uncomfortable but not extreme so there's no thought of retreating. The diesel drones rhythmically as progress to windward is slowly made. Rhythmically it runs, until the rpm drops for a moment.

Engine rpm returns to its pre-set levels so quickly that the captain can't be sure they actually dropped at all. Did rough seas dislodge debris in the fuel tank? Is it now clogging the fuel filters? A few moments later, all uncertainty is extinguished when engine rpm dips again. The scenic coastline will be a lee shore should the diesel die.

Most boats have very simple fuel systems (**Figure 1**) that would benefit from a few upgrades. Engine rooms littered with valves in tedious, obscured locations where it requires a detective's insight to understand how the system works and what to do to make changes in the fuel flow directions. Filters may be impossible to reach or are obsolete models without water separation capabilities. Fuel lines are often cheap, non-certified deteriorating rubber with hose clamps slicing through jackets.

Unraveling the mess in an engine room can be fairly simple and involves three easy do-it-yourself projects. First, install a fuel polishing system that cleans and circulates fuel on demand (**Figure 2**). This is especially important to boats like sailboats because diesel has a short shelf life and doesn't store well (more on that later). Second, install a dual-element secondary filter on the main engine. With the turn of a valve handle, an operator can instantly shift to a clean filter, even change-out the dirty one while the engine continues to run. This is especially important for single-engine boats. Lastly, simplify the system by centralizing valves into a manifold, "valve farm" location (**Figure 3**).

Figure 1: Typical Twin Engine Application



Joe VanVeenen

A typical, twin engine installation with two tanks.
1 Cross-over valves closed under normal operation. Starboard engine draws and returns from/to starboard tank. Port engine draws and returns from/to port tank.

Know thy Enemy

There are four primary culprits in fuel system failure: dirt, water, algae and fuel decay. Dirt is self explanatory but the other three deserve a closer look. Water destroys injectors very quickly and, because it's heavier than diesel, it sinks to the bottom of a tank, precisely where fuel is drawn. Water invariably occurs in fuel tanks where small amounts commonly accumulate from condensation. Other culprits include leaky deck-fill fittings (check gaskets or O-rings regularly) and ill-planned fuel vents that are vulnerable to water intrusion in rough weather. Also, the original fuel source may be contaminated, an especially difficult problem in Third World countries. Most modern fuel filters include water separators but they become overwhelmed with more than a few ounces of water. Transparent bowls let you keep an eye on this process.

An anaerobic strain of algae prospers in the boundary layer of diesel and water present in almost all tanks. As algae decays, the dead cells sink and form sludge in the bottom of the tank. Rough seas agitate the fuel and dislodge this goo, which then is drawn into the fuel supply line where it clogs filters. Biocide additives kill algae and may temporarily eradicate the problem

Clearly labeled valves.

Best is to have all valves organized in a logical manifold system.

but you'll need lots of replacement filters to get you through the transition period.

As fuel ages, it decays. Tar-like globules of asphaltenes precipitate and sink to the floor of the tank. Sailors and long-range trawlers are especially vulnerable because fuel starts to degrade within 90 days and these miserly boats may keep fuel aboard for months or years. The best solution is to use your boat and consume the fuel. Fuel stabilizers and regular circulation can help, though you'll need a good supply of filters until the globules are resuspended. [Ed: For details on what additives are available, when to use them and test results refer to DIY 2001-#3 issue.]

Simple Fuel System Upgrades

The further a boat ventures from home, whether power or sail, the more robust the system has to be. For many cruisers venturing into remote areas where fuel may be questionable and fuel conditioning supplies non-existent, a robust fuel system is especially important. The following is a list of "best practices" for initial fuel system design. Not all elements can be retrofitted into an existing system but it's a good list to consider (**Figure 4**).

Clearly mark and map valves for easy access and organize plumbing in a logical layout. "Valves should be clearly labeled with purpose and flow direction," according to Bob Senter who sees a lot of engine rooms as senior technical trainer with Alaska Diesel, builder of Northern Lights generators and Lugger diesels. "A schematic board with color coding and icons for all engines and tanks is very helpful. If possible, mechanically link valves in a way that prevents them from being mistakenly being turned off," explains Bob. Best is really a centrally located and well-designed valve farm (manifold). Often, valves are scattered throughout an engine room in inaccessible places. Sometimes, adjunct equipment has been installed (homespun transfer systems for example) and have so many scattered, unmarked valves. Fuel supply/return manifolds should have spare outlets so fuel supply lines to future equipment installations (generator, diesel heater, etc.) can be easily added. If you're designing and fabricating a manifold system for your boat, make sure you check with ABYC H-33, Diesel Fuel Systems, for the requirements for fittings. It might be tempting to use cheap, ordinary plumbing fittings but the plastic ones will probably not comply with the fire test requirements of the standard. [Ed: Construction details for one example of a plumbing manifold appear in DIY 2002#2 issue.] Look at **Figure 2** and imagine an actual engine room with a valve farm. It looks simple on paper but can be very confusing in an engine room, especially with more than two fuel tanks.

Dual-mounted water separating filters. Note vacuum gauge.

Calibrated sight tube made of standard plumbing fittings and Lexan tubing.

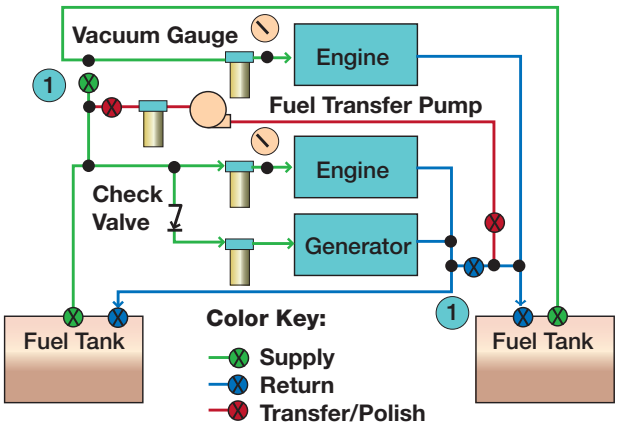
Install a remotely mounted secondary filtration system. Ideally, there should be dual filters mounted side-by-side that can be instantly switched so a clean filter can be brought online quickly and the clogged filter changed without disruption to engine operation. If you only have a single fuel filter for your main engine, you are vulnerable. If your filters clog, you will have to change filters in a rocking, pitching boat. A better solution is to install a hot standby filter. You can make your own with two single filter housings and a bevy of valves befitting a nuclear reactor (and the hope that you know what valves to turn when the time comes) or get a purpose-built unit from Racor. The Racor unit is much more compact and you just turn a single handle. Convenience comes at a price; this unit starts at about US$750 plus fittings.

Certified fuel hose is marked with SAE, UL, USCG and/or ISO standards' compliance information. Only the SAE and USCG marked hose is approved for compliance with ABYC standards. The mandatory USCG fuel system requirements do not apply to diesel powered boats. ISO standards' compliance is mandatory for diesel powered boats built in the countries where ISO is the law of the land.

Install calibrated sight tubes. Fuel gauges are notoriously inaccurate and

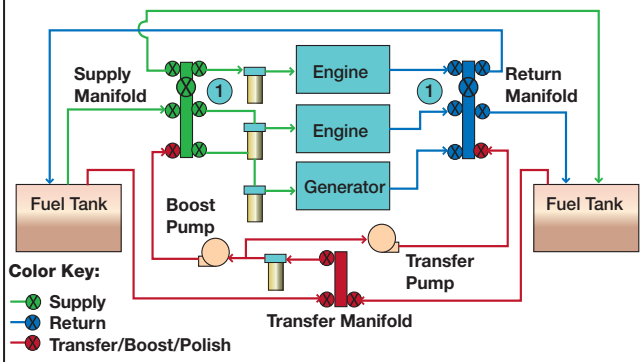
Having the ability to switch the fuel supply to a day tank makes troubleshooting possible while the engine continues to run.

Figure 2: Simple Transfer/Polish System



Simple transfer/polish system works fine but cannot be operated while the engine is running due to contention issues. Nevertheless, this is a great retrofit as long as you do not need to transfer fuel while underway.
1 Cross-over valves closed under normal operation. Starboard engine draws and returns from/to starboard tank. Port engine draws and returns from/to port tank.

Figure 3: Organizing Valves Into Manifolds



Organizing valves into manifolds on twin engine installation, while there is more equipment, is vastly more flexible, intuitive and easily managed. When you need to make a fast decision, you have a greater likelihood of getting it right the first time. This configuration also lets the operator bleed any engine by using the boost pump to pressurize the supply manifold.
1 Cross-over valve closed under normal operation. Starboard engine draws and returns from/to starboard tank. Port engine draws and returns from/to port tank. All connections to fuel tanks have valves, always in "on" position.

other aftermarket monitoring systems require significant interpretation. Sight tubes are bulletproof. If the boat has two tanks, it's handy to have the ability to transfer fuel between tanks and trim the boat. If it has more than two tanks, it's mandatory to be able to perform this function.

Install a polishing system (**Figure 2**). The further you venture from home, the higher on your list of fix-it priorities this should be. Fuel polishing services are expensive and sometimes need repeated service. Fuel polishing is nothing more than filtering and circulating onboard fuel and is part of a full-feature fuel transfer system (refer to typical schematics throughout this article). If you are considering hiring a tech-

nician to polish the suspicious fuel onboard the used boat you have just bought, why not have the technician install this system and do it yourself?

A drain-off at the lowest point of the tank is useful to remove water. Use only certified fuel lines that are well protected from chafe.

Install a vacuum gauge on the engine side of a secondary filter (as shown in photo on page 28). If you have a Racor filter housing, replace the tee-handle on the top with a vacuum gauge. Otherwise, tee into the supply line between the engine and the filter and install a gauge. As the filter clogs, the engine has to pull harder, which creates a vacuum. Once the vacuum starts to crest 5" hg, you will need to start planning when to change the filter. At 7" hg, its time to change it.

Install a low-flow "boost" pump in the supply side to simplify bleeding the engine. If your fuel valves are arranged in manifolds, pressurizing the entire supply manifold lets you bleed any engine (generator, etc). Also, if filters start to clog, the pump pushes fuel through the filters, extending their range in a pinch.

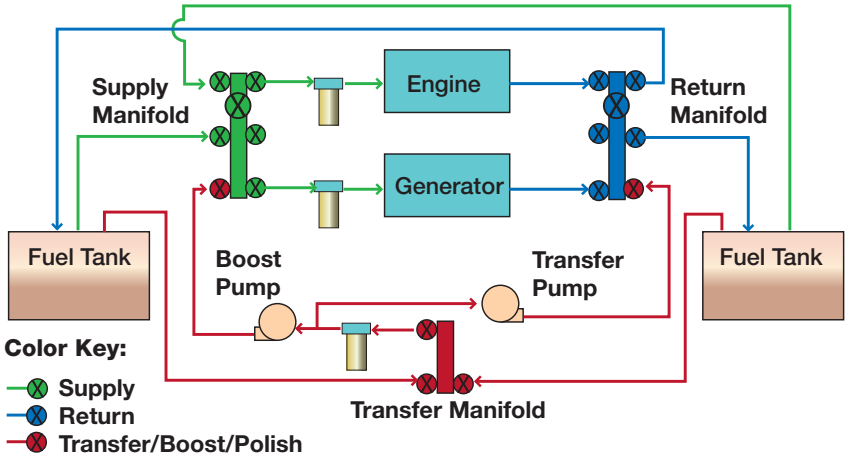
Add a day tank that holds enough fuel for five to 24 hours of running at cruising speed. Obviously, this is only practical for slower, long-range cruising boats that have modest fuel requirements. The main tanks act as a reservoir where fuel is stored until it's filtered and pumped into the day tank. If a fuel problem develops, the day tank gives several hours of running time for the operator to solve the problem.

The final and perhaps easiest do-it-yourself project is to upgrade your skills. Take a diesel education course or hire your mechanic for a few hours. Talk to your engine manufacturer and see if it offers a course. Education is always a great investment.

Most boaters take their fuel system for granted. It's easy to do and unfortunately, many boat builders respond to market indifference by only installing basic fuel systems. Think about that hapless captain in the opening sequence of this article. What would happen if this happened on your boat? Do you have a vacuum gauge and can you tell if your filters are clogging? If they were, what would you do? With just a few of these upgrades, you can avoid this situation altogether and, if you did find yourself in trouble, you would merely switch a valve and press a new filter into service without the engine missing a beat.

About the author: Peter Pisciotta is a USCG licensed 100-ton master, past commercial captain and current owner of SeaSkills Personal School of Seamanship (www.SeaSkills.com).

Figure 4: Full Feature Single Engine Fuel System



Single engine fuel system with all valves organized into easily accessible manifolds. Boost pump allows bleeding of the engine or gen-set.

Case Study: Nordhavn

Very few recreational powerboats are capable of crossing oceans. There is one builder who specifically designs its boats to do just that. In fact, several of its boats have circumnavigated the globe, including a 40' (12m) that, in 2001, sprinted around the world in just 170 days. Although a factory sponsored event, this boat was essentially a production boat with the same 965gal (3,652L) capacity that all Nordhavn 40's carry.

Fuel range was tight on the 2,300 nautical mile California to Hawaii leg so Pacific Asian Enterprises (PAE), parent to Nordhavn and Mason Yachts, developed a clever idea to monitor consumption. In addition to fuel flow meters (i.e., Floscan), a 1gal (3.78L) fuel tank calibrated to the 1/10 gallon was installed. At least once a day, the actual consumption was measured over time. The boat arrived with over 100gal (378.5L) of fuel in reserve.

Fuel management is critical. The engineers at PAE developed several novel ideas that have been incorporated into modern designs. "Fuel management systems need to be as simple as possible," according to PAE president Dan Streech. "Long distance voyaging can be tiring and stressful so it's easy to make a mistake. Switching the wrong valves could over-fill a tank and dump hundreds of gallons of fuel overboard. In addition to the environmental issues, it could easily mean falling short of the destination," eplains Dan.

After hundreds of thousands of ocean miles of research and development, PAE introduced a simplified fuel system on its Nordhavn 47 that has been

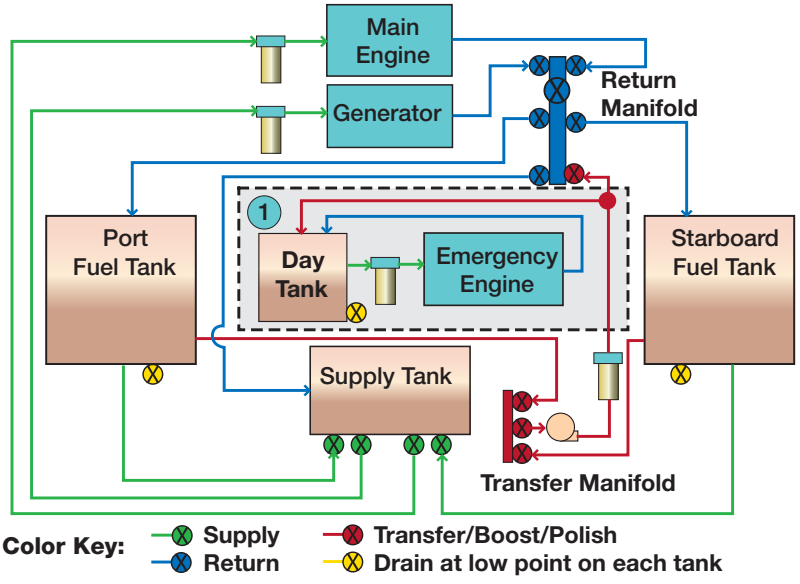
Calibrated fuel tank gauge simplifies daily fuel checks.

incorporated into all subsequent models. Two main saddle tanks are outboard of the main engine (1,425gal/5394L total). A third 70gal (265L) supply tank is centered just forward of the engine and sits relatively low, though well clear of bilge water. This configuration enables several novel design elements: the supply tank can either be gravity fed from the main tanks or filtered through a transfer/polishing system; by using a central supply tank, the main tanks can be drained completely dry without risk of introducing air into the engine feed fuel and no reserve fuel need remain in the tanks; all valves are accessible and clearly marked.

Virtually all Nordhavns come equipped with a wing engine, a complete spare propulsion unit including shaft and prop that can be used as a back-up should the main engine or shaft fail. To isolate the wing engine from potential fuel contamination problems, it draws its fuel from a small day tank that can only be replenished from a filtered source. PAE also limits tank condensation by routing the return line to the bottom of the tank so the hot diesel is cooled by the fuel in the tank, which keeps water from vaporizing and condensing.

While this robust fuel system adds substantially to the price of the boat, owners appreciate the well-engineered systems. — *PP*

Figure 5: Nordhavn 47 Improved Fuel System



Joe VanVeenen

Nordhavn 47 improved fuel system incorporates three fuel supply tanks. All connections to fuel tanks have valves, always in "on" position.
1 Emergency or wing engine is a dedicated propulsion unit with shaft and prop.

Packaged Fuel Management Systems

Algae-X utilizes magnetic fuel conditioning technology to enhance engine reliability and prevent engine damage.

Fuel polishing systems from Algae-X (www.algae-x.net) combine fuel conditioning, filtration and water separation. Algae-X fuel conditioners installed between the supply tanks and primary filters are said to enhance the combustion process to improve engine performance. These units utilize magnetic fuel conditioning technology to change fuel characteristics that ultimately results in improved filterability, combustibility and stability. The FPS unit consists of an Algae-X fuel conditioner to reverse the process of fuel deterioration and buildup of tank sludge and stabilize the fuel; a centrifugal water separation system removes water; and a fine filter removes solid contaminants.

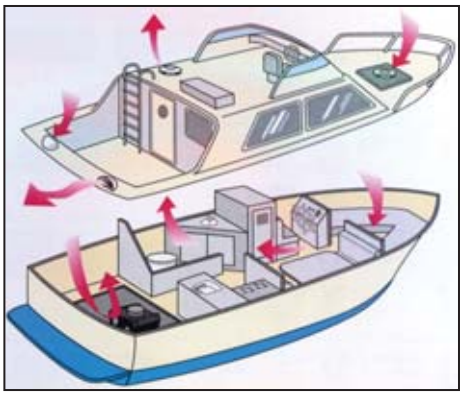
Algae-X FPS fuel-polishing system is an affordable solution to eliminate water, sediments and particulate while reconditioning and stabilizing the fuel.

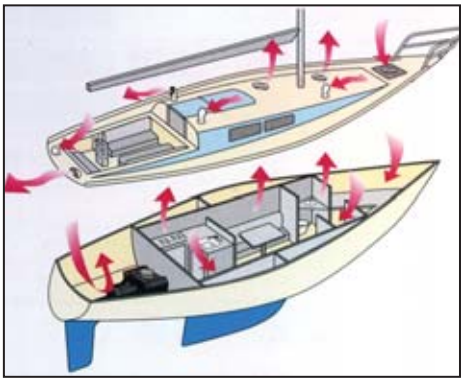
If you are skeptical of this technology consider that units are available from an increasing number of boat builders and engine suppliers. According to Bill O'Connell of Algae-X, fuel conditioners are standard equipment on Carolina Classics, Christensen Yachts, Cruisers Yachts, DanMar Power Cats, Nordhavn and Shamrock. Additionally, Detroit Diesel distributors worldwide sell Algae-X fuel conditioning products and fuel polishing systems. Other engine suppliers include several Caterpillar, Cummins, Westerbeke and Yanmar distributors.
— *Jan Mundy*

A Survival Guide To Ventilation

Good condensation appears on the outside of cold beverages. Bad condensation leads to soggy potato chips, wet bunks, musty air and with time, mildew, mold and corrosion. That's why every boat owner should know how to eliminate the "bad" by improving onboard ventilation.

By Sue Canfield





Nicro Ventilation

Suggested placement of passive and active vents: (top) Underway, even in foul weather, clamshell vents circulate air through the engine compartment while active intake and exhaust solar vents move air throughout the cabin. (bottom) Passive cowl and solar vents move air throughout the entire cabin. Both layouts would benefit from opening deck hatches and using interior 12-volt fans. In fair weather, at anchor or in port, hatches, ports and doors can be opened to provide additional ventilation.

When moist warm air is cooled, it drops its moisture. Outdoors, this moisture is called rain. Inside a boat, the moisture that collects on hull and cabin surfaces is called condensation or sweat. However, when condensation gets so heavy it begins to drip (typically above your bunk), you can call it "rain" too.

The solution would appear to be simple. Either you keep the air in your boat's cabin from being moist or you keep the moist cabin air from being cooled. The devil is in the details. Just consider how air inside a boat becomes moist (humid). First, there's ambient humidity outside the boat, which can vary from say 30% to 100%. Then there's the water vapor we all exhale as a function of respiration and the moisture produced when cooking or showering. Unvented (no chimney) fuel-burning appliances, such as galley stoves and cabin heaters, put a gallon (3.78L) or more of moisture into the air for every gallon (3.78L) of fuel they burn. Last, but not least, there may be standing water in the bilge.

Fortunately, humidity belowdecks can be minimized by ventilation (bringing in less humid air from outside) and by using electrical appliances or fuel-burning appliances with vented combustion chambers. If shorepower is available, you can even use a dehumidifier. (Tip: when you leave your boat unattended, it's best to have the condensate drain directly overboard via a dedicated thru-hull or sink drain rather than into the bilge or a shower sump, where a pump is needed to get the water out of the boat.)

One of the best ways to battle humidity belowdecks is to keep the bilges dry and I mean completely dry! If your boat's bilge pumps don't discharge all the water use a bucket and sponge or a Shop Vac (wet) to remove what's left behind. After doing this for a few weeks, you will have a much better idea just how much water is leaking in and be motivated to track down its source(s). Then you can eliminate the leak(s) by rebedding deck hardware and thru-hulls, recaulking ports and windows or whatever else may be required. Your reward will be a dry, sweet-smelling boat, which is no small achievement. [Ed: Details on finding and fixing leaks below the waterline appear in DIY 2004-#1.]

Ventilation is Divine

When cabin humidity levels rise, use passive and active (mechanical or powered) ventilation as needed to bring in fresh air and to exhaust stale air. Ventilation is also essential in hot weather to moderate cabin temperatures and, in cold weather, to circulate heat throughout the boat. Effective ventilation requires at least two openings to the outside: an intake (add to) and an exhaust (remove). In the absence of either, you'll never get proper airflow. Ideally, the intake should be at one end of the boat (cabin or compartment) and the exhaust at the other. Generally speaking, if a hatch is positioned so the airflow outside the boat is deflected downward, it will bring air inside (intake). If positioned to deflect the airflow outside the boat upward, the hatch will create a partial vacuum and air will be sucked from the boat (exhaust). Opening ports, windows and doors function as intakes or exhausts depending on their location relative to the airflow outside the boat. Cowl vents, which can be turned to face in any direction, serve as an intake or exhaust as needed.

My 37' (11.2m) sailboat was designed for offshore use. It has three hatches (including a large butterfly hatch and louvered companionway doors), 11 opening ports and four Dorade vents. Consequently, there are many ventilation options available. I lived aboard comfortably, winter and summer, for more than 10 years. In my work as a marine surveyor, however, I've seen many boats that have little or no provision for passive or active ventilation. When hatches, ports, windows and doors are closed, there is no air movement absent air conditioning (or heating) system. High humidity and condensation — in the absence adequate

ventilation — will damage electronics and cause fabrics to deteriorate, metal to corrode, paint to peel and wood to rot. Fortunately, there are a number of options for improving a boat's ventilation.

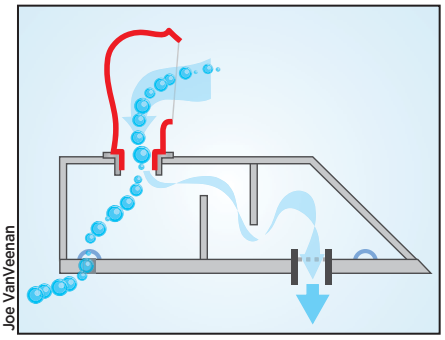
The trick is to use your boat's hatches, ports, windows and vents to provide adequate ventilation in fair weather and foul. At anchor is easiest because the airflow (wind) is predictably from ahead. In fair weather, the foredeck hatch can be left open to act as an intake (if hinged on its aft edge) or exhaust (if hinged on its forward edge). An aft door or hatch is then used for air intake or exhaust as needed. Opening ports and windows are typically of greatest use when your boat's tied up in port, where the wind might come from any direction. (Remember, when there's a gasoline-powered engine or generator running onboard or on a boat alongside, exercise special caution to ensure that deadly carbon monoxide doesn't enter your boat.)

Passive Ventilation

When underway, forward facing (aft hinged) hatches may be closed to avoid taking on water. In heavy seas or rain, most, if not all hatches, ports and windows are closed. At these times, passive cowl vents provide intake air and are most effective when mounted on top of a Dorade box or water trap. [Ed: Plans to construct a Dorade box appeared in DIY 1996-#2 issue and are available on the MRT "Boat Refit" CD-ROM.] Typically made of fiberglass or wood, a Dorade box covers a duct into the cabin that's offset from the ventilator and the box has holes so that any water that enters drains out. The air duct inside the box should have a raised lip to keep water out of the cabin.

Other types of passive vents, such as mushroom or clamshell, are less effective than "baffled" cowls for cabin ventilation, but they work well in other applications. A mushroom vent, operable from inside the boat, can also be used to close off the air duct inside a Dorade box, though this restricts the airflow. This avoids the need to go on deck to remove the cowl and replace it with a threaded plate when unusually heavy seas or weather threaten. Mushroom vents can be installed vertically too, on the side of a trunk cabin or over an exhaust fan duct from the galley or head. I use a low-profile mushroom vent as a deck cap for my boat's cabin heater flue pipe. In heavy weather, it can be closed to keep water from entering the flue.

Taller and wider is best when is comes to cowl vents for optimum airflow. A cowl vent with an opening that's 4" (10cm) in diameter will allow roughly twice the airflow of a 3" (7.6cm) vent of like design.



Joe VanVeenan

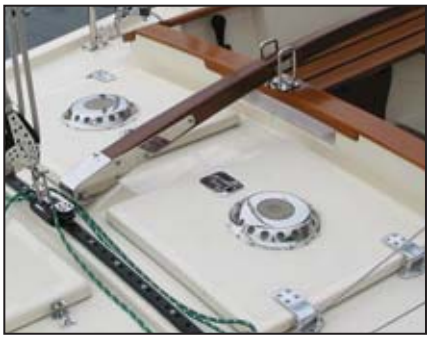
How a Dorade vent works: baffles prevent any water from entering the interior and water exits via drain holes while air is funneled below.

Non-baffled cowl or clamshell vents are best used where water intake is unlikely; for example, where the vent opening faces downward or away from the expected airflow. Clamshell vents are often used to cover a cable pass through, an application where airflow normally isn't an issue.

Active Ventilation

The airflow of cowl or mushroom vents is limited by the amount of air rushing over them. Powered mushroom vents, which operate day and night in all kinds of weather, are many boaters' first choice. These vents may be powered, either alone or in combination, by solar cells, an integral rechargeable Nicad battery, and/or 12-volt ship's power. They can be set to function as an intake or exhaust vent as needed. When there's little air moving over the deck, a powered mushroom vent provides more airflow than a baffled cowl vent. Solar vents are a godsend for boats that are left unattended for even a few days. A solar-powered fan operates without any drain on the battery provided there is sunlight (even marginal brightness). At night, when there is a slight breeze, it acts as a mushroom ventilator to exhaust or intake air. Combination solar vents provide 24-hour ventilation. Sunlight, when avail-

Vetus fiberglass water trap drains off any water that enters through the cowl vent and can be closed off in foul weather with the included stainless-steel mushroom vent.



(top) Solar vent mounted on hatch provides intake air to aft cabin, resulting in a sweet smelling boat. (bottom) Solar vents ventilate aft lazarette to minimize condensation and its unsavory side effects.

able, powers either an intake or exhaust fan and, when overcast and at nighttime, the fan runs off an internal battery (solar powered).

When using a powered vent, you'll find that some are quieter than others, either initially and/or with wear over time. Consequently, it may be better to install a powered vent in your boat's head than directly above the V-berth. The fact that powered vents can fail (most often electrically) should be considered when upgrading your boat's ventilation system. If you spend many nights onboard, it's best to carry a spare.

Forward and aft facing hatches and large cowl vents on Dorade boxes offer optimal intake and exhaust ventilation. Underway and in foul weather, hatches may have to be closed to avoid taking on water. When a boat is left unattended, at anchor or in port, open hatches can also invite thieves. Consequently, it's best to ensure that your boat has sufficient vents to provide adequate airflow when all hatches are closed. Two or more solar vents added to this arrangement would prevent cabin air from becoming unbearably stagnant when hatches are closed.

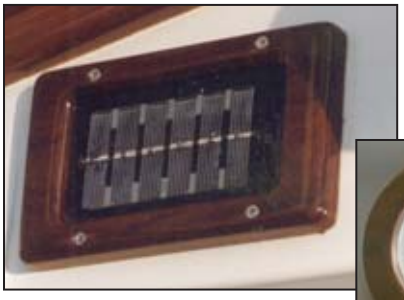
Upgrading Your Ventilation System

There are no set rules governing how many vents you should have and where they should be located. A boat's natural ventilation can travel in any direction, fore and aft, port or starboard. Before you buy and install hatches, ports or vents, experiment with what's already available on your boat. When underway, at anchor and in port, adjust your hatches, ports and vents to optimize ventilation. Use a candle (watch out for dripping wax), incense or (worst case if you're smoking it) cigarette or cigar to help you see air movement and locate dead spots. With experience, you'll find out what works best and where ventilation needs to be improved. If you use incense, you're also likely to meet some interesting folks from neighboring boats.

Marine stores sell clamshell, cowl, mushroom and solar vents in styles to fit any boat. Vents can be installed in a hatch or through the deck, cabin top or sides. Before cutting holes in your deck make certain you won't accidentally be cutting through wiring or structural supports. Measure twice, cut once. A saber saw can be used, but a hole cutter of the proper size will give a more accurate cut. Be sure to seal any exposed deck core against water intrusion before installing the new vent and use an appropriate sealant (e.g., 3M 4200) under the vent flange.

(left and below) Low amperage 12-volt fans can be used to augment a boat's ventilation system and increase the effectiveness of its air conditioning and/or heating system too.

(below) Solar powered fan mounted under a mushroom vent increases the flow of exhaust air in cabins and heads and has its own off/on switch.



Cabin fans, including hard wired 12-volt fixed or oscillating fans and battery-powered portable fans, can be used to augment a boat's ventilation system and to increase the effectiveness of its air conditioning and heating systems too. I installed a 12-volt exhaust fan in the head and one above the vented propane heater. Later, I used a windscoop (for use when anchored) for my boat's double-hinged forward hatch.

Lockers, Bilges and Bunks

Providing adequate ventilation through a boat means storage lockers and bilges must be ventilated as well. Solid locker doors should be louvered or have cane inserts, grilles or decorative cutouts that allow air movement. If the locker doors on your boat are not ventilated, they can be easily modified or replaced. While woven cane panels (real or synthetic) are not typically

Sue Canfield

Mounted in the head compartment is a 12-volt powered exhaust fan in Dorade box duct.

Use passive cabin "vents," such as (left) cane door panels installed on cabin lockers and (bottom) louvered plastic vents from MarineEast or stainless-steel vent grilles, to facilitate air movement through lockers and small compartments.

available at marine stores, they are sold by many boatbuilding supply shops or available from canoe and kayak builders who use them in chair seats. (Or search the Internet. Go to www.google.com and search for "woven cane insert or panel.") Cutouts (with screens or grilles if appropriate) can also be used in the backs and/or bottoms of drawers and lockers to provide additional ventilation.

Condensation that collects on locker floors and under mattresses can be a particularly annoying problem. Here too, there are several solutions. Dri-Deck self-draining ventilated vinyl panels are readily cut and custom fit to any locker or bunk. These interlocking "waffle" panels facilitate air circulation and the evaporation of moisture. I've used them successfully on locker floors for many years. Ventair (www.ventairusa.com), a 1/2" (12mm) thick, three-dimensional nylon mesh with polyester cover, can also be used under mattresses. It's lighter and easier to move about (when accessing storage lockers under berths) than Dri-Dek, and its inherent resilience provides additional cushioning.

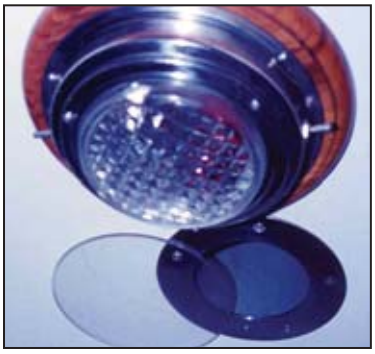
Flow Adjustments

As you work to improve ventilation onboard, don't forget that you may want to adjust airflow in late fall, winter or early spring. Most of the ventilation gear available in marine stores is intended for summer use, so you may need to get creative. When I lived aboard during winters in Maryland, I fabricated sliding acrylic panels to close off the louvered portion of the anchor locker and companionway doors. I adjusted the airflow from Dorade vents using acrylic discs. Since the discs were transparent, I left them in place throughout the year.

Insulation Makes a Difference

Without adequate insulation, the temperature inside a fiberglass or metal boat will quickly respond to the temperature outside. When it's hot outside, it will get hotter inside. And, when the temperature outside falls below the temperature inside, the hull, cabin and any metal-framed hatches or portholes will sweat. Wood is a better insulator than fiberglass or metal. Consequently, wood boats and wood-framed hatches have fewer condensation problems. Fortunately, the hatches on my boat are all framed with wood. I do get condensation on the cast bronze opening ports, but there are teak rails underneath that will catch and hold drips until they evaporate or are sponged away.

Cored (balsa or foam) fiberglass construction, typically used in fiberglass decks and some hulls, has both thermal and acoustic insulating qualities. If your boat's hull and deck are cored, you may find you need no other insulation to minimize condensation. However, if the hull is solid fiberglass and you use your boat in cold waters or cold weather, you'll very likely want to install insulation. There many different insulating materials to choose from so do some research and pick what will work best for your boat, geographic location, and the type of boating you do. [Ed: For details on selecting and installing cabin insulation, refer to "Smart Cabin Interiors" in DIY 2004-#4 issue.]



Sue Canfield

Cover-up

Shielding your boat's cabin from a hot summer's sun with a well-fitting awning also helps to keep temperatures at least 10°F (5°C) cooler belowdecks in summer. When I ran my boat's air-conditioning on hot, muggy days in Maryland, I appreciated the cool air, but disliked the noise and sense of being "canned." With a couple of simple (no

(continues on page 39)

Sacha

(continued from page 37)

battens, no frame) awnings, I didn't need air-conditioning during my six years in southern California and Hawaii.

Sue Canfield

A good awning helps to keep the interior cooler in summer. (bottom) Passive Davis Windscoop funnels even the lightest breeze down through the hatch.

For a relatively small amount of money you can make a dramatic difference in the comfort of your boat. U.S. prices for vents (including deck plates) start at $25 for a stainless-steel clamshell; up to $130 for stainless-steel low-profile or mushroom vents or $30 for a plastic one; $80 for a 4" (10cm) screw-in PVC cowl vent and about $350 for the same size in stainless-steel with a mosquito screen and threaded deck plate plus an extra $161 for a Vetus water trap; and $200 or less for a day-night solar vent.

Using a system of both intake and exhaust, passive and active vents, you can achieve a comfortable level of cross-ventilation that will keep mold, mildew and corrosion at bay. Just imagine having no more cooking odors, musty air or mildew in the cabin. Good ventilation (and insulation) will help to keep you, your crew and boat happy and healthy. Let your motto be: "The only good condensation belowdecks is on the outside of a cold beverage!"

About the author: Susan Canfield is a marine surveyor in Annapolis, Maryland. A frequent DIY contributor, she also teaches "Surveying Fiberglass Boats" at WoodenBoat School in Brooklin, Maine.

Additional Reading: Cruisers and liveaboards will particularly benefit from reading "The Warm Dry Boat" by Roger McAfee (Nighthawk Marine, 2003, 131 pages).

ELECTRONICS

Communication Breaker

Peter Pisciotta

When you get your ship together, make sure you've done all the paperwork to make your communication equipment legal. Here's what you need to know about licensing a VHF marine radio, EPIRB and SSB but were afraid to ask.

By Janet Ross

Recently, a client of mine for documentation services inquired about "registering" various electronic receiving and transmitting devices on her boat. She was looking for one-stop shopping to get all the ship's papers in order and handling these requirements seemed quite complementary to my primary professional focus. So, after agreeing to process the paperwork for all the ship's needs, I knew I'd be facing a learning curve with the Federal Communications Commission (FCC), the U.S. agency that oversees the use (and misuse) of the broadcast airways, some of which carry signals for marine electronics such as the very high frequency (VHF) radio. At first, I felt as though I was looking for the needle in the haystack as I navigated the FCC website on my voyage toward a thorough understanding of the requirements that affect recreational boaters and the communication equipment most often used on their boats.

I'd anticipated an adventure in bureaucracy and I was not disappointed. First, determining which equipment needed what in terms of licensing or registration led to having to locate the appropriate forms and instructions for processing them. I also spoke with friends and associates that I know are boaters. Few of them knew much, if anything, about the FCC requirements for recreational marine transceiving equipment. They buy the toys and worry about the rules of the game later. They don't see any risks associated with the status (or lack of it) of their VHF radios, including the handheld ones they carry when away from the mother ship.

Radio Legalese

The Telecommunications Act of 1996 permits recreational boaters to have and use a VHF radio, an EPIRB and a marine radar without having an FCC ship station license. This change in the law encourages boaters to have and use proven communications' safety equipment without the encumbrances of complex licensing requirements. The key word here is "recreational." Only recreational boaters are exempted from ship station licensing. What is required is that you apply for a new marine radio operator permit or a renewal of marine radio operator permit (as is applicable to your situation). You can use a handheld, portable VHF without additional licensing as long as the use is on a recreational boat and you are in "domestic" (U.S.) waters.

Both of these permits cited above require that you file FCC form 159, Fee Remittance Advice and form 605 Quick-Form Application for a new or renewal radio operator permit and to remit the processing $55 fee. You can download all forms and the instructions for completing them, then file your applications and pay the fees electronically from the United States Coast Guard (USCG) website (www.navcen.uscg.gov/marcomms/othrcoms/ fcc.htm). All that having been said, if you have a high frequency single-sideband transceiver or a marine satellite terminal or you are required to carry a marine radio under any other regulation, you must still carry a FCC ship station license.

Without FCC form 159 you can't do much else to advance the FCC application process. This two-page form must accompany any payment to the FCC for all permits. In addition to its function as a remittance form, it establishes your FCC identity. True to bureaucratic form, this form comes with three pages of instructions. Once you have completed form 159, you can move on to the FCC form 605, another two-page fill in the blanks. No other form works so don't even try the old FCC 404, 404A, 405A, B, et al. There are nine pages of guidance for filling out the 605 and its applicable schedules. There is a silver lining in this cloud of paper and it is that once you've done the paperwork, you can use your radio because Schedule F

of the 605 becomes your Temporary Operator Permit. Talk is cheap!

Canadian regulations are not much different than those for U.S. recreational boaters. There's that word (recreational) again. It's the key word for both countries. Any person who uses a VHF radio to transmit must have a Restricted Radiotelephone Operator's Certificate (ROC) with maritime qualifications, which is a single issue, lifetime certificate. The sole examiner for this license is the Canadian Power & Sail Squadrons (CPS). Canadians can procure a lifetime ROC by either taking a VHF course or they can study the information in the Study Guide for the Restricted Operator's Certificate (RIC-23) at home and then take a short test (fee and passport photo required) to earn their competency and ROC. Anyone who has a current certificate remains qualified to operate a VHF radio. For more information on the ROC, contact the CPS by logging onto www.cps-ecp.ca or call toll-free to 888/277-2628.

Anyone who uses a VHF radio in Canadian waters must follow the procedures described in the VHF Radiotelephone Practices and Procedures Regulations. Canada recognizes the American certificate. U.S. and Canada had been working on a reciprocal agreement that would have relieved Canadian boaters of certain licensing requirements when sailing in U.S. waters but those discussions were abandoned with the change in security attitudes following 9/11.

As is the case in the U.S., pleasure boats no longer need a ship station license to use a VHF in Canadian but, if you travel outside Canada, you may require one. If you take advantage of the Exemption of Radio Apparatus on Board a Ship, you must stop using your old callsign. Your name, boat name or hull license number is the substitute for the callsign. Your own name is best as that matches the name you would use on a Float Plan given to the Coast Guard. The exemption applies only in Canadian and International waters. In any other country, all stations must be licensed unless there is a treaty between the administrations involved.

EPIRB Timetable

One other critical communication device, the emergency position-indicating radio beacon (EPIRB), plays a crucial role in locating boater's in distress. If you take your boat offshore or use it in any open waters, you should consider taking an EPIRB along for the ride. No moaning about the cost. The price you pay is negligible when compared to the safety factor should you ever need to activate it. EPIRBs are designed to save your life by alerting rescue authorities and indicating your location if you are in trouble. As this technology developed, several classes and categories of EPIRBs have come and gone, leaving the Category I 406/121.5 MHz as the unit the USCG recommends. The 406 MHz EPIRB was designed to operate with satellites. The signal frequency is designated internationally for use only for distress. The 406 MHz EPIRB, having an integral GPS navigation receiver, sends accurate location as well as identification information to rescue authorities immediately upon activation. Such EPIRBs are the best you can buy.

While a FCC ship station license is no longer required to purchase or carry an EPIRB, there is a registration requirement. Proper registration is mandated by FCC regulations and enforced by the USCG. When you purchase a new or a used 406 MHz EPIRB, you must register it with the National Oceanic and Atmospheric Administration (NOAA). If you change your boat, your address or primary phone number you must re-register your EPIRB with NOAA. If you sell your EPIRB, make sure the purchaser re-registers the EPIRB, or you may be called by the Coast Guard if it later becomes activated.

Your life may be saved as a result of registering emergency information. Activate a properly registered EPIRB and the Coast Guard uses the registration information to immediately begin action on the case. Your information is sent automatically to the appropriate USCG Search and Rescue (SAR) Rescue Coordination Center (RCC) for response who then contact the emergency phone numbers you provided on the registration form. You should frequently update your contacts with as much about your intended voyage as possible. The more information given, the better prepared SAR personnel can react. Download 406 MHz EPIRB registration forms from the NOAA SARSAT homepage (www.sarsat.noaa.gov), then mail or fax completed forms to SARSAT Beacon Registration, E/SP3, Rm 3320, FB-4, NOAA, 5200 Auth Road, Suitland MD 20746-4304. For further information or to request registration forms call toll free at 888/212-SAVE (7283). From outside the U.S., call 301/457-5430 or fax to 301/568-8649. There is no charge for this service.

Pat Kearns


Official 406 MHz EPIRB Registration Form

The online registration capability is a significant advantage to EPIRB owners and they can update their registration information as often as it changes. It's important to note, however, that your registration is valid for only two years. You are required to re-register your EPIRB every two years so that contact information is up-to-date.

Canadian boaters carrying an EPIRB must register them with the National Beacon Registry at 800/727-9414. In early 2005, it's expected that Global Maritime Distress and Safety System will be added to the course and the ROC exam.

The air is free and so are the airways but using regulated communication equipment legally does require attention to a few licensing details.

About the author: Janet Ross heads up the yacht documentation division of a marine service company in Naples, Florida. DIY readers can pick her brain at vesseldoc@comcast.net.

TROUBLE SHOOTING ENGINE

Corrosion Protection

Knowing what causes corrosion and how to test for it will ensure your sterndrive unit is protected from being eaten by corrosion's effects.

By Steve Auger

Most boat owners know about the effects of corrosion. Repairs due to corrosion damage are very expensive, especially if a new drive is required. There are two types of corrosion: galvanic and stray current corrosion.

Galvanic corrosion takes place when two dissimilar metals like stainless steel and aluminum are bolted (bonded) together and then submerged. Stainless steel is a noble metal, so it's considered as the more stable of the pair and is referred to as a cathode. Aluminum is less stable and as such is referred to as an anode. When the two metals are submerged, electrons flow out of the aluminum into the stainless steel. This current flow consumes the aluminum thus causing corrosion. One way to deter this migration of electrons is by installing a "sacrificial" metal, one that is intended to have its electrons consumed. This metal becomes a sacrificial anode, wasting away (from electron loss) on purpose. Modern anodes are made of zinc (for saltwater applications) and magnesium (for freshwater applications). Both are more anodic than the aluminum components on the drive unit. These anodes corrode sacrificially so that the more noble metals (stainless steel, aluminum) can survive. In order for this type of system to work all sterndrive components must be in continuity with the engine ground (battery negative) and anodes must be in good condition. Anodes require replacement when they are 50% consumed, which is typical of saltwater boats, or become covered with marine growth on freshwater boats, which acts like an insulator. Never rely on the anode's appearance to determine anode wear. Give it a squeeze and it might turn to powder in your hands.

Continuity Check

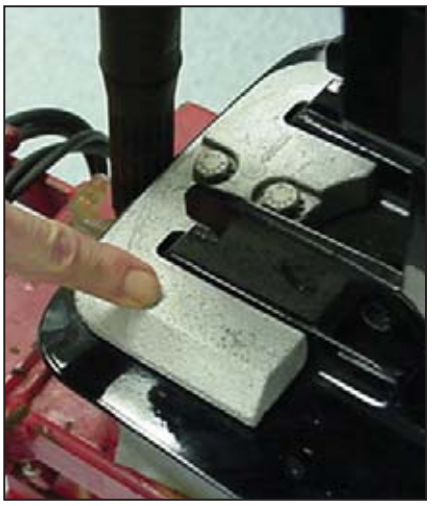
The boat must be hauled out of the water to perform a continuity check to determine if anodes are in continuity with the engine ground. Using a digital multimeter (preferably one that reads in milli-volts and milli-ohms), connect the black lead to the engine ground and use the red lead to contact each sacrificial anode. The reading should be no more than 150 milli-ohms. If resistance is higher, clean the contact between the anode and the sterndrive and then recheck. If the value is still too high, one of the continuity conductors is likely missing or broken. Also check the black continuity wire between the engine and the transom assembly. Replace any wires that are broken, frayed or that have cracked insulation and then, launch the boat.

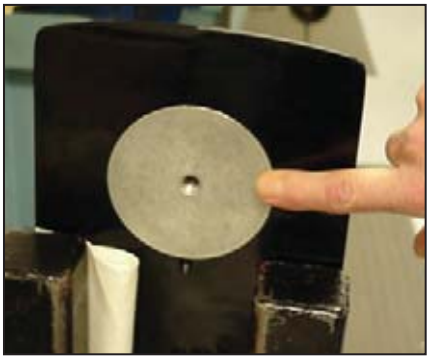
Potential Testing

A hull potential test determines if anodes are, in fact, protecting the sterndrive. The boat must be in the water for at least eight hours in its usual mooring location prior to performing this test. You'll need a reference electrode and a digital multimeter. (Electrodes are available from Mercury Marine dealers, part 91-76675t1, for about US$100.) Set the multimeter on DC millivolts. Connect the black lead to battery neg-

TIP: Never Paint

Anodes must be in contact with water (the electrolyte) to work. Paint prevents anodes or the Mercathode electrode assembly from protecting the drive unit against corrosion.





All sterndrives have sacrificial anodes made of an alloy that is more anodic than the aluminum alloy used in the drive unit. Anodes are located: (from the top) above the anti-cavitation plate; as the trim tab; and underneath the transom near the trim cylinder.

Besides the engine ground wires (shown), the continuity circuit consists of straps mounted near the steering lever, bell housing and gimbal ring, plus ground plates, star washers and washers.

The 12-volt Mercathode system acts as an electronic sacrificial anode and consists of two components: (top) a reference electrode and anode in a single housing that connects to the gimbal housing and a (bottom) controller that installs on the engine. This system requires water to operate and automatically shuts off when the boat is hauled.

ative and, using an approximately 3' to 5' (88cm to 152 cm) long wooden pole (an old broom handle works), dangle the reference electrode, which has been connected to the red lead, about 6" (15cm) from the propeller without letting it actually touch it or the sterndrive. In saltwater, the meter should read no less than 850 millivolts and no more than 1,100 millivolts. If the value is below 850, there is insufficient anodic protection. If all anodes are grounded correctly and in good condition, you may need to invest in an electronic galvanic control device, such as the Mercathode system offered by Mercury Marine. Where the meter reads above 1,100 millivolts, there is too much anodic protection, which can lead to paint blistering or pitting. Hit the sweet spot, around 1,000 millivolts, and the engine's covered. The same process applies in freshwater; however, the voltage values are 750 millivolts minimum and 1,050 millivolts maximum. Around 900 millivolts is ideal for freshwater use.

AC Voltage

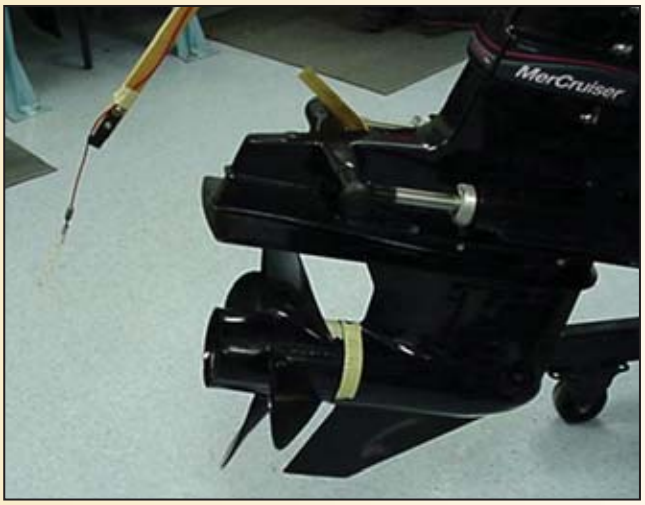
Galvanic corrosion also occurs in boats equipped with shorepower. This takes place when voltage flows from the marina's electrical box, through the green neutral safety circuit, which connects to the sterndrive engine ground circuit. Because the sterndrive is in continuity with the shorepower supply, this current attempts to seek a natural ground as it flows out of the boat and corrodes the sterndrive. A shorepower galvanic isolator, such as the Mercury Galvanic Isolator (part 888557T010, $350) uses a diode network to take the

A Mercury Galvanic Isolator passes AC but not DC current and installs in the boat's shorepower grounding conductor to break the grounding circuit.

boat out of continuity with the shorepower ground yet still allows the current needed to supply the boat's 110/120 volt AC panel, thus protecting the sterndrive. If you already have a galvanic isolator and suspect that it's not functioning correctly, you can have it easily tested by a qualified marine technician.

Wiring Amiss

Stray current corrosion occurs when current leaves its normal path for a path of less resistance. Corrosive effects take place with much more dramatic results and in a much shorter time than galvanic corrosion. The most common cause of stray current corrosion occurs when wiring with damaged insulation becomes submerged, exposing bare wire. Current then flows through the aluminum sterndrive or engine oil pan causing severe corrosion. For example, if your sterndrive transom assembly has massive corrosion on the port side only, the wires to the trim limit switch are likely damaged causing stray current corrosion. Stray current corrosion also takes place in the bilge when the bilge pump or bilge blower supply wires are improperly connected and are submerged in bilge water. Always install electrical connections well above the normal bilge waterline. Use heat-shrink, adhesive-lined terminals and separate busbars for positive and negative (ground) connections. Be sure engine battery cables are the correct size, in good condition and supported high above the bilge, well clear of normal bilgewater levels. Mercury offers a publication called Marine Corrosion Protection Guide, $2.50, part 90-881813-01 that details all causes and cures of marine corrosion.



This photo illustrates the position of the reference electrode, in relation to the propeller and sterndrive, to test hull potential. This test is always conducted with the boat in its usual mooring for at least 8 hours prior to the testing.

TIP: Curb Corrosion

Keeping the sterndrive clean, touching-up any exposed metal with fresh paint and then applying a quality wax all aid in preventing galvanic corrosion.

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

Prime Coats

Follow these steps from the pros to prepare surfaces for painting, to apply antifouling to aluminum, fiberglass and steel boats and underwater running gear, to varnish or oil brightwork and to refinish interiors, aluminum fittings, bilges and vinyl cabintops.

By Jan Mundy

As any professional painter will attest, surface preparation is one of the most important elements of an effective paint job. Experience has shown that little things can cause major problems when it comes to preparing a boat for painting. Start with a clean surface and keep the surface clean through all of the steps. Contamination includes oil, wax, sanding residue and moisture. Moisture causes problems with primers and finish coats when it becomes entrapped in the primer (more about this later).

The first step in a painting job is to remove any contaminants that may be on the surface, such as grease, oil or wax that will ruin a paint job. Waxes containing silicone or Teflon are especially hard to remove. Sanding or sand blasting does not remove surface contamination. In fact, sanding or sandblasting an oily or waxy surface will cause the contaminants to be ground into the surface, making it harder to remove. Surface contamination causes fisheyes or craters in the paint or even delamination of the coating.

Start by washing the surface to be painted with soap and water using a stiff bristled brush or Scotch-Brite pad and a lot of elbow grease. Be sure to rinse thoroughly to remove the soap residue. After washing and rinsing the hull, degrease the surface with a solvent that is manufactured especially for cleaning, such as Interlux Fiberglass Solvent Wash 202 or Special Thinner 216. Use two rags when wiping, a rag soaked with the cleaning solvent and a clean, dry rag. Wipe the cleaning solvent over a 4 sq.ft (.37 sq.m) area and then come back over the same area with a clean dry rag. Change rags frequently to ensure removal of all contamination; otherwise, you are just moving it from one place to another. When cleaning, pay special attention to areas around exhaust ports, under fuel vents, places where teak oils can come into contact with the fiberglass or metal and areas where fenders rub against the hull, as these are more difficult to clean. Repeat this process until the entire surface is clean. To be certain that all wax and other contaminants have been removed, spray water over the surface. If the water beads up, wipe again with Interlux Fiberglass Solvent Wash 202. When the water sheets off, you're ready to paint.

The quality of the finish and durability of the paint is only as good as the prep work.

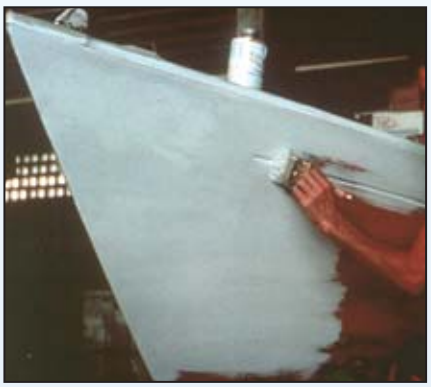
Look for areas that bead water, meaning there is still wax present and you need to reapply the cleaner and scrub more aggressively.

Surface contamination caused an orange peel effect on this surface coated with Toplac, a one-part polyurethane paint.

Undercoating

Once you are satisfied that the surface is fair, one or two coats of primer or undercoater is often applied. Color changes are easily noticed through the finish coats and primer colors are chosen based on how closely they match the finish color. Primer selection is also based on the choice of finish paint. A two-part polyurethane, for example, often uses a different primer than a one-part paint.

After the final application of primer/undercoater, more sanding is required. Start sanding with 120-grit to 150-grit paper to remove any mistakes that occurred in application such as orange peel or sags. Leave the recommended anchor pattern or "tooth" when sanding. Too much and the sand scratches show



Properly prepped gelcoat receives a coat of primer applied with a natural bristle brush.

through; too little and the paint will not adhere. The final sanding for topside finishes is usually 320-grit wet or dry sandpaper; 80 to 120 grit for antifouling paints. After sanding the primer, remove the sanding residue by using a cloth, dampened with the thinner that you are using in the paint. Using a compatible thinner eliminates any problems with the primer and, should any solvent residue remain on the surface, it's fully compatible with the next coat.

Too much moisture causes loss of gloss or, even worse, can cause coatings to blister when overcoated with primer or finish coats. It's best to sand the primer and apply the topcoat the same day if possible, especially when working outside.

Sand by Number

It's always best when sanding to sand "through the numbers." That means that, if you start sanding a surface with 80-grit paper but need to end up with 220-grit paper, then you must sand the surface with 120 paper, then 150 paper, then 180 paper and then, finally, 220 sandpaper. This results in a smoother surface by ensuring that all of the sand scratches from the previous sandpaper are removed. Sanding with 220-grit sandpaper will not remove the sanding profile left by 80-grit paper or 120 for that matter.

Never sand by hand because you'll cause directional scratches that are difficult to sand out. Instead, use a dual-action sander with a soft interface pad and a contact paper, such as 3M Hookit or 3M Stikit discs. This produces swirl marks that are much easier to sand out ("through the numbers") than directional scratches. For sanding little spot repairs, use precut scallop disks that adhere to a finger pad. Dry sanding tends to cause pointloading, where sanding dust embeds itself into the sandpaper causing a deeper scratch. Using freecut papers that contain a dry lubricant reduces pointloading but not completely. Cleaning the paper frequently with a Scotch-Brite Clean & Prep Scuff Sponge helps to remove some of the accumulated sanding dust. Always disconnect the power when cleaning the pad or changing paper. Pointloading is the one downfall of dry sanding, though it's much faster than wet sanding. Wet sandpaper, conversely, last's much longer and is self-cleaning. Always pre-soak a wetpaper before using to soften the paper.

(top) A painter's sanding kit includes 3M Hookit discs, freecut dry sandpaper and wetpaper in various grits, and scallop discs and pad. (bottom) Clean dry sandpaper with a Scotch-Brite Clean & Prep Scuff Sponge to remove accumulated sanding dust and extend paper life.

Use it with a soft pad or 3M Scotch-Brite Clean & Prep Sponge. Never wrap wetpaper around fingers or you'll get indents in the surface. It's best to cross-sand, changing direction when wet sanding, to eliminate directional scratches.

Masking Tricks

Masking tape is are one product where cheaper is never better. You already know this if you've had the unfortunate experience of scraping off a gluey mess after using the inexpensive, light colored, run-of-the-mill stuff on your boat. If you insist on using inexpensive masking tape, never leave it on for more than two to three hours in sunlight. Certain 3M Marine tapes can be left on until the job is complete. 3M Long Mask is good for up to seven days; 3M 2080 Safe-Release tape works for up to three months without leaving an adhesive transfer. It's best to remove masking tapes when the coating is slight-

Other than a worn waterline, this boat's bottom paint is in good condition and requires just a thorough washing, light sanding then recoat.

ly tacky. (Tip: always pull off tape at a 45° angle to the taped line.) A trick used by professionals when painting multiple coats is to first apply a 3M weather-resistant tape then overlay it with a cheap masking tape. This outer tape is removed after every coat, leaving the good tape in position to mark the line. Retape with the cheap stuff before applying the next coat.

Temperature Counts

Sanding and prepping when the weather is cold is not a problem except for the person doing the work. Applying antifouling paints should be done when the air and hull temperature is above 50F (10C). The reason for this is to make sure the paint dries thoroughly and cures properly. Antifouling paint is applied in a fairly heavy coat, 4mils to 5mils wet, which equates to about five sheets of standard copypaper. On a cold hull, the paint dries on the outside (closet to the atmosphere) but thoroughly dry (closest to the hull surface) can be a problem. Copolymer antifouling, like Micron, will wear faster while a hard paint, like Fiberglass Bottomkote, will not be as hard as designed and will begin to wear during the season and may even flake off when hauled out for winter storage. If you cannot paint in ideal temperatures, you're better to apply soft bottom paints, like Red Hand, Bottomkote or Bottomkote XXX, which dry okay when temperatures fall below 50F (10C). VC17m, a hard antifouling, also dries down to 40F (5C).

The author's preference is to wet sand bottom paints before reapplying a new coat.

Where the bottom finish is in good condition, all that's required is a thorough wash with a boat soap followed by a light sanding to provide some tooth for the new paint to stick to. As the surface is already wet, my preference is to wet sand with 80-grit wetpaper. It saves time waiting for the hull to dry and you have little concern for toxic sanding dust. I wear latex gloves and an old foul-weather suit with the cuffs and legs taped to protect skin from the toxic residue. I used to apply antifouling paints with a foam roller and, even though it had a solvent-resistant core, it still disintegrated, leaving foam bits over the wet paint. Now, I use a 2" (5cm) thick sponge. It doesn't dissolve and when it starts to compress from the weight of the paint, I simply toss it out and grab another one. Be sure to don thick rubber gloves if you use this application method. The result is a smooth finish free of any air bubbles or brush strokes.

There's nothing quiet so elegant as newly varnished woodwork.

To renew a teak and holly veneer cabin sole, wash with TSP then lightly sand with 180 grit. The coating of choice is Ultimate Sole, which provides a durable, glossy finish with non-slip properties.

It's common to run the antifouling paint up to 3" (7.6cm) above the actual waterline and then paint the boot top. There are paints sold specifically for boot tops or you can use polyurethane. To apply, wash the hull, degrease with solvent and then sand with 120-grit paper. Tape the line using 3M Long Mask and apply two to three coats with a natural bristle brush or a 3" (7.6cm) roller followed by a brush (the roll and tip method) if the width of the boot top allows. A quart would suffice with some left over for touch up. If you need to locate the boot top-waterline, use the water hose method. [Ed: This is detailed in DIY 1997-#4 issue and also on the MRT "Painting & Refinishing" CD-ROM.] Tip: For a cleaner waterline spray with Captain Phab Pro-Tect (wwwcaptainphab.com).

Wood Care

Newly varnished, gleaming brightwork looks elegant and gives a boat "yachty" appeal but maintaining wood finishes comes with a high labor pricetag. Constant exposure to salt, humidity and sunlight can rapidly deteriorate varnishes and other finishes like oils, as well. Ignore brightwork and it peels, the wood becomes weathered, even black from exposures to water, dirt and pollutants in the atmosphere. Failure to prepare the wood properly or apply the recommended number of base coats and the coating soon begins to peel. (I swear my next boat will have no wood on the exterior.)

Regardless of the protective coating you choose to use, maintaining that coating is key to preserving the finish and wood underneath.

There are several kinds and qualities of marine varnish. They run the gamut from traditional "natural" varnishes to man-made polyurethane or urethane clear coatings, in either solvent or water based flavors.

Natural products are classed as "soft" coatings, for they are flexible; man-made varnishes are harder and more brittle, making them the best choice on surfaces subject to foot traffic, wear and chafe (cabin soles, cockpits, rubrails, etc.)

Like paints, all varnishes and oils

Tip: How Much Footage?

Use this formula to estimate square footage below the waterline: boat length times beam times .85. Remember to double that amount for two coats and triple for three coats.

What's the Difference between Primer and Undercoater?

Over the years, these words have become almost interchangeable but, when it gets down to basics, a primer it something that is put on the substrate and an undercoater is used in relation to the finish. You prime the aluminum or fiberglass or even over a previously painted surface. You can use an anti-corrosive primer on steel. Undercoater is used under the finish to improve the surface. Paint companies have produced products that do both so that work time is reduced and the job is made easier.

work best at 70F (21C) and should never be applied in direct sunlight or in high humidity. One-part traditional varnishes require a build up of six to 10 coats, followed by one or more maintenance coats annually. Two-part varnishes have the advantage of requiring fewer coats (three is normal). By drying faster, they also pickup less air suspended dust so they require less sanding between coats.

Apply several thin coats rather than fewer thick ones, which take longer to dry. When applying on bare wood, it's advisable to seal the wood by thinning the first coat by 50% and lightly "wet" sanding to remove any raised grain. Between each coat, sand with 280-grit to 400-grit dry paper or rub with fine bronze wool to eliminate dust particles. To eliminate sanding between coats try Epifanes Woodfinish. It's easy to apply, doesn't require sanding between coats and is compatible with traditional varnishes. It dries overnight and can be recoated without sanding within 72 hours of the previous coat. This means that you can apply seven coats in seven days.

Of the oil finishes, Cetol remains the coating of choice for most boaters. You'll get a more durable finish if you apply three coats of the mat (Marine Light) followed by two coats of the gloss, waiting 24 hours between coats. A new product that shows merit is Amazon's Teak Lustre from MDR (www.mdramazon.com). This single-part water-based acrylic coating for teak dries within 15 minutes and is sandable in 45 minutes. This means that you can easily apply the recommended three coats in a single day. One application claims to keep teak looking great for up to three years. Better yet, it can be applied directly over Amazon's Teak Oil (do a spot test first before overcoating other teak oil brands.) Teak Lustre is non-toxic, contains no VOCs, clean up is with water and it doesn't change the surface color of the teak. When refinishing a teak and holly cabin sole (floor) you can use varnish (slippery) or apply Ultimate Sole, which offers a glossy look without the slip.

Interior Refinishing

When paint peels on interior spaces, it's likely that the surface was never properly prepped. Old paint suffering from poor adhesion must be stripped. There is no magical, "easy" method here. Don't use heat stripping, which can damage the substrate beneath it. Some chemical strippers are safe to use in interior spaces but these tend to make a mess. A better

approach is to knock off any loose paint with a paint scraper and remove the rest with a dual-action sander and 80-grit sandpaper discs (i.e. 3M Hookit discs). Wear a full faceshield and a disposable Tyvec paper suit with hood. A respirator is also strongly recommended. On older boats, old paint could contain lead pigments so you should be very cautious with the dust.

Make sure the surface is thoroughly abraided and then sand by the numbers (see page 46). Clean off all dust and apply at least two coats of a one-part polyurethane (i.e. Interlux Brightside or Toplac) or marine enamel. The objective is to end up with a reasonably glossy surface that is easily cleaned, so that should mold form, it can't gain a foothold. (Mold prefers a porous surface as it's easier to put down roots.)

Barnacle-Proofing Underwater Metals

According to the experts at Interlux, there is an antifouling method to protect bronze and stainless-steel shafts, struts, props, trim tabs, thru-hull fittings and even stern thrusters from barnacles. Painting these areas requires special attention to initial surface preparation in order to improve adhesion.

The idea is to isolate the copper in the antifouling paint from the bronze of the strut. The cuprous oxide in the antifouling paint is less noble than the bronze in the strut and if you don't prime properly, the paint's antifouling properties will be compromised. The result of not properly priming the bronze could be loss of antifouling protection and the strut will become fouled or burn back may occur. Burn back looks just like it sounds, the paint looks as if it has been burned in concentric circles

No antifouling on this outdrive results in excesive drag, slower speeds and increased fuel consumption. An antifouling specially formulated for aluminum outdrives, such as Trilux Prop & Drive, is the solution.

Final coat of Interprotect 2000E applied to running gear.

emanating from the strut or thru-hull or strainer.

The longevity of this system will probably not equal that of the remainder of the boat bottom, due to the abuse of the service speeds (rpm) these parts must withstand. However, excellent results have been obtained using the following steps. First, degrease the metal surface with Interlux Fiberglass Solvent Wash 202 or Special Thinner 216. Next, bring metal to a uniform bright finish by sandblasting with non-ferrous blast media, such as clean silica sand, or grind using coarse to medium emery cloth. Solvent wipe to remove blast or sanding residue. Immediately, apply one thin coat of Interlux Viny-Lux Primewash 353/354 thinned 25% with Viny-Lux Solvent 355. If this is not done within 24 hours of blasting or sanding, you'll need to reblast or sand with coarse emery cloth. Primewash is a metal etcher containing vinyl butyral resin, phosphoric acid and a little bit of zinc chromate. The acid cuts through the oxidation and the vinyl resin gives the primer something to hold onto and the zinc chromate adds some anticorrosion protection. Metal etchers are the weak link in the chain and instructions must be followed very carefully.

Allow Viny-Lux Primewash 353/354 to dry a minimum of one hour but no more then 24 hours and apply four coats of Interprotect 2000E/2001E following dry times on the label. If fairing is necessary, fair between first and second coats of Interprotect.

If you don't want to prep the gear down to bare metal, coat the surface with two to three coats of a single-part primer, such as Primocon and then apply the 2000E. Apply two to three coats of a non-vinyl antifouling paint. Hard antifouling paints work best such as Fiberglass Bottomkote or Ultra for this application. On aluminum use Trilux 33, Trilux or Tri-Lux II. Note: if dry times for Interprotect cannot be followed, use the following alternate system. Apply four coats of Primocon YPA984 over the Viny-Lux Primewash 353/354. On rivets and welded seams apply a minimum of five coats. Finish with at least three coats of antifouling paint.

Aluminum Like New

It's not difficult to restore aluminum fittings, such as a ladder, rubrail, tower, etc., it's just labor intensive. When aluminum begins to show its age, have it surface blasted if the part is easily removed or, if not, grind it to "bright" metal. Apply one coat of zinc chromate etching primer (i.e Interlux Viny-lux Primewash 353/354), followed immediately with an epoxy primer/surfacer such as Interlux Epoxy Barrier-Kote 404/414 or Awlgrip 545. Metals, especially aluminum, begin oxidizing immediately when exposed to the air and the longer that oxidation builds up the more difficult it is to coat. Finish with a polyurethane topcoat of your choice. The epoxy primer may or may not need sanding depending on the exact coating system and overcoat interval.

When painting aluminum, it's a good idea to apply extra coats of primer over riveted or welded areas. These areas need extra care as the rivets are seldom made of the same grade of aluminum as the boat. *(Continues on page 52)*

Tip : Easy Fix for Old Coatings

If you're unsure what type of antifouling paint is currently on the hull, yet the coating is in good condition and adhering, rather than remove it, brush or roll on Primocon primer. This improves adhesion and prevents cracking of the new antifouling paint. It's compatible with all antifouling paints except VC and VC17.

Get Your Ducks in a Row Before Buying or Selling a Boat

Once you've decided you're ready for a new boat, you don't want anything to slow down the process. So before the wheeling and dealing begins, make sure to have all your loose ends tied up neatly.

BoatU.S. Members have access to a number of valuable online services such as FREE estimates of the fair market value of your boat as well as FREE insurance quotes and affordable financing.

We will also handle the cumbersome details of your transaction such as escrow, settlement and documentation services at BoatUS.com. These services are available only to BoatU.S. Members and are well worth checking out!

Visit the Boat Buyer Services page at BoatUS.com *Today!*

It's a one-stop source of information that can help the process of buying or selling a boat go as smoothly and quickly as possible.

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***at* BoatUS.com**

(Continued from page 50)

Steel Treatments

According to DIY's shop expert Nick Bailey, the best coatings for steel boats, when you compare cost versus performance, are not the yachty paints you buy at marine stores or even the consumer-oriented renovation and construction paints found at hardware stores like Home Depot. What you want are industrial coatings used in shipyards and heavy marine construction like offshore oil derricks. These high-performance coatings are cheaper and often easier to use but may not have the broader color selection. Nick's preference is Devoe Coatings, a division of Ameron (www.devoecoatings.com/index-working.html). These paints can usually only be purchased from a wholesale distributor. If you are lucky, the small quantity (a gallon) packaging may be available. Devoe Bar-Rust (several versions) is a fantastic epoxy anticorrosion primer. There are also cheap antifoulings (the ABC series), urethanes and epoxy topcoats and Devgrip 189, a slip-resistant coating.

Bilge Clean-up

Painting accessible bilge areas with a high-gloss, smooth finish coating helps to keep dirt, grime and mold (can't stick to a smooth surface) from accumulating in bilge. If the fiberglass is in good condition begin by scrubbing well using soap and water and a stiff brush. If necessary, wash all surfaces with a 3% beach solution to remove any mold spores. Rinse with freshwater and allow to dry. Degrease by wiping with a rag soaked in Fiberglass Solvent Wash 202 or use Fiberglass Surface Prep YMA601. Sand with 180-grit paper then vacuum up the sanding residue and follow with a tack rag. For surfaces in poor condition, clean as above then sand with 80-grit paper. Apply PreKote 4279. Now apply one or more coats of Interlux BilgeKote to bilge areas. Be sure to wear a respirator and use fans to ventilate the cabin and bilge.

Recoating Vinyl

Some older cruisers have a white vinyl (not canvas) material, similar to the fake convertible tops on cars, over the cabintop. When this becomes dingy, you'll want to clean it. Conventional marine paints are normally not recommended for this purpose because of their hardness. Due to the flexibility of the surface, the paints would be prone to cracking. Some people have had success using paint like Interlux Yacht Enamel because it's not as hard as the one-part polyurethane paints. You have to be careful to apply it in thin coats. A better alternative is to apply MDR Inflatable Top Coat #784. To apply, first degrease the top with MDR Crazy Clean or similar to remove all oil, grease even fingerprints. Don't use a solvent as it brings plasticizers to the surface and makes the vinyl tacky so nothing sticks to it.

— with contributions from Nick Bailey and Jim Seidel of Interlux Paints.

Did you know that...

…performance of solvent-based paint strippers is greatly reduced at low temperatures. Optimal working temperature of Interlux 299, for example, is 50F to 70F (10C to 21C).

…even if your paint was mixed at the store, stir it thoroughly before each use. Antifouling paints require periodic stirring in the can or roller tray while applying.

…if you apply varnish with a foam brush, sponge or soft cloth, you won't end up with visible brush strokes over any portion of the finish.

… a "hazy" or glossless finish generally means that moisture from dew, rain or simply extreme humidity has entered the finish prior to the film drying.

…you can keep your aluminum sterndrive clean by coating it with Trilux Prop & Drive or other antifouling formulated for safe use on aluminum components.

…on decks, two-part polyurethane works best because it resists abrasion better than one-part urethanes.

…you cannot overcoat a two-part with a one-part polyurethane paint. To check, rub a small area with a cotton swab dipped in acetone. If the paint dissolves or wrinkles within 10 minutes, it's a one-part product.

…a quick humidity check is to wet a small area and, if it dries without 15 minutes, it's okay to paint. If it doesn't dry, it's too humid.

…once you've selected your paint, do a compatibility test. Select a small, inconspicuous spot and apply one coat. Crosshatch the surface with a sharp knife, lay some masking tape overtop and pull off. If the paint comes off, you'll need to remove the existing finish.

…a better tack rag for removing dust before varnishing are 3M Scotch-Brite "dry" Performance Cloths. These lint-free cloths can be used with solvents, are reusable (wash as needed) and don't need to be stored in a sealed plastic bag.

…a frequent application of a spray wax (e.g. 3M Clean & Wax that adds a new dose of UV-inhibitors, will extend the life of an existing painted or varnished coating.

…to preserve a polyurethane finish, such as Awlgrip, Imron or Interthane, wash the surface frequently with Awlwash Wash Down Concentrate (73234), diluted as specified on the label. Rinse well and wipe with a clean chamois. Don't let this cleaner dry on the surface. Follow with Awlcare Protective Polymer Sealer (73240) to maintain and/or restore the gloss. Never wash the topsides with marine soaps or any cleaners containing alkalis, acids or abrasives.

…3M Marine has a Perfect-it system for painted finishes that includes a color restorer and glaze. If you have applied the Awlgrip protective gloss and are unable to regain the gloss, the Perfect-it system will revive the paint and give you a few more years before the surface needs repainting. Perfect-it is available from many auto detailing shops.
— JM

POWER BOAT RIGGING

The Trim Truth

A boat that has bow-down or stern-down trim will typically move slower through the water, give a wetter ride, is slower to plane and generally doesn't "feel" good at the helm. Balancing trim involves rearranging gear, adding stern wedges or installing trim tabs. Here's how.

By Roger Marshall

"How's your trim?" I was asked many years ago when setting up a racing boat. "No idea," I replied, not quite sure if I was being asked whether it was my self or the boat whose trim was in question. "Was it level, down by the stern or down by the bow?" Now, I understood the question, though at the time I had no idea that trim affects performance.

Trim is the fore and aft "attitude" of the boat. A boat that is down by the stern, with its transom deep in the water, is slow to plane and hard to keep on plane. It also causes a large wake when in displacement (non-planing) mode (i.e. wake boarding boats are deliberately trimmed down by the stern to generate a large wake). Stern-down trim is usually caused by too much weight aft. With the current generation of four-stroke outboard engines replacing lighter two-stroke engines, many older designs tend to trim down by the stern.

When a boat is down by the bow, it also has difficulty getting on plane. It tends to push water in front of it, and it might have a very wet foredeck (bow deck area). In a seaway, trim down by the bow can be dangerous. Bow-down trim is often caused by installing anchor chain too far forward in a boat that is not designed to carry it. When you figure that an anchor for a 30' (9.1m) boat can weigh 25lb to 30lb (11kg to 13.6kg), that a windlass weighs about 40lb (18kg), and that 200' (61kg) of 3/8" (9mm) chain weighs 340lb (154kg), you can see how easily this problem arises. Locating this much weight forward in the boat is equivalent to having two large adults permanently standing on your boat's bow. When such a boat gets onto a plane, the extra weight forward tips the bow down and the boat comes off plane, which brings the hull back into balance and lets it get onto a plane again. When this motion continues and results in a series of on/off plane performance, the boat is porpoising, which can only be eliminated by moving weight farther aft until the boat trims level both in displacement and planing mode. This effect can also be reduced by trim tabs and wedges, both of which are discussed later.

To maximize trim you need to consider where to stow all heavy objects, such as batteries and anchors. The best practice is to concentrate the heaviest weights near the hull centerline. Never try to balance a heavy weight in the bow with another heavy weight aft. Suppose you add anchor chain and a heavy anchor to the bow on a boat not designed for them, putting the bow down by a considerable amount. Then, you mount the dinghy aft on the swim platform to balance the increased weight forward. Not a good idea. You've now hung heavy weights off both ends, resulting in a see-saw effect, producing another unpleasant and potentially dangerous motion that lessens your enjoyment of the boat.

Author's boat floats stern-down, as noted by the white boot stripe, after mounting a heavy four-stroke outboard.

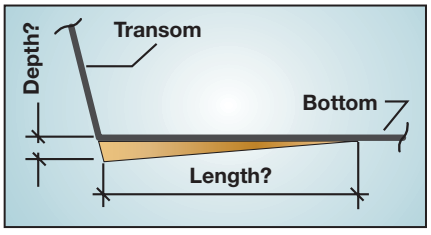
On the Level

So, how do you ensure that your boat will float level? The easiest way is to put it in the water and adjust gear until you get level trim. What happens when a new boat is launched and it floats out of trim? In the old days, builders would surreptitiously launch the boat before the official launching date, check the trim and boot stripe level, haul the boat, correct any trim problems by putting strategically located lumps of lead in the bilge, repaint the boot stripe in the right place and then launch the boat again for the official launching. Today, designers use sophisticated computer programs to determine exactly where the boat should float. Still, builders surreptitiously launch the boat, check the trim…correct any trim problems... .

Entering Wedges

If you, like me, have an older planing boat and you stick a heavy four-stroke outboard motor on the stern, your boat will probably float like mine does, stern down. While this is not a major disadvantage on a small boat, which tends to have more horsepower than needed, it's a slight disadvantage when it comes to getting a larger boat on plane.

The best approach is to adjust the trim angle. According to Lindsey Lord's book,



Trial and error is the only means to accurately determine the length and depth of a transverse wedge.

Long narrow tabs used on high-speed powerboats.

"Naval Architecture of Planing Hulls," the ideal planing angle is around 3° to 5° of bow-up trim. There are several ways to obtain this angle. The easiest is to move crew around until the boat is trimmed properly. Another way to get the ideal planing angle is to install a wedge at the stern. This is a transverse wedge running across the boat bottom at the transom. Its size depends on the size of the boat. For, let's say, a 24-footer (7.3m), it might be only a 1/2" (12mm) deep at its thickest (trailing) end and 18" (46cm) long. There are no hard and fast rules for wedge size. You need to sand or shave thickness off the wedge to get it to work at its optimum potential. One story tells about a powerboat around 90' (27.4m) long that had a wedge fitted. It was hauled and launched several times while the architect measured trim at acceleration. Once the job was done, the boat ran for years at a perfect trim angle.

Wedges work best when the boat runs at a constant speed. However, most powerboats don't run at a constant speed, so most people resort to installing trim tabs. Trim tabs allow the planing attitude to be adjusted while the boat is underway. For example, if the boat trims up by the bow as it transitions onto a plane, the tab is cranked down a little more to adjust the trim angle until the boat is at its optimum trim attitude for the speed run. If there is a crosswind, the tab on one side can be lowered slightly to compensate for the slight heel that the crosswind creates.

Trim tabs come in a number of different sizes depending on the boat size, type and speed capability. Smaller, slower boats tend to have wider and shorter tabs. The way to get the best size tab for your boat is to talk to the tab manufacturer. Most tabs are operated by means of an electro-hydraulic control. When you press the control switch or toggle a joystick, an electrical pulse is created that causes a hydraulic pump to turn. This, in turn, causes the hydraulic actuators to raise or lower the tab. I predict that one of the next great steps we will see in the electronic/hydraulic control systems is an automatically adjusted trim tab. Just dial in the optimum trim angle for your boat and the tabs will automatically sense the boat's attitude and set the tabs accordingly.

Installing Trim Tabs

Trim tabs need to be located fairly precisely. They should be about 3" to 4" (7.6cm to 10cm) inboard from the edge of the hull chine and around 1/4" to 3/8" (6mm to 9mm) up from the bottom of the hull. The farther out the tabs are from the hull centerline, the more effectively they operate. Before installing tabs, make sure that the outboard turns fully without hitting them. I installed Bennett (www.bennetttrimtabs.com) trim tabs on my SeaCraft and the manufacturer recommends a minimum of 8" (20cm) from tab edge to the motor centerline.

Measuring placement for tabs.

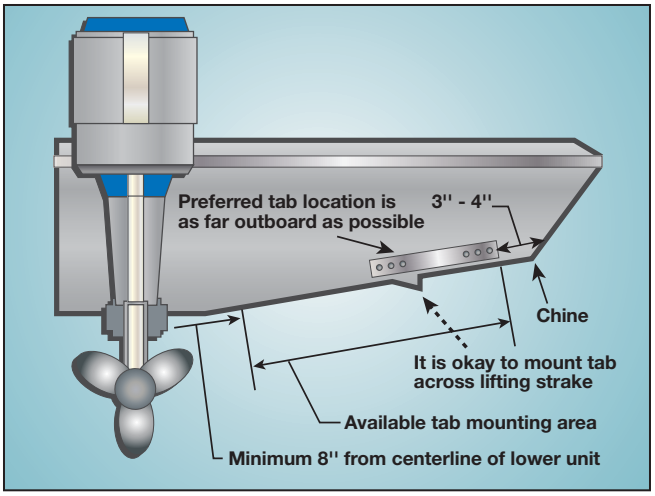
Bennett tab kits contain the hydraulic fluid and everything you need to complete the installation. Installed first is the backing plate. Using the backing plate as a template, mark the hole locations and check the hull inside for any obstructions. (Alternatively, drill a small pilot hole.) If you are drilling into solid fiberglass (uncored), drill the correctly sized hole. If you are drilling into core material, I would advise drilling an oversized hole, filling it with epoxy resin and then drilling the correct sized hole when the epoxy has set. [Ed: This procedure is known as the potting technique.] This forms a barrier between the fastener and the core to prevent water from migrating into the core. All screw holes were touched up with the countersink bit that makes a small recess in the gelcoat. This prevents splitting of the fiberglass and allows caulking to form a small donut that helps to prevent water ingress.

Correct placement of outboard edge of tab.

Mounting the actuator to the tab plate is a simple bolt-on job. Install the backing plate, tab and hinge plate with the actuator. Now, you have to make some careful measurements. I found that the best way to do this is to set a straight edge against the hull bottom running fore and aft. Measure the distance from the straight edge to the backing plate at the transom. It should be about 1/4" (6mm) to 3/8" (9mm). Set the aft end of the tab at 5/8" (15mm) to 3/4" (19mm) above the straight edge. I found that the easiest way to get the tab correctly located was to cut a 5/8" (15mm) block and

Drilling hole for the hydraulic tubing.

After applying a generous bead of caulking around drilled holes, actuator is fastened to the transom.



Locating proper trim tab placement per the Bennett installation manual.

position it at the aft end of the tab on the straight edge. Now, place the actuator against the hull. Bennett recommends that you slide the template sheet behind the actuator mounting and tape it to the hull. I didn't. I marked the three holes in the top pad of the actuator and drilled them out very gently. I hate drilling holes in my boat.

The next job is to drill the center hole for the hydraulic tubing that connects to the actuator. Bennett recommends that you drill a 3/4" (19mm) hole in the transom and fill it with sealant. I drilled a 5/16" (8mm) hole first and then made a 3/4" (19mm) hole deep enough to hold the 7/16" (11mm) locking nut that holds the hydraulic tubing in place. I just didn't like the idea of drilling a 3/4" (19mm) hole all the way through the 2" (5cm) thick transom. At this point, I ran the hydraulic tubing from the center console to the actuator and connected it. All that remained to do was to screw the actuator to the transom with the #14 x 1-1/2" (38mm) screws provided. Note that the hydraulic tubing cannot be bent at 90°. It has to be formed very carefully around corners to avoid kinking.

Next, install the hydraulic power unit. It comes with a bracket and all you do is screw the bracket to the hull or console and slide the unit into the bracket. You'll need about 3" (7.6cm) above the bracket to slide the unit into it. Place this unit in a dry location where it will not get drenched or submerged. Run the ground wire to the nearest grounding point and connect the hydraulic tubing by tightening the 1/2" (12mm) nuts. Use a wrench to torque them up snugly. Fill the reservoir with the automotive transmission fluid contained in the kit.

Now install the rocker switch by drilling a 1" (25mm) diameter hole and cutting it square to fit the switch. It was wired so that the bow-up and bow-down modes worked properly according to the manual. The final job is to purge the hydraulics by setting the tabs to the maximum down angle, letting them stay down for 15 seconds, then raising them to the maximum up position for 15 seconds. Once you have done that a couple of times you should have purged all the air out of the system. Now refill the fluid level in the reservoir.

That's it. Put the boat in the water and enjoy your new tabs. When accelerating onto a plane, bring the tabs down a little to help trim the bow down and get the boat on plane faster. Trial and error operation will help you find the optimum trim angle to get your boat onto a plane quickly. When running at speed, the only reason to use tabs is to keep the boat's bow a little lower so that the trim angle stays around 4° or 5°. If your boat naturally trims at that angle, you will not need much in the way of tab angle. If you are in a heavy crosswind, lower tab on that side of the hull and bring the boat back to level.

About the author: When not editing magazines, writing books and magazine articles or designing boats, Roger Marshall finds some time to refit his family's fleet of boats.

Tip: Tab Docking

Always place tabs in the up position when your boat is docked or moored to prevent barnacle growth on the actuator piston, which would cause tabs to jam.

Seamless Integration

Just as a football team huddles before each play, a skipper and crew should develop a game plan for docking or anchoring.

Story and Photos by Peter Pisciotta

Voice activated walkie-talkie with headset.

Anchoring: Crew points forward and to starboard indicating the direction the helmsman needs to go.

The afternoon sun is low and winds rage a steady 25 knots as a 40-ton, single-engine trawler squeezes through the breakwater into Astoria, Oregon's east marina basin. Tom and Sue are not new to boating but they are new to this boat and new to Astoria, having just spent three days at sea. Tom nervously circles and surveys his limited options. The yacht leans noticeably from an especially angry gust as Sue questions "where are we going to dock?"

"Over there" Tom vaguely says as he points his chin over his right shoulder. Sue has no idea what preparations are needed, what fenders or lines to set. More importantly, Tom is oblivious to Sue's uncertainty. Unless they do a better job of communicating, docking will be a messy, perhaps damaging maneuver, culminating in yelling and hard feelings.

There are two phases of communication: planning and execution (more detail on this in a later). Planning can be a very short conversation. I used to command an 85' (26m) dinner charter yacht. When we departed a side-tie, I'd assess the prevailing winds and currents, then tell the deck mate what order to cast-off the dock lines. We had a prior understanding that dock lines were numbered from bow to stern so "one, three, two" meant cast off the bow line first, then the stern line and finally, the midship line. With only three words, commands were clear, succinct and actionable.

Communicating 101

Set aside time to discuss and prepare yourself and your crew by finding a safe area to practice. The helmsman's skill is doubly taxed since "hovering" a boat in windy conditions is tricky and novice crews need extra time, so find a safe haven. Too often an ad-hoc plan is devised enroute when the captain is distracted, leaving the crew no time to clarify and respond, a surefire recipe for aggravation.

Instructions should be clear and specific: "We'll tie-up to the dock abreast of the yellow box with the bow abreast of the third piling. We'll need lines and fenders on the starboard side." Of course, details will vary depending upon the experience of the skipper and crew (both individually and as a team) but always err on the side of precision. If crew orders are unclear, speak-up.

Esther and Dennis Bruckel have been cruising the Great Circle Loop for over 10 years. They have also crewed on friends' boats, including a trip to Tahiti several years ago. "When docking in a new location, we go around once for a good look, assess wind and currents and formulate a plan," explained Dennis. "If it doesn't work out, we retreat and try again with improved knowledge."

After a task is completed, crew should acknowledge completion in unambiguous language, such as "anchor is free," for example. I recently watched a couple back a large trawler into a slip. The crew was at the stern and totally invisible to the helmsman in the pilothouse. As the swim step approached the head of the slip, the crew yelled "good" instead of "stop." The helmsman interpreted this as "good, keep doing what you're doing" and proceeded to crunch the swim step into the concrete bulkhead, nearly injuring the crew.

Use terms everyone understands. If the helmsman can see the crew, approximating distance by using outstretched arms slowly coming together is intuitive but some boats don't allow mutual visibility so verbal cues are needed. Describing relative distance, like "you're 10-feet away…" is easy for some people but not all. One couple I met used "rugs" as their unit of measure as both could easily estimate distance by visualizing a throw rug in their salon.

Mutual Admiration

Once a maneuver has been planned, prepared and communicated, it's time to execute. Unlike the planning phase, where one person can do most of the work, executing is a team effort. There is an interesting dynamic with experienced teams where vessel control shifts from captain to crew during maneuvers. Notice how crew actually has control in each of the following situations.

Casting off lines. The captain is powerless until the crew clears all lines and assures everyone is onboard. Effectively, the crew has control until all lines are clear.

Sail handling, especially in heavy weather. The helmsman's role is to maintain an upwind heading until the sail handler indicates completion.

Dropping anchor. As soon as the anchor drops out of the bow roller, the crew is giving instructions to the helmsman on how to handle the boat. Weighing anchor is similar. Control of the boat does not pass back to the captain until the anchor breaks free of the bottom.

Docking control becomes dynamic the moment a line is secured to the dock. If a bowline is too short, the helmsman has no control. If crew does not properly tie a cleat hitch, the boat will drift while the helmsman has assumed the crew has control (tied-up in this case) when the boat is actually underway (adrift).

Crew brings hand up indicating she is about to ask the boat be put in neutral.

Closed fist: Asking the helmsman to go into neutral.

Crew waves back: Asking helmsman to put the engine in reverse.

10 Tips for Better Communications

1. Practice your short game.
2. Never yell or even raise your voice.
3. Never jump if the boat isn't close; retreat and try again.
4. Use clear, succinct language.
5. Be patient.
6. Plan ahead.
7. Acknowledge tasks ("Stern line clear!").
8. Have a contingency plan.
9. Be specific.
10. Ask questions.

Maneuvering a boat with springlines (warping) is an age-old practice of "levering" a boat in close quarters. [Ed: Using springlines in different docking situations is well documented in DIY 2004-#4 issue.] It's perhaps the highest art form of skipper/crew communications because control shifts dynamically between skipper and crew.

A task driven, time sensitive dialogue takes place during maneuvers. The crew waits for a specific moment to execute a task, the helmsman then needs to hold the boat while the task is completed. Crisp and clear statements signal transition (e.g. "Stern line clear!") but environmental obstacles like wind noise, engine noise and physical distance can make conversation impossible. So captain and crew need to agree upon other communication methods.

Sign Language

Bob and Marie Austin have been cruising for over 20 years. Bob typically takes the helm during most maneuvers (though Marie is fully capable). "Communications during anchoring is purely by hand signals," says Bob. "Marie looks at the cove as we circle through it before dropping anchor and points out features, good and bad. Her decision as to anchoring places holds equal weight with mine." Hand signaling is a great way to communicate. An arm motioning forward means go forward. A raised closed fist means neutral, an arm motioning backward means go into reverse. Whatever signals you devise, make them simple, obvious, and consistent and, most importantly, practice with crew.

Two-way radio communication devices are a good option, especially popular with cruising couples on large boats. Newer devices use a voice-activated headset making them hands free so you can talk in conversational tones. I recently worked with two brothers who each had severe hearing loss. They wore headsets constantly and it really enabled them to enjoy their 45' (13.7m) motor yacht.

Role Models

The captain usually gets all the glory but good crew should not be underestimated. Ginger Rogers, Fred Astaire's lesser known dance partner, reminded people, "I do what he does backwards and in high-heels." Perhaps the best crews are also accomplished captains. Dave Parker and Linda Lewis were both accomplished helmsman when they met eight years ago. When they moved aboard a boat and prepared to go cruising several years ago, they agreed on almost everything, except who would be captain. They compromised by trading roles annually. Linda and David became excellent crew by becoming excellent helmsmen.

Practice and training are important because it takes time to build confidence in each other. Many maneuvers require precise timing and crisp execution. A good helmsman will factor in the crew's ability to perform. For example, securing a line to a dock in adverse conditions (perhaps a strong wind blowing off the dock) requires crew agility and experience. The maneuver may need to be altered or abandoned unless the helmsman is confident the crew can safely and quickly execute.

Roles change over time so be flexible. Martha and Dave have been boaters most of the 30 years they have been married. Dave was always at the controls while Martha handled lines. For two years, they planned to cruise their Grand Banks 42 to the Pacific Northwest when Martha's maneuverability was cut short by chronic hip problems. Rather than abandon their cruising dream, they switched roles. Martha hired an instructor to teach her docking skills and Dave became the line handler. It was a difficult transition but eventually they felt confident in their new roles.

Close quarters maneuvering is a team effort requiring captain and crew be synchronized. Preparation is important, which means prior planning. It takes patience and communication and sometimes flexibility.

Back in Astoria, Sue presses for more information. "Tom, 'over there' is not a plan. I need more information so I will know how to set docklines and fenders." Tom replies, "Okay, you're right. I'll make a port turn and land starboard to the end of the dock, right next to the pumpout station. In case the wind prevents me from turning, it's possible we'll end up portside to. Just to be sure, let's set full fenders and lines on both sides." Ten minutes later, Tom and Sue are admiring the sunset tied up starboard to the dock in Astoria, Oregon.

About the author: Peter Pisciotta is a USCG licensed 100-ton master, past commercial captain and current owner of SeaSkills Personal School of Seamanship (www.SeaSkills.com). He is a frequent contributor to DIY and lectures on safety and educational topics at West Marine Trawler Fests, Safety at Sea Seminars and Strictly Sail Pacific. He has delivered yachts from Alaska to New Jersey, primarily along the rugged Pacific Coast. He can be contacted at peter@seaskills.com.

PROJECTS

Teak and Holly Flooring

Classic teak and holly wood flooring enriches any boat's interior. The luxury appeal of these exotic woods, while enhancing the appearance of your craft, requires planning, patience, time and money.

By George and Sheilah Van Nostrand

The first step in laying a new cabin sole (floor) is to decide the extent of the area to be covered including stairs, stairwells, locker floors etc. You must also consider whether you will frame the perimeter of these areas and/or the floor hatches with solid teak lumber strips or apply laminated teak and holly plywood only. The framing method effects the picture perfect that embellishes the rich appearance of the teak and holly ply. More importantly, it provides waterproof protection for the end grain of the plywood when joining pieces together. A cost-effective option may be to frame the hatches only.

There are three considerations when choosing the appropriate thickness: the integrity of the sub-floor, plywood weight and the cost. If the existing sole is uneven, with low and high spots greater than 1/8" (3mm), a condition easily determined by the use of an appropriate length straight edge, 1/4" (6mm) plywood may not conform to the irregularities that will result in an unappealing appearance. A better choice is either the 1/2" or 3/4" ply (12mm or 19mm) as it would mask the sole unevenness.

The second consideration is the weight of the plywood being added to the floorboards (hatches) and, inevitably, the overall weight added to the boat. A 4' x 8', 1/4" (1.2m x 2.4m, 12mm) sheet of teak and holly weighs 23lb (10.4kg). A 1/2" (12mm) sheet of the same dimensions weighs 47lb (21kg) and 3/4" (19mm) weighs 71lb (32kg). Do the math and determine what you"ll be adding to your boat's weight and, just as important, what additional weight you are adding to the hatches.

As the weight increases, so does the cost factor. A full sheet of teak and holly plywood sold by Noahs in Toronto, Ontario (www.noahsmarine.com), ranges from CDN$285 for 1/4" (6mm) to CDN$360 for 3/4" (19mm). Solid 1" (25mm) square teak for framing sells for CDN$3.58 per linear foot (30cm) including millwork. Add the cost of additional materials, such as tools, adhesives and finishing products.

Measure the total area to be covered in square feet (meters) and make a diagram to determine the number of plywood sheets and /or solid teak framing material required. Having checked the sole for evenness, determined the plywood thickness required and considered the plywood weight factors, purchase your plywood. If you choose to incorporate teak framing, begin by calculating the number of running feet (meters) required and decide on the desired width. Have the solid teak lumber ripped to the desired width and planed to the exact thickness to match the plywood/laminate dimension. Reserve left over teak for making plugs (bungs) to cover the screw heads.

Measuring and Cutting

Plywood and framing (if used) are precut and dry fitted before being glued and/or screwed to the sub-floor to ensure a perfect end result.

Cut framework pieces first, using mitred corners, and dry fit them into place around the perimeter. When fitting frames around hatches, allow sufficient clearance to raise hatches easily without binding. You need to square the ends before cutting the teak and holly ply. Measure the distance from the side edges (long side) to the first available holly strip in several places to make sure the measurements are equal. If they are not, use a large square and straight edge to square the sheet so the teak and holly strips line up.

With all frame pieces still in place, carefully measure the interior area(s) of the frames for the laminated plywood panels to fit snugly inside. Plan ahead to ensure that the holly strips align properly with the adjoining panels. Now, cut the plywood panels and dry fit them into place. [Tip: To prevent marring delicate surfaces, such as this plywood, lay duct tape over the bottom of the saw's foot. To prevent splintering plywood when cutting, always use a panel blade, score the cutline on the finished (top) side with an awl and lay masking tape along the cut line on the bottom — Ed.] Check for sufficient clearance at the hatch covers and make any adjustments necessary to ensure a good fit that pleases the eye. When all pieces fit properly, number the back of each panel according to your diagram. Apply two or three coats of epoxy resin to the back and sides of each panel for waterproofing. You are now ready to fasten them to the sole.

Fastening Methods

If installing over a fiberglass sole, start with the perimeter frames (if used) and apply a polyurethane sealant such as 3M 4200. Lay a bead close to the underside edges to affect a solid waterproof seal as the bead expands out to the edges under pressure. If necessary, apply weights to ensure a solid fix. The panels are secured in similar fashion with a bead close to the edges and at 6" (15cm) intervals throughout (across) the back of the panel. Again, weights, such as sandbags or lifting weights, are recommended. (The recommended drying time is six hours minimum.)

Essentially, the procedure for applying teak and holly to a wood sub-floor is exactly as outlined for a fiberglass sole with one exception. You must now decide whether or not to fasten the teak and holly ply to the wood sub-floor with countersunk screws and plugs covering the screwheads. The recommended distance between rows of screws is 6" to 8" (15cm to 20cm) apart. If using this method more for cosmetic reasons rather than to securely affix the panels, this distance could be increased for a pleasing visual effect. With an indelible marker, indicate the pattern of screw holes and plugs in the frames and panels by creating a grid with strings and drilling a countersink according to the thickness of the plywood used. This process is not recommended if you have used 1/4" (6mm) ply. Use black headed screws

Teak frames, 1" x 5/8" (25mm x 16mm) mounted around the salon perimeter and hatches.

All screw heads are covered with teak plugs. Note that the holly strips align properly with adjoining panels.

instead if you wish to add firmly fix this plywood.

Next, insert the screws, having first applied a generous coating of polyurethane sealant to the threads to complete the integrity of waterproofing. Purchase a plug maker equal to the diameter of countersunk hole and drill enough plugs from the spare solid teak frames to complete the job. Apply wood glue to the base of the plug and tap each into place, paying close attention to orient the grain of each plug so all line up. [Ed: I prefer to set plugs in the same coating (i.e. oil or varnish) as used to finish the sole.] Let the plugs set for a minimum of six hours.

Using a sharp chisel slightly larger than the diameter of the plug and a wood or rubber mallet, shear off the top of the plug about 1/16" (1.5mm) above floor level. Don't cut flush or you risk chipping the plug and having to fill it. With medium grit sandpaper on a block of wood, sand the plug flush to the floor. Avoid score marks on the unprotected teak/holly ply. Be very careful when handling this plywood as the face (finished side) veneer is very, very thin and easily damaged. Mark and chisel the recess for hatch lifting rings. Installation of these is the very last job.

Finish Coat

There are different ways to protect the new sole. You can seal and protect it with three coats of epoxy resin and then varnish. This method provides a harder surface and may protect from dents inflicted by objects dropped on the floor. If you choose to go bare, seal the sole with teak oil, though oil tends to attract dirt and requires routine reapplication. Better yet, apply a semi-gloss interior varnish directly over the bare teak. This requires several thin coats but gives a rich glowing finish that will charm you and your guests. This method wears well and only requires a light sanding with 400-grit and reapplication of a couple of coats of varnish every few years. [Ed: Alternatively, apply Ultimate Sole, a new product that has gar-

nered rave reviews from DIY readers. Easy to apply, it seals the wood and provides a glossy finish that isn't slippery when wet.] Now, mount the lifting rings on the hatch boards.

Teak soles are easily maintained with sweeping and washing with a gentle detergent and water as needed.

About the authors: George van Nostrand is a retired automotive and marine technician who has owned both wood and fiberglass cruisers for 36 years. His wife Sheilah, a retired nurse, compliments their collective restoration and maintainence skills with wood working, fiberglass and painting and varnishing projects on their 1975 Tollycraft, "Dream Catcher."

Like-New Coaming Boxes

By Richard Asztalos, "Charisma," Mt. Clemens, Michigan

My boat's plastic coaming boxes were in bad shape with chips and dings from flying winch handles and such. As I couldn't find any replacements of the same size, I decided to take the boxes out and repair them.

Boxes were first scrubbed clean with dish soap and then rough sanded with 80-grit paper. Chips and dings were then filled with a ready-mix epoxy applied as smoothly as possible. (I used Marine-Tex but System 3 and others work well.) A day later, the epoxy was sanded with 80-grit paper and then 120 grit, followed by a finish wet-sanding over the entire box interior with 220 wet/dry paper. Boxes then received two coats of Pettit EasyPoxy (**1**) with a light sanding with 220 grit paper and cleaning with Interlux 333 (**2**) between coats. After the paint dried, Cetol refinished fiddles were reattached and a piece of carpet cut to fit was laid into the boxes and held in place with Life-Calk (**3**). Life-Calk was applied to the back side of the coaming frame (**4**) to create a waterproof seal and the box reassembled with screws, just hand tightened. Screws were then tightened about one and half turns after the caulking had set. Carpet (**5**) provides padding to protect the surface and cushion the sound when winch handles, flashlights, tools, etc., are tossed in the boxes.

Custom Switch Labels

By Peter Caplen

As more and more electronic equipment is installed onboard, the need for clear and unambiguous switch labels becomes more important. There are a variety of standard switch labels available but quite often they are the wrong size and shape, the wrong style or just totally unintelligible icons.

The solution is to make your own. These can be as professional looking as anything you'll buy and can perfectly match the style and color scheme of your boat. They'll also be in a style that both skipper and crew can understand. All that is needed is a computer, a printer and a laminating machine

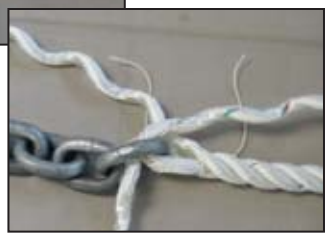
and, if you don't have any of these, you will certainly know someone who has.

When I built my boat "Pershilla" in 1987, I fitted 30 switches on the instrument panel in anticipation of adding equipment over the years. When launched, the boat had just 10 switches in use and now, only seven spares remain. Even I, as skipper, was having difficulty remembering the functions of some of these switches and I knew I had to find a solution.

After carefully measuring the horizontal distance between each switch and the vertical spacing available between the rows, I designed a simple strip of labels for each row. I use Corel Draw 7 software (**6**) but any basic drawing program will do the job. To avoid overcomplicating, I chose bold black lettering on a plain background, and printed this onto a pale yellow card that roughly matches the vinyl covering of the instrument panel. Card stock makes for a more robust label than standard copypaper although, once laminated, this makes little difference. The printed card was then slipped into a laminating pouch and passed through the laminator. If you do not have access to a laminator, most copy shops will laminate it for you. Label strips were then carefully cut out using a sharp utility knife (**7**). Cutting the sheet after laminating means there is no sealed edge around the label and could lead to dampness getting into the edges of the card. However, labels I previously made this way have lasted for six years so far. If mounting the labels in an open cockpit or area subject to moisture, I would suggest cutting the labels to size and laminating them individually to provide a sealed edge around each one. The finished labels were then glued into position (**8**) using a contact adhesive. Labels for other areas, such as this fuse compartment (**9**), are just as easily created.

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.

Easy Rope-to-Chain Splice *(Continued from page 7)*



3 Begin tucking the strands using the common over one, under one, three-strand splice. Start with the middle strand (**a**). Insert the fid at a 90° angle to the standing part of the line. Be careful not to catch any fibers. Lay the middle strand on the fid and push both through. Never untwist the line by hand to open up the line. Next take the strand closest to you (**b**) and lay it over the strand you just tucked under and under the next strand just below it. Turn the splice over and tuck the last strand (**c**) under the one remaining strand in the standing part. All tucks will be at the same point on the standing part. Gently pull each strand just to take up the slack.

4 Hold the splice upside down to check your work. All strands should all be at the same height and 120° apart. If two strands were incorrectly tucked under the same fiber, they would hang side by side.

5 Make the second tuck, passing each strand over one, and under the very next one, starting with strand two (**d**), then strand three, turn the splice and tuck strand one (**e**). Always select the fiber closest to the strand. Mike finds it more convenient to work with the chain suspended rather than on a table (done for photo purposes). Hold up the splice to check that the strands lie evenly. Lightly tension the strands.

6 Continue tucking, always in the same order: strand two, strand three, then strand one. Each strand passes over the next strand on the standing part then tucks under the following one. Always rotate your splice in the same direction (away from you) when tucking the last strand (one). Hold up the splice after each tuck and if you make a mistake, undo the strands and start again. Try to avoid untwisting the fibers. This doesn't affect the strength of the splice, it's purely an aesthetics issue. As you continue tucking, the line becomes tighter, which makes it more difficult to insert the fid. Another reason for not pulling tightly on the strands.

7 Mike recommends making five tucks. This follows the rope manufacturers' recommendations for the number of tucks, albeit many windlass manufacturers suggest just three tucks. Strength is not the issue. “Five tucks offers a better transition between the wider chain and splice and thinner anchorline,” explains Mike.

8 Tighten the splice. Don't pull the strands so tight that the line bunches the fibers together. The goal is to apply the same amount of the tension as on the standing part of the line so the splice flexes and bends easily.

9 After the fifth tuck, taper the strands to prevent bunching

in the gypsy and to minimize chafe. Take strand three (ignore strand two) and make one more over one, under one tuck. Now take strand one and make two tucks.

10 Trim off the excess line using a hot knife or cut with scissors and burn the ends with a match or lighter. This seals the ends to the standing part so they don't unravel.

When lowering the anchor the momentum and weight of the chain pulls a properly formed splice through the gypsy. By not overtightening the splice it remains pliable so it flows freely around the gypsy, allowing a smooth transition from rope to chain.

View from the Stern

(Continued from page 64)

You can understand why some boats have deadrise and others don't. In general, boats intended for bays and estuaries have less deadrise than boats intended for operation in high seas and at high speeds. If the sea state and boat speed are known, an optimum deadrise can be determined for any length of boat. The rub is that most boats don't operate at a constant speed and in a constant sea state, so a compromise deadrise is used. For production boats that must operate in many different sea states and at variable speeds, deadrise is selected based on the primary purpose for which the boat is intended. For example, a boat that will putter around a sheltered bay might have a deadrise angle as low as 5° or maybe it will have a flat-bottom if it will almost always operate in smooth water. A typical example is a clam skiff that usually operates in a sheltered bay early in the morning when there is little sea breeze. In contrast, a sport fishing boat intended to go offshore and operate at speeds to about 30 knots might have a deadrise of 12° to 16°, whereas a high-speed powerboat operating at speeds of up to 80 mph (129 km-h) might have a deadrise angle of up to 22° to 24°.

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.

View from the **Stern**

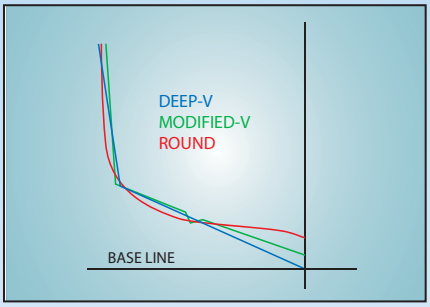
Will that be Hard or Soft?

Deadrise, measured in degrees, determines a boat's ride characteristics. Some boats ride hard, others give a softer ride. Which type of bottom is best depends largely on where you go boating.

By Roger Marshall

In pre-plywood days almost every boat was built with a rounded bottom and these slower powerboats tended to give a smooth ride. Of course, in those days, engines weren't very powerful and hull shapes usually had gently curved lines to allow the boats to go through the water without harsh pounding. As technology changed, so boat designed changed to accommodate it. High powered engines drove boats faster and the hulls could plane, skimming over the water, provided that the hull was shaped properly for planing. As the concept of planing became better understood and its benefits were sought, boats became wider.

To get a feel for why wider is better when it comes to planing, think of an airplane wing. The wider the wingspan, the greater the lift that is obtained and the easier it is for the airplane to fly. Similarly, the greater the beam of a hull, the easier it is for a boat to get on a plane. As boat bottoms became wider, they also became flatter longitudinally, which also made it achieve the planing effect. However, a wide, flat-bottomed boat tends to pound the water instead of slipping through it, so the concept of deadrise came into being. Deadrise is the angle from horizontal to the hull or the angle in which the hull rises from the keel to chine. The measurement is usually taken at the transom for convenience. However, as a design guide, designers use deadrise at various stations on the lines plan. These stations cannot be found on a finished hull without very careful measurement. Some say deadrise was first developed by Ray Hunt back in the late 1950s but there is enough evidence to suggest that deadrise was around long before then. What Hunt did was to incorporate longitudinal strakes on his "Moppie" designs to provide additional lift and get the boat on a plane earlier.



Stern shapes determine ride, handling and performance.

In general, a deep deadrise gives a softer ride than low deadrise. Think of a knife going through butter. If you use the sharp edge of the knife, it slides through the butter easily. If you use the flat side of the knife, it mashes the butter outwards. If, instead of a knife you used a wedge, you'd find that the wedge would go only so far into the butter until its width stopped it from going farther. By adjusting the angle on the wedge, you could adjust how far it went into the butter. Deadrise on a boat is rather like a wedge pushed into butter in that it goes only so far into the water before its width stops it. If you add chine strakes, the impact is a little harder and it stops faster.

So now let's consider different degrees of deadrise. A flat-bottomed boat mashes the water flat, spreading it out to the sides and giving a jarring ride. A boat with a moderate deadrise ("vee") moderates the ride, reducing the pounding motion or the sensation of slamming into the water. A boat with a very deep vee goes a long way into the water but eventually the reserve of buoyancy in the upper part of the hull stops it (you hope!).

Which type of bottom is best depends partly on the conditions to be encountered. If you design a flat-bottomed boat, it will skim across the water generating maximum lift but as soon as it encounters a wave, it will slam down hard and must either slow down or inflict a painful, possibly damaging, blow to the boat or the crew. This says that flat-bottomed boats are best used where they are unlikely to encounter waves or heavy seas. A vee hull, on the other hand, can absorb wave impacts as it sinks into a wave, so it will work well in a seaway. As the boat goes faster, so it needs to sink farther into the waves to recover from the impact. Therefore, a good designer will give a high-speed boat more deadrise to absorb the heavier impacts. Simple isn't it?

Now that we have laid down these basics, let's turn to another problem. A boat with a high deadrise is not flat-bottomed enough to generate sufficient lift to get it on a plane quickly. It takes a long time to haul its transom out of the water. Quite frankly, that's not good enough for most powerboaters, so designers use another neat trick. They put strakes along the hull to generate lift. These strakes aren't wide enough to cause problems when the boat impacts the water. By placing them strategically along the length of the hull, each strake works to get the boat on plane. Then, as the boat rises onto the plane, each strake lifts out of the water and its resistance disappears. So ultimately, at full speed, the boat is riding on just the lower strake and the bottom of the hull. You can now begin to see how clever designers are. Using lots of strakes helps to get a boat onto a plane and once the strakes are out of the water, their drag is eliminated and the hull is able to plane easily. To increase lift when the boat is running at full speed, some designers put a flat pad at the back end of the hull. This gives the benefits of a flat-bottomed boat along with all the benefits of a deep-vee hull. Pretty smart, huh?

(Continues on page 63)