CONTENTS 2006-2

Columns

Departments

Currents

Edited by Jan Mundy

Battery Switcheroo

In the Talkback Q&A column titled, "Switch Protocol," in DIY 2005-#3 issue, John Payne suggests starting the engine with the battery selector switch on "1" then switching to "Both" to charge batteries with the engine running. Bad idea! Then on page 27, John correctly states that such a procedure will probably blow diodes in the alternator. My battery selector switch came with the warning, "Stop engine before switching batteries" printed on it for that very reason. If you are concerned about creating a surge for electronics by starting the engine in the "Both" position, the best bet is a battery isolator and two switches. In this way, you have dedicated banks for start and house loads. There's no concern for house loads draining the start battery or starting the engine and browning out electronics. Finally, the isolator automatically delivers charge current to both banks so you don't blow diodes while switching.

Jamie Halpin, "Windsong," St. Clair Beach, Ontario

John Payne replies: Starting a switch in "Both" and going to one isn't a bad idea as switches are make-before-break so don't cause any issue on transfer unless it's a really cheap and not very well-constructed switch. Diodes fail when a switch is switched to "Off," breaking the circuit with spike and surge causing diode failure. There is a fundamental difference between the two actions. If a switch has a warning then the manufacturer obviously is covering itself and the alternative is to use the advanced field switching function, if fitted, which cuts off excitation to the alternator. While a two-battery setup, without a switch, is something I advocate strongly. The reality, however, is that the three-position switch setup with one charge source is a common arrangement.

Real C&C Deal

Owners of older boats rarely have access to information relating to the boat's history, construction or original parts. If you own a C&C sailboat built from 1970 to the late '90s, South Shore Yachts has the original build files for most hulls. Files contain a collection of information about how the boats were built, such as standard parts and accessories lists, service records, quality control checks, sales contracts, shipping records and rigging specs. Cost is CDN$35 for an original (not photocopied) build file. Contact South Shore at 950/368-4340 or online at www.southshoreyachts.com who will need your boat's hull identification number (HIN). If you can't locate the number on the hull itself, you'll find it on your registration or documentation papers.

Online Tide Charts For Mass Boaters

Boaters cruising New England waters can access tide tables for Massachusetts waters from the Massachusetts Marine Trades Association's website at www.boatma.com/tides/index.html. The site is a free public service that offers predicted tide tables for 68 Massachusetts' ports and harbors for review, download and printing. Predicted local tide charts are calculated estimates based on presumptions of average weather conditions; wind direction, wind speed and vagaries of barometric pressure may produce higher or lower tides than predicted. All tables include times and height of high and low tide and the moon phase and sunrise and sunset times. All calculations are converted to Eastern daylight time.

A Case For Hydrocarbon Contaminants

Lee Mairs article "Cleaning Fuel" in DIY 2006-#1 issue is an excellent discussion of diesel fuel filtration and maintenance issues. Reference to bacteria and their "dead bodies" and the use of biocides, however, misses a key point and perpetuates many common misperceptions regarding filter clogging, etc. The main cause of filter clogging is not the dead bodies of bacteria. Bacteria are extremely tiny at less than 1/2 micron and, while their activities in the tank do create some biomass that contributes to dirty filters, the vast majority of black slimy deposits that appear on filter elements (and tank bottoms) are comprised of hydrocarbons. Diesel is prone

Anchor Line: Where Less is More

Yale Cordage

Comparison of 150' (45.7m) of three-strand nylon line (left) to the same length of Yale eight-strand nylon Brait (right).

Three-strand twisted nylon remains the preferred anchor line for many boaters albeit it's uncooperative when coiled or flaked and has a tendency to kink, especially when used with windlasses, causing jams and stowage is always a problem due to bulkiness. Brait, Yale Cordage's nylon anchor line, solves many of the problems associated with three-strand rodes. Its eight-strand, plaited construction eliminates twist so Brait doesn't kink when coiled or when passing through a windlass. When loaded, this line elongates, apparently absorbing up to 75% more energy compared to other anchor rodes, thus increasing the rode's holding power and reducing the shock loading on deck hardware. Brait is a good choice for small anchor lockers because it stows in less than half the space required by three-strand line. Where space isn't a concern, you now have the option of packing longer lengths in the same locker space.

Yale has published a 20-page technical paper on anchoring technology that reviews anchoring systems and offers recommendations for boats up to 60' (18m). The "white paper" is available at no charge on request (Tel: 207/282-3396) or download it from www.yalecordage.com.

to the formation of sediments from the fuel itself. Today's refining techniques, including catalytic cracking, produce fuel product that is relatively unstable, resulting in the clustering of hydrocarbon molecules and eventually sedimentation of asphaltene and other heavy ends of fuel. This process is also responsible for poor combustion characteristics, resulting in loss of power and soot emissions, as well as injector damage and clogged filters. According to Chevron's Technical Review of Diesel Fuels the best advice is to practice good boatkeeping by preventing the accumulation of water in fuel tanks. In addition to a fuel-water separator, installing an onboard fuel polishing system, such as our FPS 500 and 750, is another way to eliminate water, prevent microbial contamination and protect the engine. Fuel deterioration is a complex subject and I invite DIY readers to log onto www.algae-x.net for a thorough review of the causes of and solutions to fuel related performance and maintenance topics.

Bill O'Connell, Algae-X International, Ft. Myers Beach, Florida

DIY "Florida" Pumpout

On page 12 in DIY 2005-#4 issue you mention the "Florida system" when discussing heads and holding tanks. What is that?

David Kerr, Falmouth, Maine

Nick Bailey replies: I use the expression to identify any sanitation system that has the option of using an onboard pump to discharge the contents of the holding tank overboard via a thru-hull. The advantage of this set-up is that not only can the holding tank be pumped out at dockside as is the normal practice but also, once outside the three-mile limit on coastal waters, it gives the capability of legally pumping the tank overboard. The usual set-up is to fit a Y-valve on the tank pumpout line and connect it to a robust self-priming diaphragm pump leading to an overboard discharge thru-hull (a macerator pump is also an option). An offshore, self-pumpout can be done by simply switching the Y-valve, opening the seacock and operating the pump. There is no legal prohibition to this plumbing design as long as the direct overboard provision is disabled where discharge of untreated sewage is illegal or where boating is done in a designated no discharge zone.

"When your boat insurance comes up for renewal, are you planning to…?" was the question recently asked on DIY's online poll. Of the three choices listed, 57.4% plan to renew their insurance without giving it a second thought; 39.1% are shopping around for comparative quotes; and 3.5% will switch to another provider. To enter DIY's current poll log onto www.diy-boat.com.

Critical Fastener Facts

There was a question posed and answered called "Alternator Breakdown" on page 12 in DIY 2005-#3 issue that raised some issues not addressed in the answer given by Bob Smith. Often failures of various components are actually caused by fastener issues that are not obvious to DIYers or even trained mechanics. First, if any component comes loose, never simply tighten it. Completely remove the fastener(s) securing it and carefully compare them

to new, unused fasteners of the same diameter and thread pitch. Many times a fastener has been over tightened, resulting in the fastener yielding or permanently stretching. This can be very subtle but represents a significant failure of the fastener, reducing its strength and usually resulting in it being effectively installed too loose. In this case, the adjusting bolt that continues to loosen may be yielded and should be inspected. The boat owner also mentions that the lower bolt "sheared." This failure mode is very rare in most fastener installations. I suspect that the fastener was yielded, resulting in under tightening, which caused what is known as fatigue failure. If you have ever needed a piece of the universal

Lesson in Fuel Contaminated Water Tank

It all started with inadvertently putting diesel fuel in my freshwater tank and now, two months later, after spending lots of money and expending tons of time, we're cruising again. There was the problem of how to dispose of the diesel, how to clean the tanks and hoses and flushing the hot water tank. One of the advantages to being on the ocean is having access to a mobile, in-water oil change service "boat" that drives to your boat and this was a simple procedure. Removing the fuel residue was more difficult. In hindsight, for the same or less money I should have replaced the water tank. Instead, I installed two access plates onto the top of the poly tank and fabricated a backing plate from a set of deck plates. I made a heavy-duty rubber gasket to seal the backing plate on the inside of the tank. On a recommendation from Simple Green, I first flushed the tank with 8 gallons (6.7L) of bleach followed by Simple Green Crystal, a commercial product available at Grainger's. (As a footnote, the bleach wasn't necessary). [Ed: Never mix bleach with any other chemicals, cleaners, etc. as a toxic reaction could occur.] Replacing hoses made the most sense but it wasn't an easy fix. This involved routing about 80' (24m) of red tracer messenger lines throughout the boat interior and then pulling through all new hose. On my to do list was replacing the sanitation hose, so I purchased 50' (15m) of SeaLand OdorSafe Plus, which I found on the web for US$7 per foot (30cm). To flush out the hot water tank, I pumped 1 gallon (3.78L) of Simple Green Crystal into the tank and then set up a flushing system, connecting the city water hose to the cold-water inlet and a drain hose to the hot water outlet. I let it run at low pressure but with a flow enough to keep the tank full so I was flushing the tank top where the diesel residue seemed to be most concentrated. (Ed: Diesel fuel is lighter than water.) I flushed it for hours. Incidentally, I discovered that the pressure relief valve in the dockside water connection fitting was not functioning and needed replacing. I take a small measure of solace in uncovering that potential hazard that, unnoticed, could have led to over pressurizing the potable water system and I dread the thought of what could have happened if something had ruptured, allowing the full flow of city water pressure to fill the boat. Though I thought the tank seemed clear of smell or taste, there was still an odor coming from the hot water side so I added Capt Phab Purge Water Tank Cleanser (www.captphab.com) as suggested by DIY's editor. Once again, I have attended another class at the College of Hard Knocks, all starting with a very dumb mistake. More than a few have assured me that I'm not the only one to do this but I'm not proud of my membership in that club. I hate plumbing but now, as with almost every DIY project, it's less of a mystery and I have a pretty thorough understanding of how it works.

Tested by DIY, Captain Phab Purge Tank Cleanser eliminates potable water odors.

Jim Discher, Long Beach, California

DIY boat owner the MARINE MAINTENANCE MAGAZINE

Publisher & Editor: Jan Mundy
VP Sales & Marketing: Steve Kalman
Designer & Illustrator: Joe VanVeenen
Webmaster: Jeff Kalman
Circulation: Britt Hardy
Copy Editing: Patricia Kearns
Technical Advisor:
Recreational Marine Experts
Cover design: Joe VanVeenen. Inset photos by Jan Mundy and Andy Pitt.
Contributors: Steve Auger, Nick Bailey, Susan Canfield, Tracy Croll, Jim Grant, Lee Mairs, Roger Marshall, John Payne

repair component, you know, the coat hanger, but didn't have cutting pliers handy, you just bend it back and forth until it starts to crack and ultimately fails. This is fatigue failure. As the alternator vibrates, it's applying and relaxing a load on the fasteners. If this load exceeds the "clamping force" or tightness of the connection, the fastener stretches and relaxes to accommodate the varying load. As these cycles continue, the fastener does just what the coat hanger did; it starts to crack. As the crack progresses across the diameter of the fastener, it produces a smooth pattern that, after ultimate failure, might be mistaken for a shear failure. Additionally, the bolt may not be of the appropriate grade or strength for the application. Installation torque charts published in engine service manuals guide us all in obtaining the right amount of "tight" for all grades, diameters and thread pitches of fasteners. Fasteners are such an important and misunderstood part of all mechanical devices that our company actually presents a training seminar for our customers to better equip them for solving and preventing fastener failures.
Douglas E. Cohen, J & D Supply, Albany, New York

Ed: After receiving Doug's letter we contacted him for a further information. His article detailing the proper selection and installation of fasteners in marine applications appears in the next issue.

Wanted: Boyen Prop Specs

DIY reader Mike Frith recently purchased a 1989 Gozzard 36 with three-blade Boyen feathering Prop. He took the prop apart for service and during reassembly he was unable to determine how to properly set the pitch. Adjusting the internal gears by trial and error isn't netting a workable solution. If you know of a Boyen service facility or have instructions for setting the pitch contact him at mfrith@istar.ca.

Free Guide to Boat Buying and Selling

Have you found a great deal on a used boat and want to know if there have been manufacturer recalls that needed correction or major complaints from other owners? Do you know what the fine print means in a sales contract? Or, if you're selling a boat, do you know what an "exclusive listing" means? The answers to these questions and many more are answered in a free 34-page guide, "Buying and Selling a Boat," from BoatU.S. and available online at www.BoatUS.com/guide or call 800-395-2628.

Sacha

ASK THE EXPERTS

Helpline info@diy-boat.com

Recoating Teak Veneer

Q: The teak veneer bulkheads of my 1998 Catalina 36 were apparently finished with a water-based polyurethane. They could use a coat of something to protect them from UV and improve their appearance. What product do you recommend and how do I clean the surface before applying?
Enrique Rodriguez, "Talisman," Jamestown, Rhode Island

A: If the coating is still in good shape, clean it well with soap and water and a green Scotch-Brite pad. Rinse with freshwater to remove all soap residue. Lightly sand with 220-grit paper and wipe with Interlux 333. Apply two to three coats of a one-part clear polyurethane, such as Interlux Goldspar. You could use a spar varnish (e.g., Schooner) but, because it's more amber in color, the veneer will appear a little darker. If the coating is in poor shape remove it with a paint stripper (e.g., Interstrip) and start over.
— Jim Seidel, Interlux

Weakened Flush

Q: I have a 1990 Cruisers 3270 with an original electric toilet that has a foot pedal to let in the seawater to fill the bowl and a button that you push for the electric flush. The system seems to be taking longer and longer to pull the seawater into the toilet. I have heard that this might be the impeller in the pump. How do I troubleshoot this?
Jeff Solomon, "Why Knot? II," Starport Landing, Ontario

A: It's difficult to give you a definite diagnosis without knowing the make and model of the electric toilet. Reduced flush water flow could be due to a clogged water intake, a tired impeller or pump motor. If you have a macerator style unit like a PAR (ITT Jabsco) model 37010, it has a single electric motor driving a dual-function pump that has a rubber impeller to draw water in and a carburetor-style macerator impeller to chop up (macerate) and flush out the sewage. For information datasheets on

Cranky marine toilets are the bane of most boat owner's existence and are not as easily serviced as their household brethren.

service and parts, including impellers, visit the Jabsco website (www.jabsco.com/jabscoIndex1-DS.asp). Other makes of toilets may have other issues. Sealand (formerly Mansfield) toilets, including the popular Vacu-Flush models, get the flush water from the potable water supply and, if that's your case, you'll need to check the supply system. A toilet that gets flush water through a seawater inlet thru-hull in the bottom of the boat can be affected by marine growth blocking the intake or a buildup of either marine growth or calcification of mineral deposits in hoses and piping. Try closing the seacock and disconnecting the intake line. Look for weeds or fouling clogging the line, connecting piping or any inline strainers. If you are certain the intake line is unobstructed, dismantle the toilet to check and replace the impeller as indicated. See the unit's datasheet detailed exploded drawing for guidance.
— Nick Bailey

Headliner Options

Q: The previous owner of my wood tri-cabin was living onboard and had installed a vapor barrier in the overhead of all cabin spaces. I pulled out the old ceiling tiles and found that water was trapped against the wood (underside of the cabintop and deck) so I removed all the barrier material. What should I use as a headliner that will also provide some insulating properties?
Ken Klepinger, Juneau, Alaska

A: 3M Thinsulate is one of the best insulating materials you can find (yes, the same stuff sewn into winter wear). Thinsulate is a hydrophobic (doesn't absorb or wick water) polymeric polypropylene microfiber used to improve thermal efficiency and interior acoustics. This means sustained temperatures, condensation control and better interior climate control efficiency. Should it become wet, it won't mildew and, once dried, it resumes its shape. Unlike working with fiberglass insulation, Thinsulate is clean (no respirator needed to keep dust out of your lungs) and easily cut with scissors or utility knife. Spray tacking in place, using Foam Fast Adhesive 74 or High Strength Adhesive 90 and then press firmly against the overhead. It's best to install battens for headliner and attachment points for lights and then conform the Thinsulate to shape, otherwise, you can cut slits in the material for existing hardware. Don't compress the insulation. It should remain fluffy for maximum R-value. Use the thickest insulation that

Lightweight 3M Thinsulate is ideal for insulating cabin ceilings.

space permits. Thinsulate, 2" (5cm) thick, has an R-value of 6 but two layers moves up the R-value to 12. The added weight is negligible for 2" (5cm) as the material weighs 21 ounces per 10.8 feet square (600 grams per meter square). That's five times lighter than some fiberglass insulation. More expensive than fiberglass or foam insulation, Thinsulate comes in a 90' (27m) minimum roll in 30" (76cm) and 60" (152cm) widths. (Check 3M's website at www.mmm.com for dealers who will cut custom lengths.)
— Jan Mundy

Rigging a Chute

Q: I hope to fly a spinnaker this year on my 31' (9.4m) C&C Corvette and need to install the mast fitting for the topping lift (there is a spinnaker halyard) before launching. What hardware do you recommend?
Stan Frost, Cobourg, Ontario

A: According to the pole experts at Forespar (www.forespar.com) you'll first need to decide whether you want an internal or external topping lift. Once that decision is made purchase either an external 360° swiveling block with an eyestrap, such as Harken 168 bullet block on a 281 or 074 eyestrap, or use an exit block, such as a Harken 088 or 287, if it's internal. More importantly is that you need to determine where to mount the leads, depending on whether you are leading the lines back to the cockpit or leaving everything at the mast. Line control in the cockpit allows the lowering or lifting the pole in conjunction with trimming.

Tonic for Leaking Gas Tank

Q: I'm working on restoring a 28' (8.5m) 1978 Skipjack. While happily ripping the inside out, I noticed some gasoline under the cabin floor. This is probably coming from the gas tank, which is a big tank that is built in and surrounded with foam. Removing it would be a major operation. I was thinking of cutting an inspection hole in an accessible area and then using a fuel tank liner product from JC Whitney called Kreem. Can you offer any other suggestions?
George Greiner, "Deltalil," Bethel Island, California

A: Metal fuel tanks that are built in and surrounded by foam are vulnerable to pitting from corrosion and the service life of any metal tank is limited by these exposures. Keep in mind that Kreem and similar products are designed for automotive use where any leaking fuel drips on the ground with only environmental impact. Boats are different as gasoline in your bilge can turn your boat into a bomb. I recommend you remove that old tank and all the surrounding material that could be fuel contaminated and spend the money on a certified and/or NMMA Type Accepted XPE (cross linked polyethylene) stock tank from Tempo or Todd or other marine gasoline fuel tank manufacturer (available from West Marine, et al). Modern plastic tanks, when properly installed, can be surrounded by foam and will never corrode. If you decide to purchase a new metal tank, make sure it's a certified type and has been tested to comply with the USCG requirements and that you install it according to USCG and ABYC requirements. ABYC H-24 requires "All non-integral tank supports,

chocks or hangers shall be separated from metallic tank surfaces by a non-metallic, non-moisture absorbent and non-abrasive material suitable for the purpose (e.g. neoprene, Teflon and high-density plastics) permanently bonded to the tank surface with impermeable, non-hydroscopic adhesive. Note: polyurethane adhesive sealant or equivalent will accomplish this. Additionally, the standard prohibits "self-wicking material, such as carpet pile…in contact with a metallic tank." The standard continues with "Metallic fuel tanks installed above flat surfaces shall be separated from the surfaces by at least 1/4" (6mm) air space when filled with fuel and the flat mounting surface shall be self-draining….Each metallic tank must be installed to allow drainage of accumulated water from the tank's surfaces when the boat is in its static floating position." Messing with the old metal tank is false economy and hazardous to your health and welfare and a home-made or non-certified tank could cost you your boat insurance or worse.
— Nick Bailey

Beware of Imitations

Q: Two years ago we had a new top made of Tempotest for our boat. Apparently, the manufacturer had a bad batch of material and it's not waterproof. The company who made the new top tried to waterproof it using 303 but when it rains water soaks through and, if it rains hard, you can feel a light mist coming through. What is the best way to waterproof this material?
Rod Christie, Guelph, Ontario

A: I'm suspect that the product sold to you is not Tempotest. There is just one acrylic yarn maker in the world that sells to various mills in Austria, Germany, Italy, Sweden and North America. Quality differences vary depending on which mill produces the finished product. Tempotest is an Italian acrylic of superior quality that retains its waterproofing qualities longer than most other acrylics. To waterproof your cover use Aqua-Tite, available at chandleries, some upholstery shops and quality marine canvas shops. To apply, spray on and let dry. It flashes off quickly so it doesn't take long to dry. It contains silicone so be careful not to spill it on any other surfaces other than the fabric.
— Jan Mundy

Solid Dependability

Q: I'm looking for the bilge switch with the highest rate of reliability. I'm concerned that sealed switches may pick up small amounts of oil in the bilge and render them useless.
Phil Wessling, "Magster,"
Falmouth, Massachusetts

A: Some of the solid state electronic sensor switches, the kind with no moving parts, have in the past had a bad reputation and may have been sensitive to oil, among other things. I notice that a quick comparison between some of my old product catalogues and what is currently available indicates some of these switches have been discontinued (e.g. Jabsco 30300-0000 Sonic switch). I also notice that West Marine no longer carries the Bilge Buddy dual probe water sensing switch. Failure to thrive in the marketplace is a good indicator of

Rule Automatic bilge pumps activate every 2.5 minutes for about 1 second to sense for a load (water) against the impeller.

product quality. West Marine now carries the Snake River Electronics solid-state switch. Also available is the Sensa Switch that seems to work on the same principle as a moisture meter. Some of these newer technology switches may prove to be immune to damage from exposure to oil. I have yet to find any kind of automatic bilge pump switch that is immune to everything but I think ITT is on the right track with the Rule-Mate automatic pumps that don't need a separate water-activated switch. The pump activates momentarily every 2.5 minutes and then keeps pumping if the internal electrical load sensor detects the pump is actually pumping water. Clever.
— Nick Bailey

Smarter Charging Improves Loads

Q: Our 1985 32' (9.7m) sloop has a Universal M25 23-hp diesel with 690 hours of use and a 55-amp alternator that charges our house battery bank of two 205 amp hour, lead-acid batteries. Our amp usage at anchor, namely a 12-volt fridge, VHF radio, reading lights, anchor light, stereo, etc., lasts a little over two days before the bank needs charging. I've read that running the engine with no load to charge the batteries causes carbon build-up. Despite all the advances in alternators and regulators, adding a 100-amp alternator steals an additional 2 hp from the engine, during bulk charging cycle I

presume. It also places additional stress on the bearings of this old engine. With all these negatives, I'm inclined to run my portable Honda 1,000-amp generator a couple hours a day to charge the batteries and save the engine. This seems to buck the current trends in advertising.
Chip Lohman, "Whispering Swan," Quantico, Virginia

A: You have a typical cruising yacht scenario and yes, light load running of any diesel causes carbonization and also glazing of cylinders. Diesels do best when running at load and when all moving parts are up to temperature. Never, ever use a portable gasoline generator on your boat. These units are not intended for use in or near your boat's accommodation spaces and there are too many documented cases of carbon monoxide (CO) poisoning and fatalities occurring from the use of these handy little power makers. You can increase the alternator to about 80 amps (similar size) on your engine easily and economically. The key is to use a smart alternator regulator (e.g., Ample Power) to maximize battery-charging efficiency and minimize run time. Also, opt for AGM batteries, which have a high charge current acceptance rate that speeds up charging by a factor of four to five times, dramatically decreasing engine run times. The extra load of an 80-amp alternator should not cause any undue stress on structurally sound engine bearings. If you currently have a 55-amp standard alternator with no smart regulator, you really are running very light. You can endure this by simply adding a smart regulator and AGM batteries and reduce the running times considerably with far greater efficiency and economy. Of course, 690 hours is relatively little engine use and Universals run very smoothly indeed and, if properly maintained, it may serve 5,600 hours or more.
— John Payne

Removing Teak Oil Stains

Q: On my 1988 Corbin 39 sailboat, I decided to oil the teak instead of varnish as I assumed it would be easier to apply but the deck is now covered with oil stains. I have tried many cleaners, to no avail. How do I remove teak oil stains from the fiberglass deck?
Guy Viger, Verdun, Quebec

A: Teak oils permeate the porous gelcoat and what's needed is a product that draws out and absorbs the oil. Solvents, paint removers and fiberglass cleaners actually drive the oil further into the gelcoat. According to our test published in DIY 2001-#2 issue, there are two products that effectively remove teak oil; namely, 3M Marine Sharpshooter (www.mmm.com) and Captain Phab Citrus Cleaner/Degreaser (www.captainphab.com). Our test boat was spotted with various brands of teak oils spilled on the side decks and transom during 10 years of routine refinishing. We just sprayed the cleaners on, scrubbed lightly and rinsed off. Both products effortlessly removed the teak oil and are available from many chandleries. As with any cleaning product, it's wise to do a sample test on an inconspicuous area first, and rinse with fresh or saltwater after using and before it dries. As a side note, the Captain Phab degreaser beats all degreasers we've tested. To use, spray on, let stand for a few minutes, then rinse off.
— Jan Mundy

Bolt Secure: The Allen screws that recess into a "dimple" in the stanchions of lifeline and handrail systems are

intended to hold the stanchion in its base but they are notorious for vibrating loose and putting the stanchion at risk for coming apart under a load (left). To avoid a possible man overboard incident, thru-drill your stanchions and bases and then secure them with bolts and an acorn nut and, of course, use a thread locker (right).

Bone Dry: Bilge pumps usually can't pull every drop of water from the bilge. If you're determined to keep your boat's bilge dry, use a meat baster to draw out any water remaining in the bilge.

Fender Reuse: You can never have enough storage "compartments" onboard so, before you toss out that permanently flattened "inflatable" fender, cut off one end of the fender, fasten it to a bulkhead and use it to stow flashlights, winch handles, etc.

Windlass Protector: An acrylic fabric cover for your windlass helps to protect it from an early demise from saltwater corrosion.

Locker Liner: Plastic panels more commonly sold for cockpit grating make ideal liners for locker bottoms to protect the hull or locker joinery from abrasion and encourage better air circulation.

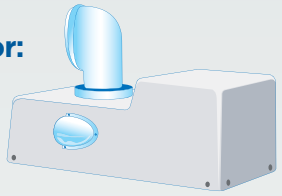
Mildew Wash: To keep mildew from settling into your deck, add some trisodium phosphate (TSP), a bleaching salt, to your boat soap in the wash bucket. Do a spot test first to check for compatibility and possible discoloring.

More Baster Uses: To clean the delicate tubes in an engine's heat exchanger, run a piece of copper wire stripped from a three-core domestic cable through each tube and then drape a towel over the opposite end and squirt water through all tubes using a meat baster. When reassembling, clean the ends well to eliminate leaks.
James Russell, Mission, British Columbia

Sparkling Clean: To remove buildup of soap, grease and dirt, once a week place a small amount of a gentle (no prescription or aggressive products) hair shampoo on a wet non-abrasive sponge and scrub the acrylic, glass and plastic components of your boat's shower and sinks.

Spill-Free Oil Changing: If you have a horizontal oil filter, oil can spill out when you remove the filter. Puncture the filter at the top with a large nail or screwdriver, then rotate the filter 180° and collect the run out in a plastic container. Now fully remove the filter and there will be very little spillage to wipe up.
Murray Charlton, Waterdown, Ontario

Vent Accelerator: To increase airflow through deck-mounted Dorade vents, mount a clamshell vent facing aft and on the inside of the box (towards the centerline) so it doesn't make contact with shins.

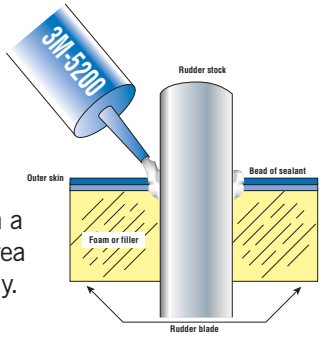


Sacha

Zinc Source: If you have a Prowell propeller and are in need of a replacement anode, the 2-1/2" (63mm) anode sold at West Marine fits and, though a little tight, exercising the prop a few times shaves the edges of the zinc enough for an acceptable fit.
Tex Hill, "Sundsvalla," Pensacola, Florida

Fool's Chrome: To determine the composition of a chrome-plated fitting take a metal file and lightly file the fitting in an inconspicuous spot (e.g., end of a rigging screw). If you see a golden color in the file mark it's bronze or brass; a silver color is likely stainless steel. Another metal that is often chromed is zamac, a zinc and lead alloy, and it's a poor choice marine hardware.

Rudder Putty: The core material in molded fiberglass rudders can get wet from water that seeps into the molding at microscopic openings that develop around the rudderstock at the top of the molding. It's not an "if" but "when" for most rudders. Dig out a 1/4" (6mm) trench surrounding the rudderstock in the top of the rudder and fill with a polyurethane sealant (e.g., 3M 5200) to seal the area against water ingress. Renew the sealant periodically.
Nick Bailey, "Looney Tunes," Toronto, Ontario



TECH TIPS WANTED

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

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

Or E-mail 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.

ABYC 4 You

Demanding the best in equipment and services shouldn't be a lot to ask.

By Pat Kearns

"Good, better, best, never let it rest until your good is better and your better, best." A little ditty my mother used to remind me that I could get away with good, strive for better or go for the gold and do my best. The same goes for getting what you want, pay for or deserve in boats and boating. Which one is good? Is there a better one? Which one is the best? Some of the answers are objective and many are subjective.

On the subjective side of the question, the only answers are opinions. If you're looking for the ultimate in objective measures of resolving the dilemmas of choice, you can consult the nationally accepted, albeit voluntary, standards developed and published by the American Boat & Yacht Council (ABYC). ABYC has been in the business of boating safety and safe boating since the '50s and is a beacon of guidance for boatbuilders, designers, equipment manufacturers, repairers, technicians and anyone else who works on your boat.

Nearly every DIY how-to article contains some reference to an ABYC standard. Why? What's in it for you? The answer to that often begets the exclamation, "There ought to be a law!" That's what we hear in the dock gossip when a boating buddy's new boat breaks down because of a problem created by an under-engineered or executed electrical system problem or the boat has an annoying leak or a chunk of fiberglass just fell off and…there ought to be a law! What these outraged boaters are saying is that somebody should do something to prevent the problems that flow from sloppy practices and shoddy materials. What they are often also demanding is that somebody makes everybody do the job the best way and with the best materials. It's the same "shot" that has been fired at automobile manufacturers, homebuilders, appliance manufacturers, tire makers and anyone and everyone who makes the goods or provides the services that we consume.

TABLE I - MATERIALS IN ALPHABETICAL ORDER

	GASOLINE ENGINES		DIESEL ENGINES	
Components	Wet Exhaust	Dry Exhaust (11)	Wet Exhaust	Dry Exhaust
exhaust pipe	aluminum (14)	aluminized steel (11)	copper -nickel (4)	aluminized steel (11) (12)
	brass pipe (6)	carbon steel (9)(13)	fiberglass (10)	carbon steel (9)(13)
	copper-nickel (4)	nickel-iron-chrome (1)	galvanized steel	nickel-iron-chrome (1)
	copper tubing (7)	nickel-iron-chrome (2)	galvanized wrought iron (12)	nickel-iron-chrome (2)
	enameled steel	stainless steel (8)	nickel-copper (3)	stainless steel (8)
	fiber reinforced plastic (10)		nickel-iron-chrome (1)	
	galvanized wrought iron (12)		nickel-iron-chrome (2)	
	nickel-copper (3)		stainless steel (8)	
	nickel-iron-chrome (1)		synth. rubber hose*(5)	
	nickel-iron-chrome (2)			
	stainless steel (8)			
	synth. rubber hose*(5)			
silencer or wet exhaust waterlift chamber	cast iron	aluminized steel (11)	cast iron	aluminized steel (11)
	copper	carbon steel (9)(13)	enameled steel	carbon steel (9)(13)
	enameled steel	nickel-iron-chrome (1)	fiber reinforced plastic (10)	nickel-iron-chrome (1)
	fiber reinforced plastic (10)	nickel-iron-chrome (2)	nickel-copper (3)	nickel-iron-chrome (2)
	nickel-copper (3)	stainless steel (8)	nickel-iron-chrome (1)	stainless steel (8)
	nickel-iron-chrome (1)		nickel-iron-chrome (2)	
	nickel-iron-chrome (2)		reinforced plastic (10)	
	reinforced plastic (10)		stainless steel (8)	
	stainless steel (8)		synth. rubber*(5)	
	synth. rubber*(5)			

We've all seen the words that are used in promotional materials about anything and everything in the marketplace that are used to convince you that a particular product or service is as good as it gets. I call these words "wonder words" because I have to wonder what they really mean. "Accepted," "Approved," "Inspected," "Required," "Certified" and "Tested" are some of the words you commonly see in advertisements, on a label or in a catalog. Do you know what they mean to you when you're buying a boat, equipment, etc.? They all imply some form of official endorsement by some authority empowered to bless the product or service.

There is relatively little "law" of the land that governs boatbuilding and its related activities and products and the scope of that coverage is limited. This is where ABYC steps in to enhance the quality, solely in terms of safety, that is to raise the bar for the manufacturers of products and systems that you find on your boat. There is the "good" that is found in the body of statutes promulgated by the U.S. Coast Guard (USCG) under the authority of the Federal Boat Safety Act of 1972. None of what those regulations cover is contradicted by ABYC and all of it is incorporated within ABYC standards. "So," you say, "why bother?" The bother is that the USCG regs reflect only the minimum demanded of the industry that serves the recreational boater. In most cases, a corresponding ABYC standard goes further, taking good (the minimum) to better but still addressing the least that one must do, for example, to comply with the requirements for a better but still minimum performance standard. Furthermore, ABYC standards cover issues not addressed by USCG requirements that are mandated by law.

To better illustrate the foregoing points, let's dissect part of an ABYC standard. For this exercise, I've chosen P-1, Installation Of Exhaust Systems For Propulsion and Auxiliary Engines (partly shown above). It's important to note at this point that the USCG does not regulate engine exhaust systems on recreational boats. I'm further refining this example to wet exhaust systems and narrowing that topic to hose and piping used in these systems. The application relates only to inboard engines (including sterndrives), both gasoline and diesel. The following is quoted from the standard (P-1.7.1.5). "Hose used in wet exhaust systems shall comply with the performance requirements of SAE J2006, Marine Exhaust Hose, or UL1129, Standard for Wet Exhaust Components for Marine Engines. All other exhaust system components shall meet the performance requirements of UL 1129, Standard for Wet Exhaust Components for Marine Engines."

Now, imagine that you are in your favorite chandlery and are planning on spending a gloomy day replacing the exhaust hose in your boat because a

CONTENTS/ PREVIOUS/ NEXT/

recent insurance survey reports that a hose does not comply with ABYC P-1. This is infuriating because you put that hose in a year ago and you know it's just fine; however, the surveyor writes that there are no markings on the hose and, because of that, the surveyor cannot testify that the hose is in compliance. Why is this a sticking point? You purchased that hose from an auto parts store because you know how expensive that marine stuff is and, well, a hose is a hose, isn't it? Besides, the installed hose looks fine. The problem is that exhaust hose has to meet a performance standard to ensure that it survives the exposures expected in a marine engine exhaust system. The factors that make marine wet exhaust hose expensive have to do with getting the right materials that can withstand the potentially high exhaust temperatures. Any failure along the way can result in flooding, carbon monoxide (CO) leaks and overheating leading to fire. That hose is part of an assembly of piping that includes hose, elbows and pipe of various materials. Some materials are rubber compounds, steel pipe, fiberglass and plastic pipe. The ABYC standard provides an excellent reference table of materials that are approved for use in a boat's exhaust system. If it isn't on the list, it isn't a type accepted for the application.

ABYC P-1 incorporates two other standards and test parameters into its own requirements. This method of using other standards within the standard is called "incorporation by reference." The Society of Automotive Engineers standard, SAE 12006, and the Underwriters Laboratories, UL 1129, are both incorporated as the primary performance requirements for hose and all other materials used in the exhaust system. To be certified, these materials are required to withstand a high heat test (1,100F/593C for two minutes at 4,900 cu. ft. per minute air flow). In the real world of running your boat, it means that certified hose or piping would survive running the engine at full power for two minutes with no cooling water and though critical, that allows for a safe engine shutdown to avoid a catastrophe. Materials that pass the tests must also be labeled as "Wet Exhaust SAE J2006," along with the manufacturer's name or trademark and year made. It's all part of meeting the standard, including the labeling. Sure, there is hose that is claimed to be "just as good" but, lacking the markings that say it's been tested, it's not in compliance and no one can presume compliance. So, that just as good hose that's in your boat now can't prove its pedigree and that's the sticking point.

If somebody tells you their product is just as good, tell them to prove it. The beauty of the ABYC standards is that they don't limit the use of any material. If you can prove it's been tested to the standard, you can use it.

Besides being DIY's technical editor, Patricia Kearns is a NAMS certified marine surveyor and operates Recreational Marine Experts Group, a marine surveying and consulting firm based in Naples, Florida.

PRO SERIES

Fiberglass Forensics

Professional boat repairers know how a boat goes together and just what can (and often does) go wrong. DIY's core doctor dons his lab coat and analyzes, probes and dissects the whys and wherefores of balsa core failures.

By Nick Bailey

Few of us in the boat repair business have engineering degrees, MBAs or doctorates of this or thatology. If we did we would probably not be getting bruised and filthy working in some grotty bilge. Our "degree" is conferred by the experiential knowledge gained from decades of getting down and dirty with boats as we dig out rotten core, peel away cheesy layers of hydrolyzed bottom laminate, drain gallons of fetid water from wet foam and work out with a grinder to find intact laminate. We know how a boat goes together and what can (and often does) go wrong. Day after day, we are called upon to rectify the results of sloppy construction, lax maintenance, collisions, water ingress and the relentless fatigue of too much time afloat.

Welcome to the world of professional boat repair. Though we're not doctors in any formal sense, people do bring us their tired, sick and wounded boats. Sometimes, a grim faced boat owner shoves a melancholy survey report across my desk and waits for me to give him the prognosis.

Digging out wet, rotten core, mostly from negligence rather than death by purely natural causes.

Specter of Mortality

According to Dutch lore a boat needs two primary attributes to survive the sea. It must be both "hecht en sterk" roughly translated as "tight" (leak free and dry) and "sturdy." Based on many post-mortem forensic examinations, we know that anything that can diminish either quality will hasten a boat's arrival to that sorrowful place where investing in a professional repair doesn't make economic sense and/or the sheer scale of the problem precludes a DIY repair. Although single skin laminates can fail, it's more common to see problems with balsa (or other wood) cored laminates, mostly in decks but sometimes also below the waterline in hulls.

In my experience, it's a brutal fact that, once a balsa core laminate is no longer "hecht," it does not remain "sterk" for long. Many common but questionable boat-building and repair practices of the past, including improperly made core penetrations, leave boats vulnerable to the covert infiltration of water into core and water that gets in and then comes out is not the problem. It's the water that gets stuck that does the dastardly deeds.

Building Blocks

For the past 40 years or so, if a rigid laminate panel without excessive weight was needed, the option was to bond a lightweight core material between fiberglass skins, as in a sandwich. The skin could be fiberglass, Kevlar or carbon fiber. The strongest, most rigid and most popular of the various core materials available is contour-cut balsa core. This material consists of a sheet of

Balsa core sheet. Note system of kerf cuts to allow contoured lay-up.

balsa wood blocks crosscut from the end grain of balsa lumber and bonded on one side to a thin fiberglass scrim. The scrim serves to hold the whole assembly together so it can be handled as one panel. Blocks are oriented on the sheet so that the front and back bonding faces are end grain only for best absorption of laminating resin and bonding adhesives. Individual balsa blocks in most panels are very precisely kerf cut and are usually only a few inches across. This allows the panel to bend and conform to the curved surfaces of most hull and deck lay-ups.

Balsa makes an ideal core material due its high strength to weight ratio and also the fact that it's engineered so moisture travels very slowly across the grain but is easily absorbed into the end grain.

Unfortunately, while these blocks nestle tightly together on the scrim side, on the other side they spread apart to reveal the open kerf cuts between the blocks. Balsa's resistance to water that intrudes into the core depends on the quality of the laminate. Where end grain is exposed, water only takes a few days to completely saturate a sample. For this reason, it's important to ensure the end grain is completely sealed against the laminate skins. The other vulnerability is the network of small gaps formed by the kerfs. They can provide a system of channels through which water introduced into the core can infiltrate and gradually saturate even a well-bonded core. Any gaps left between panels or around core edges are also potential infiltration routes.

Typical balsa weighs only about 9lb per cubic foot. Under a microscope it has an elongated honeycomb structure that is actually mostly air. The wood

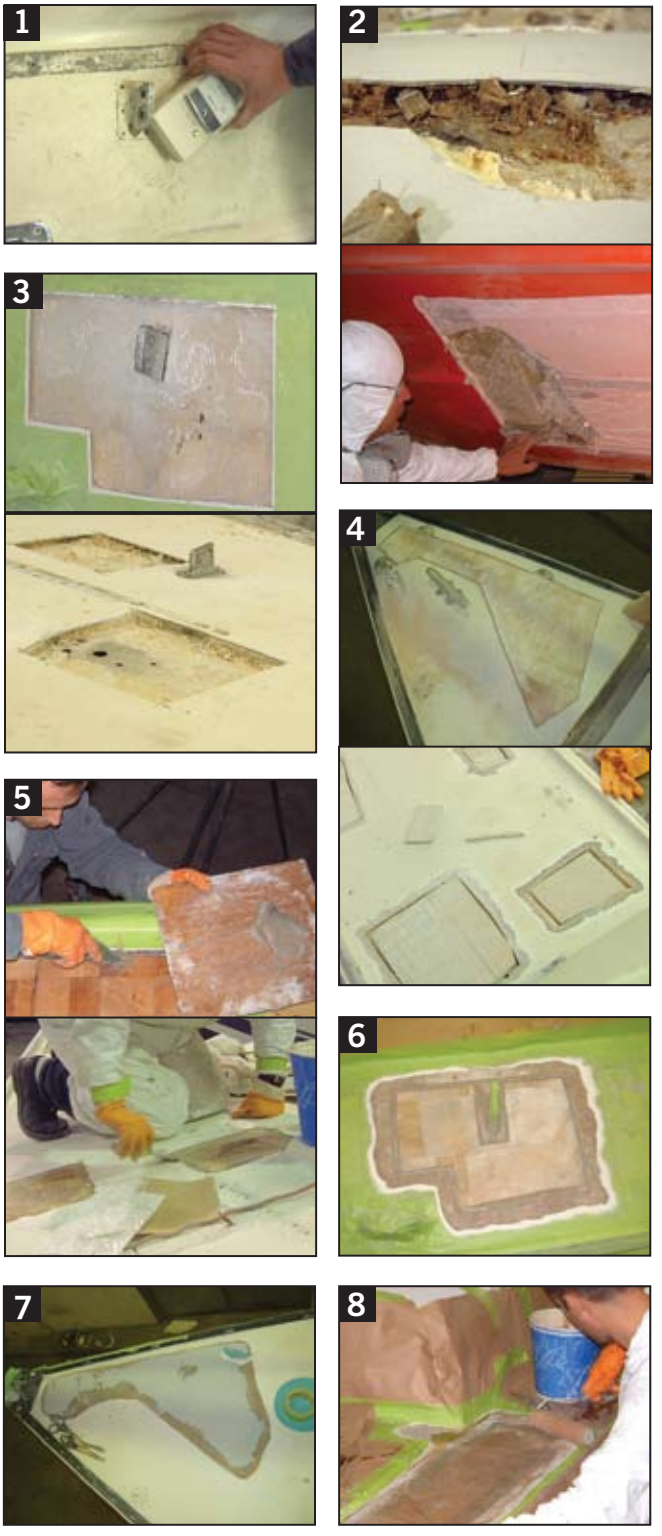
CONTENTS/ PREVIOUS/ NEXT/

A fully saturated, rotted core sample. Note the pool of water left behind on the blue paper.

fibers alone in balsa are considered to be fully water saturated when the moisture content reaches 28% by weight adding another 2.5lb per square foot. A balsa core sample at this "fiber saturation point" (FSP) moisture level would feel only slightly damp to the touch and would indicate as moderate on most moisture meters. However, this is only the first stage of saturation. From here on, the air spaces in the balsa cellular structure fill up with water and, at maximum saturation, the water in the sample exceeds the weight of the balsa by a factor approaching 300%. A moisture meter reading of saturated core at 250% bounces the needle to full-scale deflection. A sample at this saturation level drips like a soaked sponge.

Recent lab studies have confirmed [Ed: Refer to DIY 2005-#2 issue, page 22] two important truths about balsa core that most of us in the trenches already assumed based on our own observations. First, balsa core can only get wet when water leaks into the core via a hole or puncture in either skin. The core won't absorb water through the skin laminates, even when the skin is blistered. This is why the proper installation of thru-hulls and sealing of hardware is the key to keeping core dry. Second, the strength of balsa (like most wood, according to the U.S. Dept of Agriculture's "Wood Handbook") is only decreased by a near maximum 20% when saturated. Unless the laminate in question is designed without the usual safety margins (e.g., breaking strength is 200% to 300% higher than the anticipated normal maximum working load), this wet strength quality is also good news. What happens next? How long can the wet core survive? This question is at the center of a huge on-going debate in the marine industry. The engineers know that conventional (untreated) balsa can rot but organic decomposition only occurs when there is moisture and oxygen available to sustain the nasty microbes and fungal growth. We know how the moisture gets in but what about the air? Can intact existing wet balsa survive if the sources of water and also presumably air leaks are sealed? Is there already enough air in the core to let rot run rampant? It probably depends a lot on the original construction quality. In my experience, as anecdotal and unscientific as it may be, the (supposedly) sealed wet balsa eventually rots.

We have had to revisit core repairs done years ago where the decision was made not to amputate the area of damp to moderately wet core that remained around the perimeter of a major core replacement. This remaining core was structurally sound and the exposed edge looked to be clean and rot free. In other words, it should have met the criteria for long-term survival as wet core. After allowing the exposed edge to dry, it was encapsulated in chopped fiber and resin and capped over with the new laminates. All hardware commu-



Typical repair sequence: 1 Core problems located by meter and sounding hammer. 2 Wet and delaminated areas cut open so the deteriorating core can be dug out and removed. 3 Old core is now gone and the inner skin cleaned and prep sanded to accept the new core. 4 New replacement core is cut and dry-fitted into place. 5 Next, the new core is bedded onto resin rich glass mat (or specialized core bonding putty). The perimeter gaps and kerf cuts are filled with a mix of chopped fiber and resin or bonding putty. 6 New core bedded and bonded in place and sanded to level, ready for lamination of the new outer skin. Note solid glass potting around the chainplate. This penetration will never allow leakage into the core again. 7 Hand lay-up of the new outer skin. 8 Repair area is filled and faired, ready for gelcoat or paint application.

nicating with it was potted and sealed. Ten years later, the area of replacement balsa was still sound and dry but the surrounding area left behind as "damp but sound" had rotted without any rise in the moisture reading. I have been around long enough to see this happen often enough that I reserve doubts about the long-term survival of moderately wet core. Maybe if it was fully saturated, it might do better because the water would displace the air required for biological activity.

Three Preventive Measures

The best quality balsa core construction devotes great attention to the following three manufacturing processes. First, a complete bond between the skin and the face of the core. This is actually fairly hard to achieve with conventional hand layup. Good cored layup can still have 10% or 15% that's sounds delaminated when surveyed. This is a "never-bond" that has been there since day one as opposed to dry delamination that may have progressed from these areas later. Modern core bonding adhesives as well as vacuum bagging or infusion lay-up achieves more consistent quality standards. [Ed: For construction details on vacuum bagging small fiberglass panels refer to "Vacuum Bagging Basics" on page 40.]

Vacuum bagging achieves better core bonding and resin penetration into the kerf system than hand lay-up but works best with low vapor pressure resins such as epoxy and vinyl ester. The high styrene content of conventional polyester resin can cause problems with bag or infusion vacuum systems.

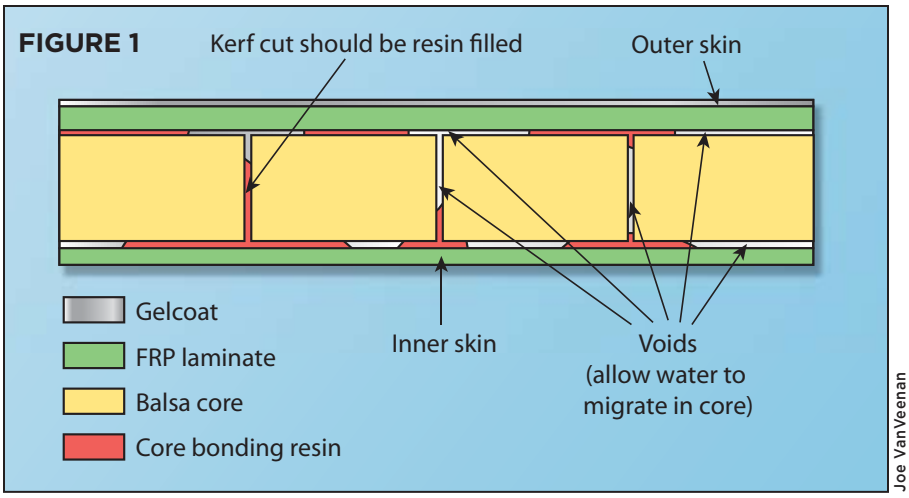


Figure 1 Enlarged cross-section of substandard balsa core lay-up.

Second, complete filling of the kerf gaps and in between the core panels with resin or bonding putty (**Figure 1**). This is also easier to achieve with modern vacuum techniques.

There are two major challenges with the hand-layup of balsa core. One is achieving a good contact bond between the core and the inner and outer skins. The other is ensuring the system of kerf cuts between the core blocks is mostly filled with resin. The first is absolutely necessary to achieve full strength, while both are required to minimize leftover voids that can allow water to migrate throughout the structure.

Lastly, gradual ramp transitions between cored and single skin areas to prevent a void or bubble running along the edge that can act as a water channel.

Most important of all is carefully avoiding penetrations into the core. Thru-hull installs in single skin areas only, deck hardware mounts onto single skin areas or the openings are potted at the time of installation, interior hardware is bonded in place and wiring attaches to clips bonded to the inside skin. Thus any and all holes penetrating the inner or outer skin in cored areas are avoided.

These methods can prevent water from spreading after it enters the core. With luck, a small problem does not become a disaster. The last item prevents water from ever getting the chance to enter the core and is the seldom-realized ideal.

There are many "hecht en sterk" boats out there that are well-built examples of balsa core construction

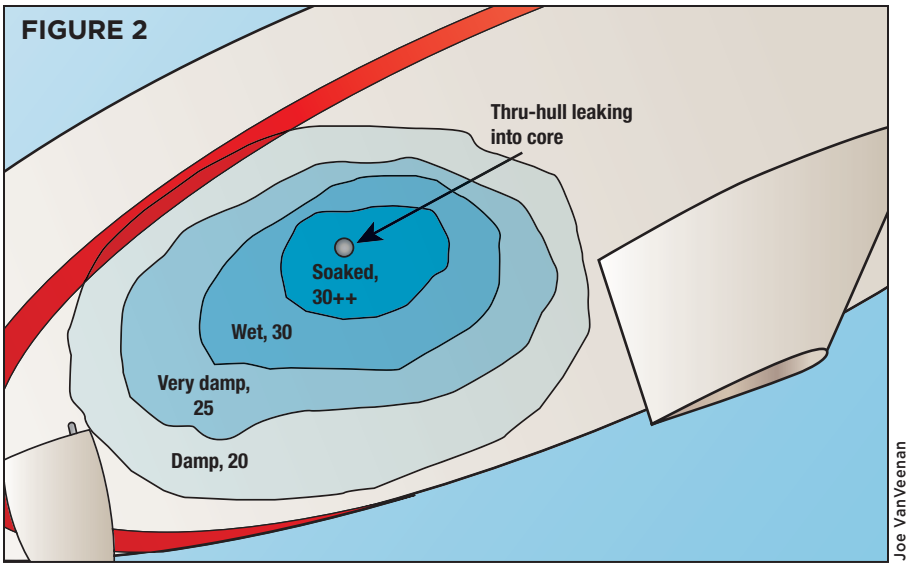


Figure 2 A diver's-eye view of a bottom with core problems. Finding the fitting that allows water to enter the core is usually straightforward. Use a moisture meter to follow the plume of increasing moisture back to the source. Tracing lines connecting areas of equal moisture (like isobars on a weather map) help to make the moisture hot spot obvious.

well sealed against water infiltration. Unfortunately, there are even more examples that never were and never will be. The following is a true case where only the names have been changed to protect the guilty.

Case Facts

The moisture meter and hammer are potent investigative tools in the hands of an experienced professional. They were certainly adequate to verify that this 26' (7.9m) sailboat was dead. It just hadn't been buried yet. This victim was a once spiffy MORC flyer that began life with every advantage. It was designed by a legend and bore the illustrious logo of an aerospace and transportation giant. The topsides and deck gleamed with an immaculate paint job. For us, this was the third example of this particular make and model we had encountered where the core had turned to soggy compost over much of the bottom. How did water get in? Why was the damage so severe?

To confirm our suspicions, we used a grease pencil to trace lines connecting areas with the same moisture readings like isobars on a weather map (**Figure 2**). As with the previous sister ships, these concentric rings were centered on a knotmeter thru-hull. This after-market item had been blithely installed straight through the bottom without any care taken to remove and pot the core at the opening. I'm sure the installation was a bargain at the time but, like a cheap tattoo done with a dirty needle, the consequence was cruel.

Of course the discovery came as a shock to the owner. There never was any leak into the bilge. The only visual evidence indicating something was amiss was a series of stress cracks, some centered on the offending thru-hull, some elsewhere. These probably developed with hull flexing due to a loss of panel stiffness as the core progressively failed. Our suspicions remained. Did freezing and expansion of water in the fully saturated core cause some cracking and contribute to the delamination process? Was this the smoking gun? The stress cracks around the thru-hull looked like the laminate had been stressed and expanded from within.

The question remained. Why did the core delaminate so badly? What came first? Did pre-existing "never-bond" allow water to spread out over wide areas between the core and the glass skins? Or did water saturation proceeding via the kerf system come first and the delamination followed only after the core became weakened by rot? If scientific studies and our own experience agree that wet balsa does not automatically delaminate, what was the cause of delamination here?

A study, conducted by Rick Strand for Sea Ray and Alcan Baltek, on the effects of freeze/thaw cycles on fully saturated (290%) balsa core laminates found that balsa would not expand beyond 2.9% of the total thickness, certainly not enough to cause cracking or delamination. Nonetheless, I have seen some interesting core samples showing what appeared as an internal rupturing of the wood grain structure that was hypothetically caused by frost damage. There are also many examples of concentric stress cracks around isolated "hot spots" of saturated core at leaking deck fittings where the laminate appeared to have swelled upwards

(top) The underside of a deck cutout. Note how the grain in this wet and deteriorated 3/4" (19mm) balsa core sample has opened up. Perhaps ruptured by frost? (middle) An inverted side view (cross section) of the same sample. Note the outer deck laminate is still well bonded and the area of worst deterioration is quite localized. A definite moisture hot spot. (bottom) A view of the outer skin and gelcoat of the same sample. Note the hairline cracks following the area of highest moisture in an otherwise "unstressed" part of the deck. Could this be a sign of stress from frost heave? Lab tests say no. Others say yes.

from within. Perhaps this only happens when there is an isolated wet spot surrounded by good core so that the frost expansion is more tightly confined. I think the jury is still out on the "damage by frost heave" hypothesis. What else could cause stress cracks that are not focused on the load point of the fitting but instead follow the outline of the highest moisture readings?

Leaving speculation behind, let's

Core samples of balsa at various stages of deterioration. (Clockwise from the lower right): A dry sample in apparently good condition that, nonetheless, produced a high moisture reading due to excessive styrene retained in the core; a wet sample showing only slight darkening still in good mechanical shape; two wet samples showing intermediate deterioration and beginning to crumble; a black, crumbly and dripping wet sample in the last throes of rot.

return to the post mortem facts of this severe, but not atypical, case. The entire bottom read wet to dripping wet on the moisture meter (25% to 30% plus). Core delamination occurred over approximately 75% of the wet area. The fact that not all wet areas had delaminated yet suggests moisture was initially spreading via an open kerf system. The delaminated core areas roughly coincided with the highest moisture readings. This experience poses a "chicken versus egg" question. Does soaked core cause delamination or delamination cause soaked core? Widespread core decomposition was confirmed by core samples with the core condition becoming progressively worse as the proximity to the offending thru-hull increased. This implies a more or less linear progression of the core deterioration over time. The core that has been wet the longest has deteriorated the most. Not all delaminated areas were severely rotted yet. This suggests the cause of delamination may be something other than crumbling core. Wear and tear on what was becoming a structurally diminished bottom, leading to gradual flex-related delamination, could be the real culprit but frost heave is still a suspect. Both may be contributing to what amounts to a destructive tag team.

Within the year, the unfortunate boat was stripped of valuables, cut up and sent to the scrap heap. Too bad really, as it was not completely unrepairable, just not economically feasible. A reconstruction of the hull consumes 300 or 400 man-hours of work and, at typical yard rates that translates to a repair bill in the $30,000 plus range. Although damage like this is not subject to insurance coverage, with a market value under $20,000, an insurance adjustor would call this boat a "constructive total loss." Only a patient, energetic DIYer with skill and vision might see it as an opportunity to resurrect the pleasure of its former life afloat.

Lessons Learned

Core can't be dried out easily and repairs are expensive and difficult. Frost heave does no real damage in the lab but I'm suspicious about its effects in the real world. Sound but wet laminate is okay structurally so it theoretically should survive if kept sealed away from air and

Additional Reading

Cored Deck Repairs	1998-#2
Selection and Use of Moisture Meters	2002-#2
Installing Hardware in Cored Hulls and Decks	2005-#2

You'll also find the above articles and more on DIY's MRT Series "Fiberglass Boat Repair." This CD-ROM shows you how to professionally survey and repair cosmetic and structural damage in fiberglass hulls, decks, transoms and cabin interiors. Includes the step-by-step rebuilding of delaminated hulls and decks, rudders and stringers; replacing wet foam flotation, the installation of thru-hulls and hardware in cored decks, moisture meter usage, filling and fairing and more!

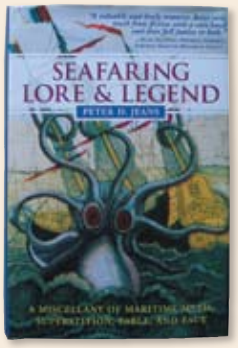
water. Only time will tell. Regardless, it is not worth cutting it out prematurely because, even if it does eventually rot, it will then at least be easier to dig out and replace.

An ounce of prevention is better than a pound of cure for wet balsa or any other kind of wet core, so keep that hardware well potted and bedded and do periodic checks with a moisture meter. [Ed: For step-by-step instructions on potting hardware refer to DIY 2005-#2 issue or DIY's MRT Series "Fiberglass Boat Repair" CD-ROM.]

The future of cored laminates is bright. Builders of new boats today have better than ever core construction techniques available and new, rot resistant balsa core (Baltek Gold) so, with no rotted core to replace and delamination to fix, I might be able to retire in 20 years.

About the author: Nick Bailey is too busy doing triage in the Bristol Marine emergency ward and getting his own boat "hecht en sterk" to think about retiring now.

•BOOK REVIEW•



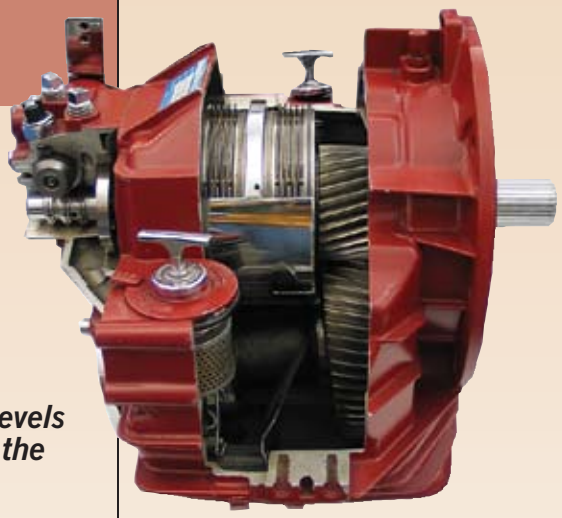
Seafaring Lore & Legend

by Peter D Jeans
370 pages, Hardcover
(McGraw-Hill US$24.95, CDN$36.95)

Peter Jeans has put together an entertaining and fascinating book, chronicling stories of ships, sailors and the sea. Drawn from both history and legend, Jeans sorts truth from fiction and writes of maritime lore from sea gods to the British Navy, from Noah to HMS Victory. Told with fascinating detail, all kinds of sea voyages are covered as well as miscellany such as the origins of naval salutes and why ships are referred to as "she." This is a book for the occasional browse through as well as a "can't put down" read as each account is individually accessible while fitting into a larger chapter subject. From the bizarre to the inspiring, each story reflects Jeans' passion, so you can "experience" shipwreck, mutiny and sea-monsters from the comfort of your own salon without the literal attack of a giant squid!

Sacha

Basics of Oil Checks



Oil is the life blood of your diesel engine. Monitoring oil levels and consumption and routine oil and filter changes keep the engine's "cardiac" system full and flowing.

By Lee Mairs

A marine diesel engine has it easy relative to its cousins who pull 18-wheelers along the highways for thousands of hours every year. Most boat engines live in relatively clean compartments, perhaps a bit warm in the summer, but nothing like life under the hood of an over-the-road tractor/trailer. Marine diesels log only a fraction of those engine hours in a season and many get a vacation in the off-season. Even in this engine-friendly environment, your diesel engine's lubricating oil has a tougher job than a marine gasoline engine. Diesel engines generally run hotter and handle heavier operational loads. And a diesel engine compression ratio is three to four times greater than a spark-ignited gasoline engine.

Diesel fuel sold in North America still contains some sulfur. While it's not enough to lubricate the engine's fuel injection pump, there's sufficient quantity to form sulfuric acid when mixed with water. This is one reason you change oil at off-season layup time. Sailboaters generally run engines at light loads, typically to charge batteries, etc., especially while at anchor, and much of the time the engine runs cool. This results in even more moisture condensing within the engine and more sulfuric acid and more damage to inner engine surfaces such as cylinder walls, journals and bearing surfaces. Since diesel engines are designed to run under load, operating a diesel at idle also creates more carbon soot. [Ed: In most engines, this soot can be sharply reduced by following the practices discussed in DIY 2004-#3 issue. Also available on the MRT Series "DIY Mechanic" CD-ROM.]

Oil Sense

Diesel engine oils are formulated differently than oils designed for use in gasoline engines. Quality marine diesel engine oil contains additives that keep soot in suspension and handle other byproducts of combustion. The American Petroleum Institute (API) classifies almost all modern engine oils for their API Service Categories. [Ed: For complete details on oil selection and analysis and API ratings, refer to DIY 2004-#3 issue.] API has a handy guide you can download at http://api-ep.api.org/filelibrary/API_MotorOilGuide_2004.pdf for reference the next time you purchase oil.

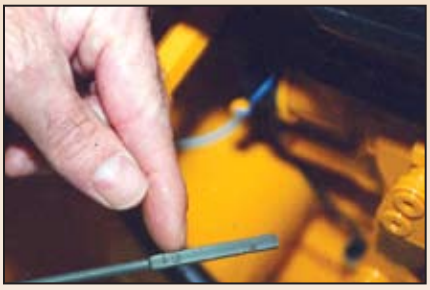
The soot byproduct of incomplete diesel fuel combustion is what turns the fresh oil black almost immediately. This doesn't necessarily mean that the oil is worn out or that your crankcase is full of sludge. However, oil does wear out as additives and detergents are gradually used up. Consult your owner's manual for the appropriate interval for oil changes. This is especially important if you cruise to other countries where high sulfur content fuel is available. In no case, leave the boat for the off-season without changing the oil and oil filters.

Oily Solutions

The easiest way to change your oil is to pump it out of the dip stick tube. Some engines have been modified with a sump plug (Manufacturers have been known to completely void warranties when this is done). Draining from the sump works provided you can fit a sufficiently large basin under the sump drain and extract the basin when full of hot oil without spilling it all over the bilge or cabin sole!

I've pumped oil from the sump with an electric drill fitted with an attachment for the job and also drained oil from the sump but a simpler and more successful tool is a vacuum pump. I modified a brass barreled PAR pump sold at most well-stocked marine stores (**Figure 1**). Adding stainless-steel hose clamps prevents the pump from coming apart in my hands on the first stroke. Clamps are also used on the barrel as well as each of the tube adapters and tubes. [Ed: My preference is one of the Pela Oil Changers and although somewhat more expensive, the powerful vacuum created by these pumps can suck out a crankcase in minutes with just a

Figure 1
Hose clamps secure tubes on author's modified PAR oil change pump to prevent spills.



(top) Pour a quantity of oil into the engine crankcase, checking the dipstick as you add more oil. (bottom) Add more as needed until you detect the oil level at the "full" mark, as shown by the top notch on most dipsticks. Don't overfill!

few strokes of the handle. Fully self-contained, the oil collects in the container for disposal later, a detail that reduces spills and saves looking for collectors.]

Every oil change begins with a warm engine. Warm oil flows more readily, making it easier to pump out. Idling at the dock doesn't do the trick, especially in cooler temperatures as engines require a load to raise operating temperature. A 30-minute cruise gets the engine oil hot and eliminates any residual moisture inside the engine. Back at the dock, turn off the engine and immediately start the oil change procedure.

To do this using a vacuum pump, stick the discharge tube into a container [not needed with the Pela unit]. Be sure it's secure so it's doesn't slip out while you pump. Remove the dipstick and set it on a clean paper towel. Insert the pump's tube into the oil sump just far enough so that you hit the bottom of the sump, then start pumping slowly. Wrap a rag around the brass barrel of the PAR pump because it gets hot from the oil. [Ed: Again, this isn't a problem with the hands-free Pela.]

DIY's editor prefers the line of self-contained, hands-free Pela Oil Changer. About 10 or so strokes is all it takes to transfer hot oil into the built-in canister.

No matter what your engine manual says the oil capacity is supposed to be, you will never get that much out. A small amount of oil remains trapped in oil galleries, baffles in the oil pan and in the oil filter. Don't worry about it. You have most of the dirty oil and crud in the container.

Pour the recommended amount of new oil into the oil fill pipe, filling it to the oil level mark on the dipstick. After a few changes, you will learn how much oil is required after each

change but still check the level each time. Don't overfill the engine with oil! Every engine manufacturer provides the details on how to determine the proper mark. Again, check your engine service manual. It's really an essential reference to have aboard. Remove the old oil filter and install a new one. I strongly recommend using only OEM filters. Consult your owner's manual for specifics. Tidy up and you are done for another year or, if you are fortunate enough to be cruising, for another 100 hours. (Ed: Keeping a clean environment demands that we dispose of all petroleum wastes in an approved manner. Most marine facilities have containers for used motor oil, which can be recycled. Check for local requirements for disposal of oily rags and paper products, which are flammable and polluters.)

Remember the Tranny

When was the last time you checked the transmission fluid? Many boaters admit that they rarely check it, one reason being that the transmission is buried behind the engine. Every transmission manufacturer has its own lubricant specifications and methods of checking the fluid. Some transmissions use the same lube oil as does the engine itself, but others require automatic transmission fluid. Generally, you'll find the specified oil displayed on the transmission label. If you're unsure about the procedure, invest in an hour of "hand holding" time with a patient mechanic. Tape record the session and then transcribe the discussion in your engine log.

Change the transmission oil immediately if it's dirty or smells like something has been burned. Your owner's manual tells you how often to change transmission fluid and roughly how much is required. Pump the old fluid out of the transmission crankcase dipstick tube using an oil pump of your choice. Again, carefully refill the transmission to the proper level. Some transmission dipsticks are extremely difficult to read, especially when you are refilling with clean fluid. You will undoubtedly utilize some salty language during this process. Yelling doesn't really help much but it does blow off the human steam. So you can see the level more easily, dab a clean, dry dipstick with a permanent marker at the full mark.

Check Rates

I always check critical fluid levels, engine and transmission oil and antifreeze (closed-cooling systems only) before leaving the dock and check battery water levels at least twice a month during the hot, summer months. I'm always amazed to see how much distilled water is required when the weather gets warm. Additionally, excessive water consumption is a symptom that you may be over-charging your battery banks.

Audible Alarms

One of ideas from the book of "bad ideas" is to add a special temperature or oil pressure gauge and remove the audible alerts. There is virtually no chance that you'll be watching the gauge when a plastic bag clogs the raw-water intake or a loose oil filter empties all the lube oil into your bilge. A loud, audible alarm is essential. Alarms sound when you first turn the ignition switch to the "on" position before the engine cranks over. After all, you have no oil pressure if the engine isn't running. Make a distinct effort to listen for the alarm prior to cranking the engine. After the engine starts, consciously listen carefully to be sure the alarm quits sounding. If you cannot hear the alarms with the engines running, install louder alarms.

Dipstick removed from engine oil crankcase indicates empty and full levels.

No Magic Solution

Don't even consider adding additives or anything else that comes out of a can to your oil before consulting the engine manufacturer or your owner's manual. If the oil producers thought there was something that would improve the oil, competition would soon force them to add it (assuming the government doesn't forbid it). Likewise, if the engine manufacturer wanted you to add some of "Uncle Willy's Magic Dust" to the lubricating oil, you had better believe that it would specify so in the manual. There is nothing you can pour out of a can that will cure a sick engine!

About the author: Lee Mairs is a graduate engineer and a retired Navy commander who holds a USCG 100-ton ocean operator's license for both sail and power.

Line notched into transmission crankcase dipstick denotes "full" mark as shown by these (top) Yanmar and (bottom) Vetus dipsticks. Transmission oil level is critical. Over full usually causes foaming and a leaky transmission. When checking levels, bring the engine up to operating temperature, then shut down and check immediately before the oil settles back down from the oil cooler and lines. Level should be at the full mark at this time.

ELECTRICAL

A Practical Approach to **Electrical System Troubleshooting**

You don't have to be an electrician to test your boat's AC or DC electrical components. With a few simple tools you can diagnose problems as they occur and fix them yourself.

By Jan Mundy

Multimeter substitutes for measuring voltage: (left to right) non-contact Volt Check, non-contact Live-Wire, AC receptacle tester and AC dual lead probe continuity tester.

Simple to use tools for measuring current: (left to right) clamp-on meter, and two tone generators, the Wire Tracker and Circuit Tracker.

There comes a time when every boat owner will need to install or reinstall or service electrical equipment. If, like me, you're not electrically adept, electricity is a mysterious force. Though I completely wired my own boat, appreciatively assisted by an electrical engineer, with barebones power systems when compared to the complex arrangements on many of today's boats, electricity's most basic concepts continue to elude me. Using an analog (VOM) multimeter requires referencing the instruction book. A multi-function, multiple range digital (DMM) exceeds my electrical acumen entirely. Am I measuring voltage or resistance? Where do I set the function switch? The wrong setting might blow a fuse or melt the leads. Although a multimeter is the most common tool used to measure electrical activity on an electrical device, I'm an advocate of the right hammer for the job and I've discovered other simple tools that the electrically challenged can use to evaluate electrical systems.

Before we look at some of these tools, a word of caution. To reduce the risk of personal injury or death from electrical shock, you must follow a few simple rules. Never work on a live circuit unless you are absolutely sure what you are doing. Disconnect the positive cable from the battery terminal and, if equipped with AC power, unplug the boat's shorepower cord from the dock power supply. Severe, life-threatening shock can occur if you're not careful. Wear rubber soled shoes and never stand in water or on damp ground when taking measurements. If possible, use one hand when taking a measurement and place the other hand in your pocket so you don't become a human circuit conductor. Before using any electrical testing equipment, you need a clear understanding of the basic parameters as outlined below. Though compliance with ABYC standards is not mandatory, you'll get better performance from and additional confidence in the safety of your electrical system if all wiring on your boat is in accordance with these standards. (Refer to page 12 in this issue for an explanation of ABYC standards).

Fundamentals

An electrical circuit consists of voltage, current, resistance and continuity. To better understand these basics; let's compare the flow of electricity to water flowing through a hose or pipe. In this analogy, voltage is the amount of pressure at the hose ends, current is the water flowing through the hose and resistance is the diameter of the hose (**Figure 1**).

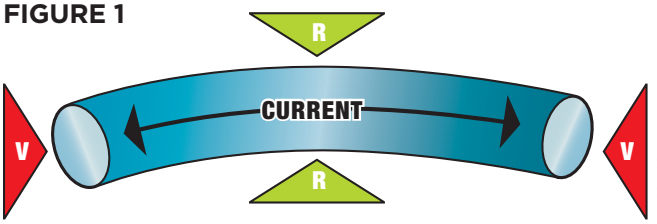
Voltage is the amount of electrical "pressure" it takes to push current through an electrical cable or wire (i.e., a conductor). To measure water pressure, a gauge inserted into the hose compares the difference between hose pressure and atmospheric pressure. Named after Italian physicist Alessandro Volta, who pioneered the battery, voltage is measured in the same way, except the reference point is negative (ground). Voltage can be either AC or DC and is usually measured at a receptacle (AC) or the electrical distribution panel (DC).

As water runs from a main delivery pipe into a residential house it passes through a water meter that measures the water flow rate. The amount of electrons (or current) flowing through a AC or DC circuit is measured in amps or milliamps (1,000th of an amp). Named after André-Marie Ampère, a French physicist who, in the early 1800s, co-discovered electromagnetism, one ampere equals 6.5 billion-billion electrons flowing through a wire every second. Do the math for a 20-amp circuit and there's mega energy here.

If the flow rate (current) is measured as water flows (amperes) through a hose at a regulated pressure (voltage),

resistance can be calculated. Similarly, electrical resistance is the amount of friction in a wire or circuit, typically stated in ohms. The relationship of current and voltage in a circuit is known as Ohm's Law, named after 19th century physicist Georg Simon Ohm. When all components in a water hose are properly attached, there will be no leaks but a loose hose clamp or broken soldered joint that creates a drip breaks

FIGURE 1



Joe VanVeenen

Electrical energy can be compared to water flowing through a hose where voltage (V) is equivalent to the amount of pressure at the hose ends, current is the equivalent of the water flowing through the hose and resistance (R) is the equivalent of diameter of the hose.

the water flow. In the same way, an uninterrupted electrical flow, which exists when connectors, terminals and wires are properly connected, makes a complete circuit. This is known as continuity. There is no continuity if any component does not make a good connection.

Fault Finding

Using a variety of measuring tools you can check the condition of a circuit, trace wires, troubleshoot and problem solve. Voltage is the most common measurement made with electrical testers. This is measured on an AC or DC energized circuit and typically at a receptacle or electrical panel. For voltage checks, either to detect the exact level or that it's present, there are various inexpensive, simple to operate dual probes, non-contact probes and voltage-continuity testers.

To determine if voltage is present in a circuit, the simplest devices are the common contact probes. For AC testing, a three-prong device plugs into a live receptacle to test for proper wiring (polarity and ground). A dual-lead probe simply lights up to confirm the voltage. Since these tools only show the presence of voltage and don't actually measure the exact value, they have limited use.

Measuring battery voltage with a digital clamp-on meter.

Dual-lead probe simply lights up to confirm the voltage.

When Live-Wire senses AC voltage in a shorepower cable, the red light glows and speaker chirps.

Non-contact voltage testers have a greater use than probes onboard a boat and, since they don't require contact with a live conductor, they protect the user from potentially dangerous voltages in high-power circuits. Two products that are popular electricians' tools are Circuit Alert and Live-Wire. Easy one-hand operation, just hold the sensor tip against an AC wire or power cord or electrical device and, if voltage is detected, the LED glows and a chirp sounds. An extra feature of the Live-Wire is a sensitivity adjustment wheel. At maximum sensitivity, this tester can read up to 8" (20cm) away, making it ideal for tracing live wires behind bulkheads (except metal-shielded wires).

A more advanced voltage tester is the multi-function Volt Check. What's nice about this tool is that it's totally automatic. The non-contact sensor detects both AC and DC voltage without having to set a function switch and there are both visual and audible signals when voltage is present. For non-contact testing, just touch a conductor with the sensor. Let's assume that a bilge pump no longer works. You first ensure there's voltage at the switch and then reach down into the bilge and touch the wires with the sensor. If there's no voltage reading, then there is a loose or broken wire between the switch and the pump. The only downside of this tool is that it reads voltage in increments, an important consideration if, for example, you need to know the precise voltage of a battery. Volt Check also indicates the presence of continuity. To check continuity of a fuse, place a lead on each fuse end. If the fuse is good, the tester beeps.

Current measurements are made easily and without contact with live circuits by using a clamp-on meter. For the DIYer looking for one tool does that it all, Ancor's digital clamp-on meter, also available in an analog version, measures AC/DC voltage to 600 volts, AC/DC current to 1,000 amps, tests continuity and has a data hold button that's invaluable when clamping in tight areas with restricted visibility. This tool safely and conveniently measures current going through a wire. To use, set the dial to the amps scale, select AC or DC and open the jaws. Simply clamp the jaws around either the positive or negative wire and it takes a reading without making contact with live conductors. Since current in equals current out, it doesn't matter which wire is clamped. When testing cable where wires are bundled together, you cannot clamp around the entire cable or you'll get a zero reading. A line splitter is used to separate the wires in an AC circuit. It plugs into a receptacle and then the AC appliance (hair dryer, blender, etc.) plugs into the splitter and the clamp meter reads current off the splitter.

To read the current passing through a DC switch, set the function switch to "A" for amps then clamp it around the positive or negative wire. To check how much current is flowing into a battery, clamp the jaws around a battery cable. The clamp meter has test leads so it also operates as a voltmeter in much the same way as a traditional multimeter. For voltage checks, set the dial to the appropriate AC or

Basic Troubleshooting Steps

All diagnostics follow a step-by-step approach. First verify the complaint, eliminate all possibilities, fix the problem or have it fixed, then verify again. Troubleshooting any electrical system follows a similar process. First, eliminate the obvious by checking battery voltage, fuses and circuit breakers. One of the most common faults is a blown fuse or tripped circuit breaker. Next, check the continuity of all circuits. A complete (closed) circuit should read zero ohms. Now, measure the voltage at pumps, electric drive motors (e.g., windlasses, bow thrusters), blowers (e.g., bilge blower) to ensure that they are within 10% of the voltage stated on the device's label. Using the clamp-on meter, clamp the jaws around either the positive or negative wire, to measure the current that the motor draws.

DC voltage setting and then place the leads across the circuit under test. Another useful application of a clamp meter is to measure voltage drop. Using the ABYC rule of thumb for voltage drop of 3% for critical electrical equipment such as bilge pumps, navigation lights and instruments and 10% for non-critical gear, first turn the electrical device(s) on and then clamp the wire and read the voltage. Where multiple devices connect to a single fuse or circuit breaker, apply power to all electrical devices on the circuit and then take a measurement.

Reading Resistance

Loose connections, undersized wiring, corroded or feebly crimped contacts all create friction in a wire or circuit. Always disconnect power to the circuit or device before measuring resistance. An inexpensive continuity tester uses its internal batteries as the circuit and beeps or lights up if there's continuity. It's a simple tool to check fuses, light bulbs, power cords or switches. A very easy check of a rocker or toggle switch, for example, is to lay the tester's tip across the two terminals at the back of the switch. As you flip it on and off the tester light should go on and off. If it stays on in both positions, the switch has a short. If no light shines, the switch isn't closing, probably due to a broken contact. The Volt Check operates in the same manner, except it uses leads and beeps on and off.

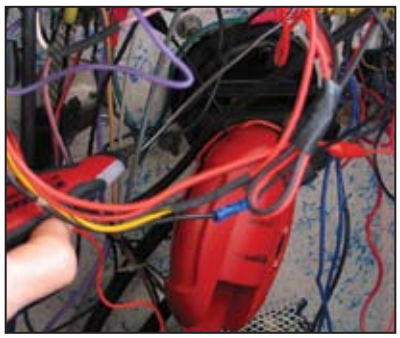
Beeper sounds and continuity light illuminates to show that resistance is low.

The handy clamp-on meter also measures resistance. Unlike a continuity tester that only identifies the presence of continuity, the clamp meter reads the exact amount of resistance in a circuit. A simple use of this function is to verify that a light bulb is burned out. Set the dial to the ohms position and short the test leads together while turning the zero ohms adjustment dial until the display reads zero. Put one lead on the bottom on the bulb, the other on the metal side of the bulb. If the reading remains at zero, the bulb is

good. Another resistance check might be a bilge pump that no longer runs. With the power disconnected, place the lead wires, positive (red) to the pump's positive wire and the negative (black) to the negative or ground wire. A reading of 1 means there is a short in the wiring or terminals.

Wire Locator

One of the biggest stumbling blocks encountered when problem solving is that few boats have wiring schematics and labeled wires. Instead, there's a distribution panel with numerous circuit breakers and a rat's nest of wires. How do you isolate a single cable run in this mess? A smart tool for this task is the Wire-Tracker tone generator. This tool consists of a transmitter, receiver and five adaptors for connecting to wiring devices, including a coax plug for coax cables (e.g., antenna cable). By sending a low-voltage current through unenergized wires (you must disconnect the power supply), it easily traces the wiring.



Wire-Tracker transmitter clips to the wire to be traced and a ground, and generates a tone along the wire that is detected by the hand-held receiver's probe.

Let's use an example of the installation of additional cabin lighting where you want to splice into the existing wiring for new reading lights in the berth area. First, disconnect the power supply. Connect one alligator clip to a suitable ground and connect the other clip to the wire you need to trace. Turn on the transmitter and set the volume on the receiver probe to max. Depress the probe's power button and touch the wires or cable with the tip. Pass the probe over the wires and adjust the sensitivity level until a tone is heard. The target wire is the one with the loudest tone and with brightest LED. To check a problematic antenna,

Additional Reading

DC Electrical Systems CD-ROM

This updated version includes many articles not found on the previous version including: sizing battery capacity, charts for calculating electrical loads, a review of systems monitors, high-output alternators, selecting and installing solar, wind and water power, wiring new electrical panels, inspecting DC bonding systems, troubleshooting engine electrical systems, easy-to-make battery cables, battery selection installation and maintenance, battery combiners and more. Articles written by marine electricians and consultants and previously published in DIY boat owner Magazine *will guide you in the maintenance, upgrade and troubleshooting of your boat's electrical system in a step-by-step approach with clearly detailed photos and illustrations. All articles follow ABYC Standards.*

connect the coax adaptor to the corresponding antenna plug and touch the cable end with the receiver. If you don't hear a tone, it probably means you have a break or a poor connection somewhere.

Another useful tool is the Circuit Tracker. This tool locates which AC circuit breaker supplies an AC receptacle on an energized circuit. A transmitter inserts into the receptacle and sends a low-level pulsating current to a receiver with a probe that's passed over the breakers. The highest signal and loudest beeping identifies the corresponding breaker.

Reading Temperature

A few years ago, I attended a seminar at IBEX, the boatbuilders' trade show held annually in Miami Beach, Florida. The presenter, Ed Sherman, a marine electrician, ABYC staffer and author of several marine technical books, suggested using an infrared temperature sensor to source electrical problems. As resistance is the amount of friction in a wire, the byproduct of too much resistance is heat. Loose connections, too small wiring, corroded or feebly crimped contacts or an overloaded bus bar all generate heat. To check a cable or conductor, apply power to the circuit and simply point the sensor at the conductor at a distance 6" to 12" away (15cm to 30cm) and read the output. Ed uses a figure of 25F (3.8C) above ambient temperature as a guideline. A temperature reading above the median suggests a problem. Radio Shack sells an infrared temperature sensor for less than US$45.

Bottom Line

Check approval markings and the voltage rating stamped on the tester and don't exceed them.

A small investment gets you a good selection of tools for doing basic electrical troubleshooting. Testers from Ancor, GB Instruments and Sperry start at US$10 for a simple continuity tester and up to US$100 for a more expensive, multi-function tool. To protect users, testers are rated into four classifications. Most of the testers mentioned in this article have a Cat III rating or maximum 600 volts. Another rating is True RMS or true-root-mean-square. All this means is that the meter provides more accurate (30% is claimed) readings when measuring the voltage and current of modern electrical devices.

As boats become more sophisticated with complex networks of electrical equipment and instrumentation onboard, having the ability to troubleshoot electrical problems without calling an electrician becomes increasingly important to save money and downtime. These electrical testers banish the mystery from effectively troubleshooting electrical and electronic gear, simplifying problem solving for the DIY electrician.

About the author: Jan Mundy is editor of DIY.

Idle Quality

Maneuvering in close quarters demands full control of your boat to prevent stalling when shifting gears through the full engine rpm range. Follow these tips to keep your sterndrive idling smoothly.

By Steve Auger

Corroded ignition components, in this case a distributor cap, causes the engine to labor resulting in poor idle quality and engine stalling.

Here is a not uncommon scenario on a boating vacation cruising the inland canal systems. As you approach the locks in your boat, you see that there is a crowd of boats waiting to enter the locks. To top things off, there is a crosswind and there isn't a lot of room to maneuver. As you slow to an idle to maneuver into the last space on the seawall, your engine stalls. You try not to panic and, if you're lucky, you may get the engine restarted and regain control, but everyone else rushes to fend off your boat. The only real damage is to the boat owner's confidence as seen by the red face of embarrassment from the stalling incident.

A marine gasoline engine must have a smooth and steady engine idle in order to prevent stalling while shifting from neutral into gear, especially when the engine has just been started and the operating temperature is below normal. A dependable engine idle is achieved by synchronizing a group of correctly functioning engine systems. These systems include the crankshaft and pistons, cooling system, valve train, ignition timing, carburetion or fuel injection, exhaust system, transmission and drive line. Starting with the basic maintenance and a qualification of systems that a gas engine requires to idle will dramatically reduce the chance of stalling.

Vacuum Check

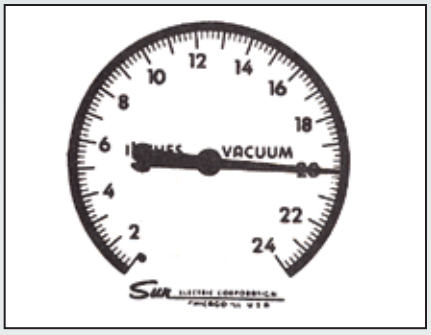
Most sterndrive engines employ a shifting system that uses shift cutout switches that interrupt the ignition system or drop the rpm to assist shifting. The sterndrive intermediate shift cable can fail and cause a stalling condition that is not related to idle quality. Verify that this sticky shift cable is not the source of stalling.

Using a vacuum gauge is by far the fastest way to determine the state of health of a gasoline engine. Connect a vacuum gauge to the intake manifold and, with the engine at operating temperature, advance the throttle to 1,000 rpm and note the movement of the vacuum gauge needle. The needle should be steady and read a value of 15 to 21 inches of vacuum (in/hg). If the needle is not steady, compare your values to the values on the chart and make the recommended repair.

Fuel and Air Mix-up

Poor fuel quality, inadequate air flow and a bad air-fuel ratio are the three primary causes of poor idle. Of course, this assumes that you have all the basics covered under maintenance, such as a good alternator, battery and battery cables and the engine has regular tune-ups including fuel filters, ignition components, water pump impellers, fluids and fluid filters.

Poor quality fuel is often the cause of poor engine performance at idle and throughout the entire rpm band. For this reason, always perform tests on qualified good fuel. For testing, fill a 5 gal-



With engine at idle, you can identify possible engine malfunction at a specific vacuum reading. To view a readable pdf of a vacuum– gauge troubleshooting chart, click here.

lon portable gas tank (the type used for small outboard engines; not a Jerry jug) with fresh fuel and connect the fuel supply line to draw from this remote tank. With the engine and battery switches turned off, remove the onboard tank fuel line from the fuel pump or filter on the engine, insert a plug in the hose and secure it with a hose clamp to prevent fuel leakage. Make sure the plug is barbed (not threaded or knurled as these can provide a path for fuel leakage) and secure it with a hose clamp. Connect the remote tank line to the engine and secure it with a hose clamp. Again, make sure any fittings you use in making these connections are barbed type, not threaded or knurled and that you are using approved type hose (per ABYC standard H-24, Gasoline Fuel Systems). Be sure to route the hose away from

Mechanics use a scan tool to read engine faults in EFI engines.

moving engine parts before starting the engine.

Some possible causes of restricted air flow are a lack of engine compartment ventilation, dirty flame arrestor, broken water shutters, collapsed mufflers or exhaust hoses and bellows. Check engine compartment vents and hoses for blockage from seawater and debris. Clean flame arrestors annually. Mufflers, water shutters and exhaust hoses need close inspection every 300 hours or three years. Always carefully inspect exhaust system components for damage after a major overheat or cooling system failure. (For tips on preventing engine overheating, refer to "Cool Running" on page 53.) Well maintained engines run well over 1,000 hours before they start to feel the effects of valve train, timing chain and gears and piston ring wear resulting in lower vacuum readings. It's possible to have the valves replaced and new seats cut in the head, which improves performance, but be aware that replacing the valves and not replacing the crankshaft or piston parts puts excess strain on the older bottom end of the engine. I would advise against replacing valves only.

In order to perform at maximum efficiency, all gasoline engines require a 14.7 to 1 air to (vaporized) fuel ratio. A dirty, leaky or maladjusted carburetor, leaking fuel pump (via the yellow sight tube), incorrect operating temperature and poor air flow all contribute to bad air-fuel ratio. Electronically fuel-injected (EFI) engines should be scanned for faults and have the coolant sensor, map sensor and throttle position sensor checked for accuracy as part of the annual maintenance. Because we don't operate our boats on a daily basis, the carburetor tends to become gummed up with the additives in today's gasoline. Adding fuel stabilizer to the fuel tank (check the label for the proper ratio) throughout the boating season dramatically reduces the accumulation of additive residues in the carburetor. Check the yellow sight tube that runs from your fuel pump to the carburetor. Droplets of gasoline there indicate the fuel pump diaphragm is leaking and the fuel pump needs replacement.

EFI engines normally have excellent idle quality due to electronic control of idle air delivery and ignition timing but ignition base timing may have to be verified before the computer can do its job correctly. There is a special procedure for setting EFI engine base ignition timing found in your service manual. Idle air control valves need to be removed and cleaned (spray carb cleaner works fine for this) about every 300 hours. If you still have idle quality issues, there may be an electronic fault causing the poor idle. A scan tool is required to read engine faults. See a dealer if you don't have your own scan tool. Most carbureted engines built after 1989 have intelligent ignition systems that require a special timing procedure before ignition timing and carburetor adjustments can be made.

Air-fuel ratio is measured at the proper operating temperature. An engine that does not operate at the correct temperature is incapable of reaching the 14.7 to 1 air-fuel ratio. Cooling systems must ensure the engine operates at the correct temperature, usually around 150F (65C) for carbureted engines and 170F (76.6C) for EFI engines. The thermostat sets this operating temperature. Never run the engine without the correct thermostat as this causes

the engine to run cold, which in turn causes cylinder wash down and premature engine failure. Engines that run too hot at idle may have a lack of water pressure, which also affects engine idling performance. In order to verify the pressure of the cooling system on most seawater cooled engines, install a 0 to 30 psi gauge in one of the block drains and run the motor, observing the block water pressure on the gauge. For closed-cooled models, measure the seawater pressure using the same gauge but installed in the drain of the heat exchanger on the seawater side. Seawater pressure values should be no lower than 1 psi or 2 psi at 1,000 rpm.

IAC Values

For sterndrive engines built before EFI and intelligent ignition (1988 and prior), there is usually a 150 rpm difference between neutral and in-gear. If you find that your rpm drop is significantly higher than this, you may have a driveline component that is dragging down the idle rpm. These can include sterndrive gimbal bearings and internal drive failures, transmission, stuffing box, prop shaft and cutless bearing issues. On water-cooled stuffing boxes, verify there is adequate water being supplied to the stuffing box. More than once I have found 75' (22.8m) of nylon rope wrapped around the propeller and shaft. This causes a number of performance problems, including stalling.

EFI engines should maintain the same idle rpm in neutral and in gear and can also suffer from drive line problems that cause stalling. The idle air valve (IAC), a computer-controlled electronic valve on EFI engines only, controls idle speed by changing the air introduced to the intake manifold. The IAC adjusts the engine idle to its highest point when the engine is cold. More air equals a higher idle speed; less air means a lower idle speed. An engine that drops rpm after shifting into gear has a very high idle IAC value. This indicates something is trying to drag the engine down and the engine likely requires servicing. A normal IAC value on a warm engine is 15 to 40 counts (a small amount of air). An engine with a drive line problem will have a high IAC value such as 100 counts. Additional air is being electronically added to overcome drag caused by the drive line component failure. The obvious repair is to identify the drive line component that is trying to drag the engine down and repair or replace it.

Idle air valve location on a multi-port injected engine.

Idle air valve location on throttle-body injected engine.

To check operation of the idle air valves (with a cold engine), turn the key to the "on" position to initialize power to the engine but not to start it. This sets the IAC at a maximum air condition. Now unplug the IAC electrical connector, start the engine and let it idle. Engine rpm will increase to 1,000 rpm as the engine warms up. After 5 minutes, reinstall the IAC electrical connector without shutting off the engine. When functioning properly, the IAC raises a cold engine to around 1,000 rpm and, as it warms up, the IAC slowly closes reducing the idle rpm until the engine is at operating temperature at which point the idle drops to 600 rpm. The IAC also allows more air during engine deceleration to help reduce the chances of stalling. If the IAC seems to be inoperative, it may just be covered with unburned fuel deposits and dirt. Remove it and clean with carburetor/choke cleaner and reinstall.

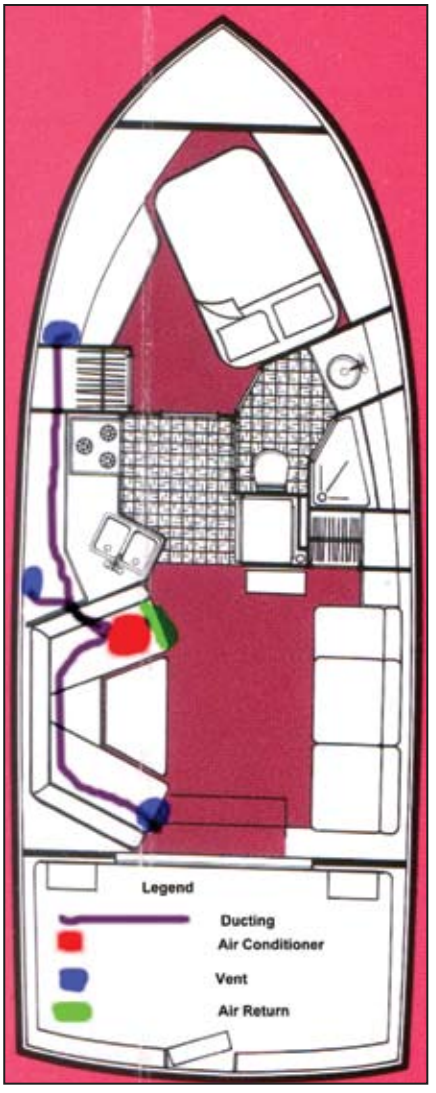
It's imperative to have full control of your boat at all engine rpm ranges in order to maneuver in tight spaces. Follow these procedures to improve your engine's idle performance and end stress over engine stalling.

About the author: Marine mechanic and DIY's engine technical advisor, Steve Auger, has more than 35 years experience in marine retail and manufacturing, mostly with Mercury Marine. A competitive boat racer in his younger years, he now races a Formula car.

Climate Control

Escape the summer heat with a do-it-yourself installed air conditioner. Include the heat option and the chilly spring and fall nights won't keep you off the water.

Story and photos by Murray Abbott



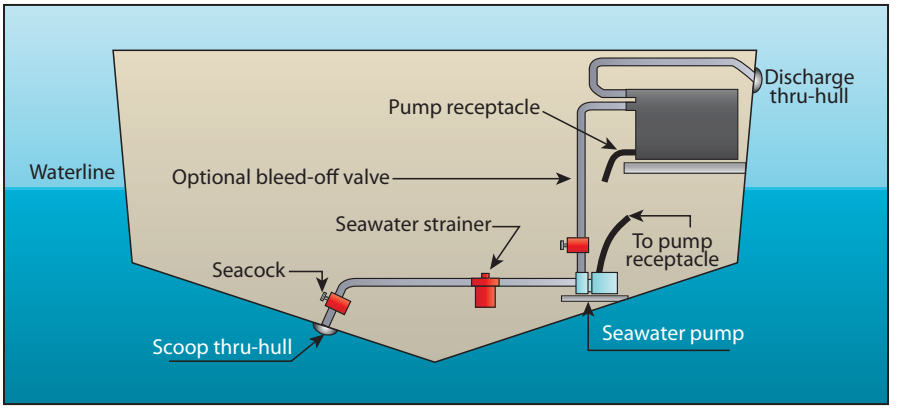
Planned installation superimposed over cabin layout.

For some time now my wife and I had been considering an air conditioning system for "Orca" our 1988 32' (9.7m) Carver Mariner. After some research, I found that there are basically two choices available: straight air conditioning or an air conditioner with a reverse cycle heat (heat pump). We spend as much time on our boat as possible since the boating season in the Great Lakes is so short. The cool mode would make the boat more liveable in the hot sticky days of summer and the heat option would give us the ability to extend the season.

A few years ago in early summer we traveled to a few local boatyards to get quotes on installing an air conditioner. The first yard laughed and told us to come back in winter, another sent a fellow to our boat to take measurements and discuss options but we never heard from them again and they did not even return calls. We did get a quote for $12,000 plus extras from another yard, which I thought was outrageous.

This negative experience prompted me to look into installing a system myself. This involved doing research at boat shows and on the web and visiting similar boats already so equipped to examine how and where the air conditioning equipment, ducting and vents were located. We located boats like ours that had air conditioning and the owners, strangers to us, were pleased to show us their installations and share their experience .

My quest led me to a reverse cycle (heat pump that could heat or cool air), 16,500 BTU air-conditioning unit from Mermaid Marine Air (www.mermaid-marineair.com) that seemed designed for a do-it-yourself installation. This unit produces 16,500 BTU in cool mode, enough to cool a 40' (12.1m) cruiser or 45' (13.7m) sailboat, and 18,000 BTU in reverse-cycle heat mode. Since our boat only has one 30-amp shore-power inlet, power consumption was critical and this unit operates at 12 amps on the cool cycle plus one amp for the standard seawater pump and 13.5 amp on the heat cycle. (Multiply the operating amperage by 1.8 to calculate the startup amperage.) Physical size of the unit was just as important as we had only a small space to put it, as was matching the BTUs for our boat size and, of course, ease of installation.



Schematic of M16 air-conditioning system installation.

Mermaid's M16 is the company's largest air conditioner. Made of stainless steel with all electrical parts standard being refrigeration components readily available anywhere, this self-contained unit arrives prewired and precharged. Mermaid recommends at least three air supply grills for this unit, two for the 4" round (10cm) ducts and one for a larger rectangular

Installing an air-conditioning unit with reverse-cycle heat converts the author's fair weather boat into a comfortable, off-season cruiser.

Measuring on the same and similar cruisers helped to determine the best mounting location on the author's boat.

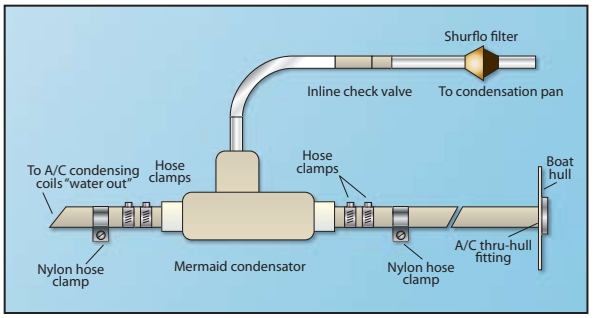
duct. There is an 11" by 14" (28cm by 35cm) air intake as well. Install kits are optional and contain all materials needed to complete the installation. I opted for the more expensive Deluxe Kit with teak vents instead of plastic. After all, I'll be looking at this for a long time. I did need to buy an extra 6' (1.8m) of ducting and one 90° elbow for the plumbing. Another interesting option Mermaid offers is a device that takes the condensation created by the air conditioner and channels it into the water outflow of the air conditioner. Other air conditioning models drain this condensation into the bilge where it's removed by the bilge pump. I prefer a dry bilge so I opted for the device, which turned out to be very simple to install.

I went to our local chandlery to order the unit but the Deluxe install kit seemed to be a problem so I then visited a new West Marine store in downtown Toronto and spoke to Larry Slivinski. Larry helped me with everything that I needed. He even called Mermaid to get a few installation tips and volunteered his assistance if I ran into a problem. Service like that is hard to find these days in many chandleries.

Fortunately, the unit fit cleanly in a dinette seat locker with only few modifications.

As with all component installations, the first step was to determine where to mount the unit. We established (from our boat visits) that air conditioners for our boat were normally installed under the dinette seat. This would involve removing access panels to allow installation of ducting, wires and plumbing. We also found places that were already cut out for the ducting. Certainly, it's best to do a thorough inspection before starting.

Installing an air conditioner involves several major tasks starting with the plumbing and then on to ducting, electrical, installing the unit itself and finally, sealing the air conditioning compartment and as we discovered later, noise proofing it.



Plumbing schematic of Mermaid condensator.

CAUTION: Read Me

Air-conditioning systems can be a killer if carbon monoxide (CO) is carried with the ducted air and ignition protection becomes critical if installing a unit in an engine room (gasoline only). No air-conditioning installation should ever be commenced without first referencing two important ABYC standards that relate to the hazards of CO and ignition protection. ABYC standard A-6, Refrigeration and Air-conditioning Equipment, states: "6.7.1.1 To minimize the potential for migration of carbon monoxide from machinery compartments containing gasoline engines to adjacent accommodation compartments, bulkhead and deck penetrations shall be in accordance with the requirements of ABYC H-2, Ventilation Of Boats Using Gasoline; 6.7.2.1 Electrical components shall be installed and electrical connections shall be made in compliance with ABYC E-8, AC Electrical Systems, and ABYC E-9 (now combined as E-11)." ABYC also publishes TH-22, Educational Information About Carbon Monoxide, a free technical information report that can be downloaded from www.abycinc.org.

There is no way this article can adequately cover all the compliance recommendations that affect each boat and equipment combination. By its nature, air-conditioning impacts the atmosphere inside the boat and all who inhabit that space. Be careful. Ignorance about CO and ignition protection issues can be fatal.

— Jan Mundy

Step 1 Plumbing

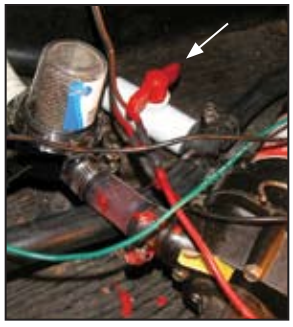
I didn't want a long hose run between the thru-hull and the air conditioner so

Water strainer mounted outside on the hull conceals the thru-hull.

Another thru-hull installed for the water outflow.

Location of (top) pump in the bilge and (bottom) water strainer on a nearby bulkhead.

(top) Below-the-waterline thru-hull connects to a ball valve, though a seacock is the preferred installation. (bottom) Same fitting visible in right foreground as well as the maze of ducting, hoses and pumps.



To prime the water pump, an inline bleed off tee-valve connects to the hose after the water pump. Since the pump mounts below the waterline, this valve is opened only when needed.

(across) Countertop cutout for larger air intake grill. (middle) Large cutout in front seat bulkhead for the return air grill. (bottom) Cut out in the countertop for one of two supply ducts with the other one installed in the forward cabin.

we found a spot for the thru-hull and valve below the salon floor. It's best if the hoses go uphill from the thru-hull to the air conditioner to eliminate air locks. I'm especially concerned about putting holes in the bottom of our boat but, by following instructions in previous DIY issues, this task was easy and fast. After drilling the hole, the thru-hull was bedded in lots of 3M 5200 adhesive sealant.

Next, we installed the water pump and this was very easy. A few screws to hold it in place, attach a hose from the thru-hull to the pump and route the electrical wire back to the air conditioner's electrical box. A bleed off valve primes the water pump and prevents water from siphoning in from the thru-hull. We mounted a seawater strainer on the bulkhead. We routed the hoses to and from the pump to the strainer and then to the air conditioning compartment. Next, we drilled yet another hole in the hull for the outflow above the waterline.

To install the condenser, we spliced the water out hose between the air conditioner and the thru-hull, inserted a tee fitting and a length of hose. Next, we connected the metal condenser supplied in the kit to the hose. We attached another hose to a one-way valve and filter and then another hose to the bottom of the condensation tray.

Step 2 Ducting

Ductwork was the most difficult, messy and time-consuming job. There was lots of cutting through fiberglass and wood, one obstacle after another, to route the ducting. Cutting the fiberglass was most easily done with a router but the itchy fiberglass dust was really irritating. We made the job more bearable by resting the hose end of a small shop vacuum beside the cutting bit to control the dust. I wished we had cut our first hole using this technique. When cutting holes in your interior for the grills there is no second chance. It's best to be 200% sure first and my wife had the final say on making those cuts.

The instructions that came with the unit suggested limiting 90° turns in the ducting to few or, better yet, none, as these restrict airflow. With the space that we had to work within, this was a very difficult constraint. I found some areas on the boat that were already roughed in for ducting and that saved lots of time in places behind cabinets.

(across) The boatbuilder had roughed in passageways for the ducting. (right) Other areas were less accessible, making it difficult to run ducting in a straight line.

Combined DC and AC power systems' electrical panel.

Thermostat installed.

Mission accomplished.

Step 3 Electrical

The unit comes with an electrical accessory box that mounts within a few feet of the air conditioner. The thermostat, air conditioner and the water pump all plug into this box. It's wired with 12/3 gauge marine cable to a 20-amp breaker in the boat's main AC panel. As the electrical panel on our boat is only 6' (1.8m) away from the breaker panel, this job was easy.

After that, we mounted the thermostat and ran the wire to the electrical box and plugged it in. This programmable thermostat comes with 20' (6m) of wire. We routed the wire from the air conditioner to the electrical panel, popped in a breaker and this job was done.

Step 4 Mounting the Unit

Mounting the air conditioner was one of the easy steps. Place it in position on top of a sound-baffling piece of rubber, connect the water in and out plumbing, electrical wiring and screw the unit to the base.

Step 5 Fine Tuning

The instructions supplied with the unit were very clear and the work was not difficult but the job consumed more than 40 hours of effort. By installing it myself, I saved at least 60% of the cost of paying for an installed system.

I was originally concerned about the load that the air conditioner would have on the electrical system. One of the reasons we selected the Mermaid unit was that the published electricity consumption was lower than competitive models. The draw was, in fact, less than having our two ceramic heaters running concurrently and still well under our 30-amp limit. Yes, we might pop a breaker if we turned on the oven and the coffee maker at the same time as the air conditioner but this happened with the two heaters and we learned to live with it.

After running the unit, the only issue we needed to address was a deafening noise that even the two supplied rubber panels mounted to the compartment top and bottom couldn't quash. I purchased 1" (25mm) thick noise barrier material from West Marine, placed it under the air conditioner and gone was the intolerable din.

— Murray Abbott is an avid DIYer and now a very happy three–season boater.

DIY Bill Of Materials

Summary of materials and costs in Canadian dollars, exlusive of taxes, to install a Mermaid Marine Air M16, 16,500 BTU air conditioner.

Mermaid Marine Air with reverse heat M16, 16,500 BTU		**$2,159.79**
Mermaid Deluxe Installation Kit		**$975.00**
1	Thermostat faceplate white	
1	5/8" thru-hull/overboard chrome	
1	Chrome drip edge	
9'	3/8" drain hose	
25'	5/8" marine hose, black, reinforced	
5'	3/4" marine hose, black, reinforced	
2	Teak 4" x 4" supply air grills	
2	Plastic transition boxes, 4" x 4" with 4" ring end	
1	Groco raw-water bronze strainer	
1	3/4" thread-to-hose PVC elbow	
1	3/4" closed end nipple	
1	Plastic transition box 8" x 6"	
1	8" x 6" supply air grill teak	
1	6" plastic hose ring	
1	6" x 6" x 4" plastic hose "Y"	
1	4" x 4" x 4" plastic hose "Y"	
1	Return teak air grill, 14" x 10"	
25'	4" non-insulated flex duct	
6'	6" non-insulated flex duct	
1	Marine circuit breaker	
30'	12/3 gauge marine cable	
30'	16/3 gauge marine cable	
8	#12 stainless-steel hose clamps	
12	#8 stainless-steel hose clamps	
1	Insulated mount pad	
18	#8, 1/2" stainless-steel screws	
4	#14, 2" stainless-steel screws	
Condenser		$269.99
Extras		
1	Ball valve (seacock)	17.00
1	Bronze water strainer	30.00
1	Bleed-off valve	12.00
20	14" wire ties	0.25
25'	4" Non-insulated flex duct	7.00
1	PVC elbow	4.00
Total Extras		**$70.25**
TOTAL		***$3,475.03**

*Approximately US$3,159.12 at 1.10 exchange rate

CONTENTS/ PREVIOUS/ NEXT/

SAILBOAT RIGGING

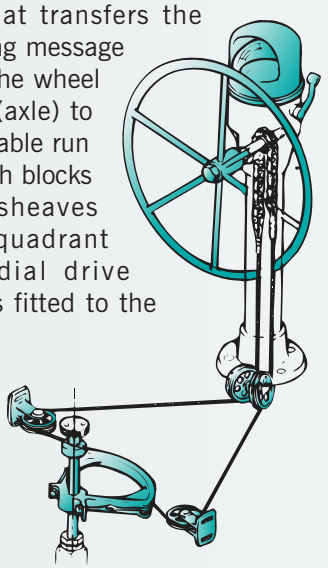
Steering Inspection: From Cables to Stops

When was the last time you inspected your boat's steering system? Routine maintenance of your boat's often out-of-sight, out-of-mind wheel steering system is critical to the safe operation of your boat.

By Roger Marshall

You are sailing offshore and you hear a bang from below. The boat slews out of control. You turn the wheel but nothing happens. What should you do? The first step is to take down your sails or set your engine to idle. Fit the emergency tiller to get you home. You don't have an emergency tiller? You'd better hope that your towing subscription is paid up. Getting to a safe harbor is your first priority but you'll also have to find and fix the problem.

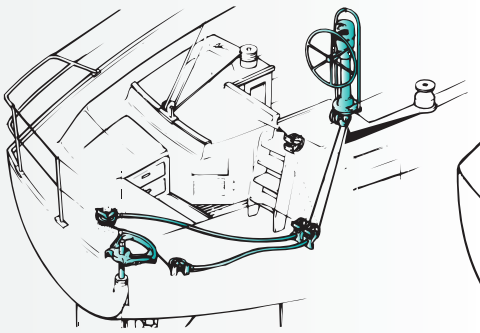
I'm amazed at how few boat owners routinely inspect the boat's steering gear. It's one of those systems that often go unnoticed until it fails and a failure here can be fatal to your voyage, long or short, inshore or offshore. If you've never explored those nether regions below the cockpit, you may not even know what kind of steering system you have. A common steering system uses a wheel mounted on a pedestal. This system uses a collection of hardware that includes a sprocket and chain assembly that transfers the steering message from the wheel shaft (axle) to wire cable run through blocks with sheaves to a quadrant or radial drive that is fitted to the rudderpost. Along the path from the helmsman's hand on the wheel to the rotation of the rudder through its arc, things can go wrong. Another common system is the push/push or push/pull cable that connects to a rack and pinion at the wheel shaft. These systems connect directly to a rudder (inboard or outboard) or other steering link or lever arm that moves a rudder or an outboard motor.

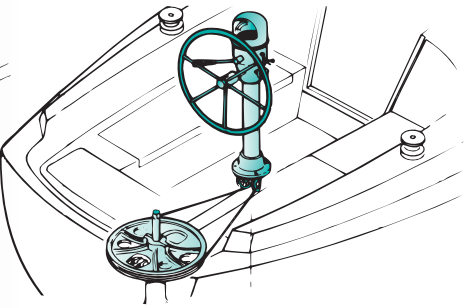


Yet another type, used mostly on powerboats, is the hydraulic system. This system incorporates a hydraulic pump at the steering wheel, hydraulic lines, a fluid reservoir and a cylinder with a ram that links to an outboard engine or the inboard steering arm and tie rod for twin engines.

Less common is direct linkage steering where the helm station is connected directly to the wheel by link rods and universal joints. Finally, there are steering systems that electronically signal steering directions from the helm to the rudder arm and some even have wireless remote controls. This is the future and it is here.

One of the most common problems on a wire cable steering system is a loose cable that has jumped off a sheave. This is not difficult to repair while at sea. Simply lever the cable back over the sheave, tighten it at the quadrant or tighten the idler block, if you have one, and head to port. Other steering failures require more in depth repairs that are better performed at dockside. Once safely in port, begin your inspection with a visual check of the entire steering system. Access for the visual inspection can be frustrating and physical access for an adjustment or repair can be more the problem than the repair itself.





Pedestal Steering Tune-up

Maintenance on the wire-to-chain pedestal steerer starts at the wheel and brake assembly in the top of the pedestal. To service these parts, it's necessary to remove the compass and binnacle cylinder from the top of the pedestal. Before removing, place an alignment mark on the compass and pedestal, using tape or removable marker, to ensure proper positioning when reinstalling. Place the compass in a sheltered location, where it won't get knocked over or damaged while you work. With the compass removed, the steerer sprocket and bearings are exposed.

The first step in the disassembly is to remove the steering wheel hub nut and the wheel. Temporarily, replace the hub nut with any 3/4" or 1" (19mm or 25mm) diameter hex nut. Now, go to the quadrant (or radial drive) and loosen the steering cables by backing off on the clamps/take up eyes. With the cables slack, lift the chain off the sprocket and tie it loosely to the back of the pedestal to prevent the chain from dropping down inside the pedestal when the wheel axle is removed.

Place a cloth under the sprocket assembly to catch any small parts that

drop out. Now, align the notch in the aftermost nylon washer with the "V" stamped on the sprocket and drive the pin out of the sprocket. Edson recommends driving this pin from the round end toward the grooved end. You are now ready to remove the wheel axle and, with a bit of luck, you won't drop half the assembly down the pedestal. Place a block of wood on the hex nut and gently tap the wheel axle out of the housing. At this point it's critical to capture each part of the assembly to avoid losing pieces down inside the pedestal.

As you pull out the axle, remove the sprocket, two nylon washers and forward needle bearing and then remove the aft needle bearing and washers. Immerse each part in a cleaning solvent (paint thinner or kerosene will do) and wipe all traces of solvent and grease off the components. Lightly lubricate needle bearings with Teflon grease while turning the wheel to ensure coverage over the entire bearing surface. Do not over grease as any drippings on the brake pads will disable the wheel brake. Oil the chain with #30 weight oil. Grease or oil (check owner's manual for specifics) all components and reassemble in the reverse order of disassembly.

Before you reassemble the unit, you should also check and lubricate the engine controls if they are mounted on the pedestal. To do this, carefully wipe grease and dirt off the ends of the cables. Oil the control handle shaft bearings with #30 motor oil, and spray the cable ends with a good quality Teflon spray. At the engine end clean the cable ends, and spray them with high quality Teflon grease. Lubricate all joints with oil or grease as required. If your cables are stiff, they either turn too sharply around a corner (stressed in a too tight radius) or there is corrosion inside the cable housing. If you suspect that, replace the cable proactively to avoid a failure. Check the alignment of the cables to make sure that the engine goes into gear smoothly and completely. If you have any doubt as to whether cables are aligned properly, have a competent mechanic check them.

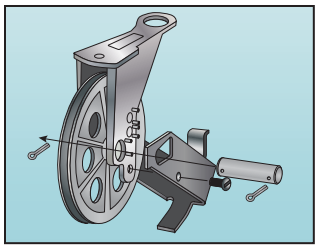
Once you have reassembled the engine controls and the steering gear, reinstall the compass. This is the time to "swing" your compass and to prepare a deviation card. [Ed: For details on swinging a compass and preparing a deviation card refer to DIY 2001-#2 issue.] At the rudder end of the steering assembly, check the cables, sheave bearings and wire for wear and make sure that all guards are in place. Grease cables with Teflon grease, sheaves and wire with #30 weight oil, as necessary. Do this once a month. When checking sheaves, look at the bolts to make sure they have not been compressed into the bulkheads or mountings. If they have, the assembly has been over-stressed and it will be necessary to beef up the backing at these attachment points to better distribute the loads. Continued stressing could cause the sheaves to pull out at their mountings. At the quadrant, tighten the steering cables to their original tension and check the cable alignment. Check the keyway on the rudderstock for wear and alignment and adjust if required. Inspect the idler under the pedestal for rust and loose grommets.

System Schematics

For boats fitted with an Edson steering system, the manufacturer offers data sheets for most production boats. These provide a simple schematic of the steering system mounted on your boat along with a parts list of steering components and a description of special installation circumstances, if required. Data sheets are available online at www.edsonmarine.com/faq/wheel_conversions.html or contact Edson customer service at 508/995-9711.

Rack and Pinion Maintenance

Like all steering systems, proper maintenance of a rack and pinion system is required to provide trouble-free service. Lubricate the rack and pinion gears, bearings and joints annually with Teflon grease. To grease the gears, it's necessary to remove the pedestal compass and housing to access the gears. Follow the directions above for disassembly and reassembly of the compass. Now, spin the wheel hard over to port then slowly turn it to starboard while applying grease to every gear tooth. The downtube and shaft bearings normally have grease fittings for lubricating the bearings. Refer to the owner's manual to locate the grease fittings for both bearings and



Joe VanVeenen

Retrofit sheave guard kits, available from Edson, help prevent derailing and jamming due to slack cables.

apply a small amount of grease. After reassembly, check the compass for accuracy.

Cable Steering Check-up

Besides a loose cable, another common problem with cable steering is that a sheave block pulls off its mounting. This is a harder problem to cure and entails remounting the block. Typically, this failure occurs when the block is mounted to a bulkhead without backing blocks or hardware and bolts pull through the bulkhead. Reinstall the block, using a 1/4" (6mm) aluminum or composite backing plate, align the components and prove your work before you extricate yourself from the unnatural position you had to assume to access the system. You may find it necessary to do some fiberglass work to complete a repair. If so, use thickened epoxy resin rather than polyester to make the necessary bonds.

Push-pull steering cables cannot be repaired and should be replaced if they have problems. In fact, according to Morse Controls a well-lubricated cable can actually hide problems until it is too late and your steering fails. Regular maintenance of your steering cables is essential to keep your boat going where you want it to go. Inspect all steering cables at least twice a season.

Many cable steering problems can be found simply by doing a thorough visual inspection of all components. Beginning at the rudder end, check that all brackets and clamps are tight and look for corrosion, broken springs, and missing or broken cotter pins. Corrosion can be seen as salt build-up on the ends of connectors. These deposits should be removed regularly. A thorough cleaning and lubricating with Lubriplate or equivalent does the job.

Inspect cable alignment. Excess misalignment causes poor performance and may lead to failure. Check too, the arc of the cable. A sharp turn at the ends causes the cable to bind. Depending on the diameter each cable has a minimum radius that it can bend around. Find out the minimum radius for your cable (add this to your maintenance log) and be sure that it's not exceeded.

Now examine the entire cable jacket. Feel it also. If you feel any bumps, cracks or cuts in the cable, replace it immediately. Look also for signs of abrasion; for example, where the cable passes through a bulkhead. This could indicate a future problem area. End fittings that separate from the jacket might indicate an area of corrosion and the cable should be replaced. Similarly, bumps felt under the jacket coating indicates that corrosion is taking place below the protective layer of plastic and that your cable may be weak or about to break. Replace it.

Look for a bent core. If you find one, it's time to replace the cable. If the sleeve has a bump in it, it may indicate that the rod has been bent and straightened. Again, for your safety, you need to replace a cable with these signs.

Having made your visual checks, now do a performance check. First operate your rudder throughout the entire range. It should operate smoothly and easily without snagging or binding. The movement should be even, without hang-ups or stickiness. If a rough spot or hang up is encountered, first check the cable from end to end to make sure that its curvature radius is within design limits. Any signs of roughness or sticking at one particular spot indicate that the cable core may be kinked and should be replaced.

Finally, it's recommended to replace cables that are 5 years or older. This is a best practice safety precaution to reduce the possibility of steering failure.

Hydraulic Checks

If you have a hydraulic steering system, you have a com-

• TIP •

Online Checklist

If your boat is equipped with an Edson steerer, the company offers a steering inspection checklist online. It lists the tasks and replacement parts and is available as an Acrobat PDF that you can view and/or print. (www.edsonintl.com/EdsonMarine/pdf/Information/EB372SteeringInspection.pdf).

23 Point Steering Inspection

Routine checking of steering cables should be part of your decommissioning and mid-summer rituals. Inspect your boat's steering system using the maintenance schedule below. It's a good idea to prepare a maintenance log, noting the component, type of lubricant, frequency of service, description of work (e.g. "Inspect," "Adjust," "Lubricate" or "Replace") and date.

Wire systems

1. Check the condition and tension of the wire and oil it lightly. Place five tissues (e.g., Kleenex) in the palm of your hand, squirt #30-weight motor oil (or similar) on the tissues and then slide them along the wire. Any broken or hooked strands will snag on the tissues and signal that the wire must be replaced. In any case, replace the wire after 5 years and, if in good condition, keep it onboard as a spare.
2. Oil the chain with #30-weight motor oil.
3. Maintain the steering wire tension. When you feel a bit of play in the steering, it's time for an inspection. Adjust by tightening the take-up eyes on the quadrant or drive wheel. With the wheel locked in place (tie off or use the pedestal brake), you should not be able to move the quadrant or drive wheel by hand.
4. After adjusting the cables, rotate the wheel slowly from stop to stop. If it doesn't turn smoothly, the chain and sprocket require servicing.
5. Grease pull-pull cables monthly with Teflon grease.
6. Inspect the cable conduit for cracks in the outer cover, abrasion of cover, kinks or sharp bends. Replace cracked, kinked or bent cable with only NMMA type accepted cable. If abrasion has not worn through outer cover, cable is still serviceable but it must be protected from further abrasion.
7. Replace corroded, worn or damaged cable ends, brackets and connections. Tighten loose parts. Spray cable ends and fittings with moisture-displacing lubricant.

Geared systems

8. Check frequently for any wear on the parts and lubricate all bearings, gears and linkages well. Use #30 weight oil for sheave bearings; Teflon grease for shaft bearings.
9. Once or twice a season, check that all connections and linkages are secure.
10. Inspect the universal joints for play and, if necessary, repack with grease to prevent wear and corrosion.
11. Check for play in the worm gear or between the pinion and gear. Do this with the rudder centered and held rigid.

All Systems

12. No matter what kind of steering system you have, annually inspect and lubricate the pedestal shaft bearings and other moving parts with Teflon grease.
13. Check the steering wheel for looseness and cracks around the hub and base of spokes. Replace wheel if cracked. Tighten retainer nut and check key if wheel is loose.
14. Regularly check all steering system or pedestal accessory screws, nuts, bolts, clevis or cotter pins for tightness and wear.
15. Clean and lubricate all moving parts with a good grade of marine grease every 3 months in freshwater areas, every month in saltwater areas. Use mild solvent, such as kerosene, for cleaning.
16. Check that all sheaves are securely bolted and well oiled.
17. Check that there is no movement between the quadrant or radial drive and the rudderpost.
18. Annually inspect the rudder stops for wear.
19. Set aside a day and inspect the system while under full load. If you see anything bend, hear anything creak or sense any other indication that there's a problem, you have the rest of the day to sort it out.
20. Inspect the condition of the emergency tiller and make sure it fits the rudderhead and operates properly.
21. Check the rudderpost tube for any signs of separation from the hull.
22. At each haulout, carefully inspect the rudderpost bearings for wear or cracking.
23. Check the stuffing box for leaks.

— Nick Bailey

pletely different set of considerations. First, check the reservoir to make sure that you have enough fluid in the system. If the reservoir is empty, find and eliminate the leak, top up the fluid level and bleed the system to eliminate air bubbles. To find leaks, first check each hydraulic connection and hose. Most leaks occur at the cylinder seals and at the points where the hose is attached to the pump. Less often, a hydraulic hose is chafed or cut and leaking. This may be harder to detect if the cable is led behind liners, is bundled with other conduits, etc. but careful inspection should reveal the problem. Remember that these leaks can puddle far from the source so follow the trail of fluid staining. Hydraulic leaks are easily spotted. They make an oily, slippery mess!

Mushy hydraulic steering or steering that locks and then frees itself is symptomatic of air or dirt in the system. The only solution in this case is to empty the entire system, flush it and refill it with new hydraulic fluid. Maintain a hydraulic system by oiling the rams lightly on a regular basis, checking fluid levels and inspecting for leaks or chafe on hoses.

Quadrants and Stops

Check the steering arm, quadrant or radial drive on the rudderstock. All should be physically attached to the stock, not held in place by a friction fit (e.g. keyed, pinned, set screws). If the quadrant is held in place by bolts with no keyway have your boatyard remove the rudder and get a keyway milled into the rudderstock and the quadrant. That is the only secure way to stop the quadrant moving on the rudderstock.

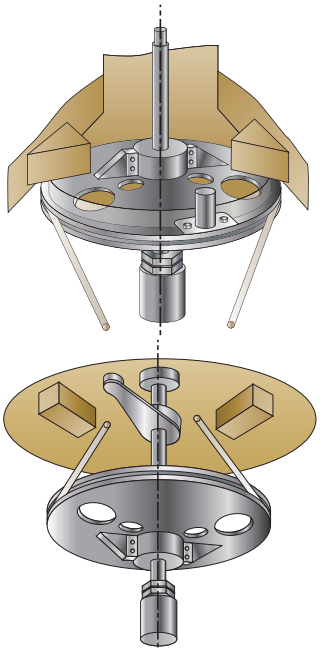
Many steering quadrants or wheel drives have rudder stops that limit the amount of rudder travel. These stops are key components to safe and reliable steering and an overstressed system can loosen or dislodge them. Make sure these stops are firmly in place by observing them as they take the expected loads when you turn the wheel hard over from stop to stop. This check often requires a team, one person to turn the wheel; one to observe the effect. In most cases 35° in either direction is about all the rud-

• TIP •

Steering Preparedness

A surveyor colleague of mine tells me that many emergency tillers are lost deep in the bilge, still wrapped in their original packaging or, sadly, their components are welded together by rust. Worse yet, when found, they don't fit or the rudderstock access port that was installed by the boatbuilder doesn't permit the tiller to align with the top of the stock. Dry fit your back up steering system at the dock and establish an action plan now — determine if you need to remove the steering wheel or how best to control the short tiller — before an emergency occurs.

— Jan Mundy



Joe VanVeenen

Sample rudder stops: (top) Wood blocks, fiberglassed in place, mount on either side above the drive wheel. (bottom) A better arrangement uses an Edson tiller arm (#836), which keeps the stops independent of the steering system.

der angle you can apply before hearing a loud "thunk" as the stop block on the quadrant hits the rudder stop. (Most quadrants take up an arc of slightly more than 70°). Many boats have inadequate or improperly cushioned stops. Some are damaged from a free wheeling rudder that isn't secured by the benefit of a wheel brake when the boat is not underway.

The rudder should turn the same distance in both directions. To check the rudder angle, next time you haul out, measure the distance from the boat's centerline to the rudder fully turned in both directions. There should be an equal amount of travel on either side.

A steering system failure can ruin a good day's outing. Always refer to a service manual and if you are not 100% certain of your skills in this area leave it to a professional technician.

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.

Additional Reading

Steering Tune-up: How to troubleshoot, maintain and service cable wheel steering systems. DIY 2001-#1

Just updated is DIY's MRT Series "Sailboat Rigging" CD-ROM that contains articles that appeared in the Sailboat Rigging column from 1995 to 2005 past DIY issues.

ShopTalk

Vacuum Bagging Basics

Vacuum bagging small fiberglass panels provides a higher strength-to-weight ratio compared to hand layup and produces a good finish on both sides. It's the ideal method to fabricate anchor lockers, hatches, tables and other small panels.

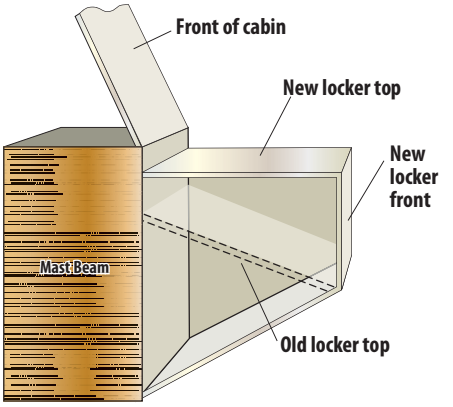
Story and photos by
Diane Selkirk and Evan Gatehouse

The anchor and fender lockers on "Ceilydh," a Wood's Meander 40' (12m) catamaran built in 1987, had begun to rot. Assembled from a combination of painted and fiberglass-coated plywood, the light construction and poor drainage had proven to be inadequate for the heavy use required of an anchor locker. Additionally, the size of the lockers made them too small for our ground tackle. So, rather than just rebuilding them from better materials, we decided to completely redesign the lockers for multi-purpose use.

The new lockers were designed to be bigger and have better drainage. Located in the middle of the boat, these lockers are in the optimal location for heavy objects. Catamarans are more sensitive than monohulls to excess weight in the ends of the boat, so we decided to use some of the increased space for a new diesel fuel tank. During the design process, we also realized the lockers could double as comfortable foredeck seating and we incorporated this idea into the design.

Using our design drawings, we prefabricated the locker panels. Prefabricating the panels allowed much of the work to be done in a controlled environment off the boat and meant that the build time in the boatyard was reduced. Although this was a relatively small project, all the panels were vacuum bagged. The bottoms of the lockers are subject to wave impacts and the extra strength of a vacuum bagged, cored panel are benefits.

When deciding if vacuum bagging is suitable for a project, consider the following pros. Vacuum bagging is the best way to securely bond the core of a fiberglass sandwich to the skins. It provides an excellent strength to weight ratio because of the higher glass-to-resin ratio and produces a good finish on both sides of the panel. As for the negatives associated with vacuum bagging, small parts are time consuming to fabricate due to the extra work involved in vacuum bagging. It's also more expensive than a standard hand layup because of the additional cost of vacuum equipment and supplies. The technique carries risk of partial failure if you don't get your vacuum bag in place before the resin begins to gel or if you have a vacuum bag leak that you cannot find. All the cons aside, this method was the best solution for our anchor lockers.

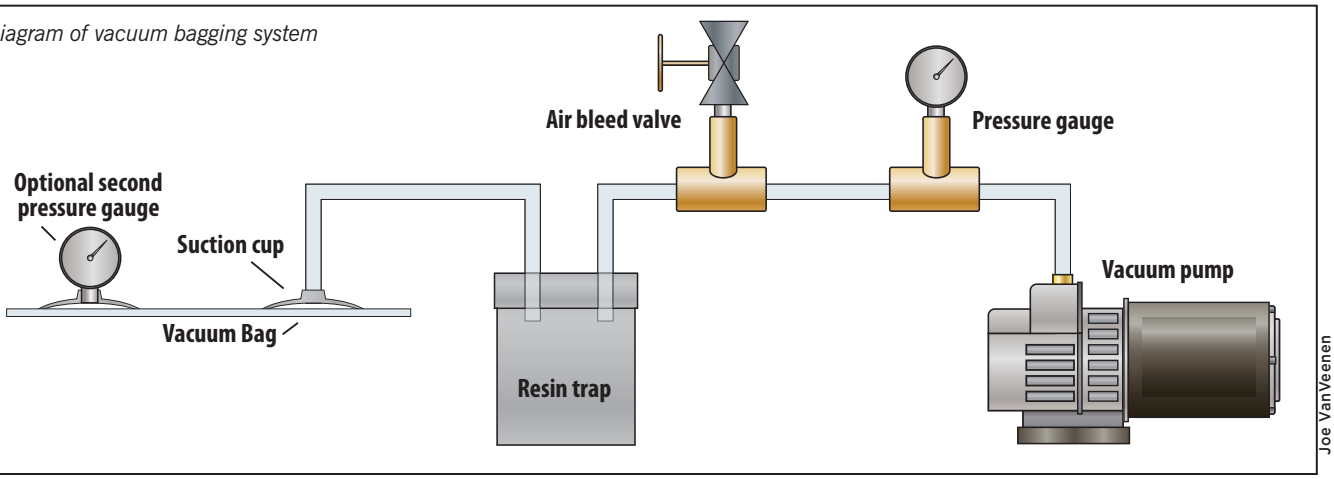


Anchor locker cross-section diagram compares old to new locker volumes.

Layup Prep

We began the layup process by testing our procedures. Before any resin was wet out or the table was waxed, we stuck down some sealant tape and some foam core. We did a trial bagging operation to see where there

Diagram of vacuum bagging system



Joe VanVeenen

Mold table with outline of a panel written on the table with indelible marker to act as a cutting template for fiberglass fabric and other vacuum bagging consumables.

Waxing the mold table with several coats of wax.

were leaks and then learned how to fix them. Then, we did a second test run by laminating a non-essential piece. Vacuum bagging requires a bit of practice, so experimentation and test runs help ensure the outcome is successful.

For the lockers, we used a flat mold surface. We marked out the outline of each part on mold table with an indelible marker. Using this outline, we used an Olfa fabric rotary cutter to cut the fiberglass fabrics that formed the skins and then used a utility knife to cut the shape from the Corecell foam core. If the core is not predrilled, it must be punctured to allow air to escape from the outside reinforcing skin. We drilled holes every 3" (75mm) apart, about 1/16" (1mm) diameter.

Typical laminate stack: (right to left) mold surface, inner fiberglass skin, foam core, outer skin, peel ply fabric, breather bleeder layer and clear vacuum bag.

While we prepared our supplies, we had a helper wax the mold table with a carnauba mold release wax. Five or six applications were required for the first part, one or two for further parts from the same table. Waxes need to harden for a few hours between coats so we allowed two days for this step.

We then used the following weight ratios and weighed out our fiberglass materials to determine the amount of resin needed for the correct fiber to resin ratios: mat 35% fiber to 65% resin; woven roving or woven cloth, 45% fiber to 55% resin; stitched uni-directional/biaxial type fabrics, 50% fiber to 50% resin and precoating balsa core, 0.5 oz/ft. sq. (150 g/sq. m) resin. Here are a few example calculations: 12oz of mat = 12oz x (0.65/0.35) = 22oz (624g) resin; 24oz of biaxial = 24oz x (0.50/0.50) = 24oz (680g) resin.

Bagging Technique

When we were ready to begin, we cut out the vacuum bag plastic, the peel ply and the breather/bleeder layer. The vacuum bag needs to be at least 12" (300mm) wider than the part on each edge. The other layers were cut to the size of the part. We applied a 1" (25mm) wide outline of masking tape to the mold surface, about 6" (150mm) away from marked outline of the part. This protected the area where the sealant tape will go from epoxy drips.

(top to bottom) Any excess bag material requires a pleat; To form a pleat in a vacuum bag apply a short amount of sealing tape to the perimeter tape, inside the pleat, then fold over the top of the short length of sealing tape; seal the bag against the short length of sealing tape, pinching it off at the top; seal the bag against the short length of sealing tape at the bottom corner; finished pleat.

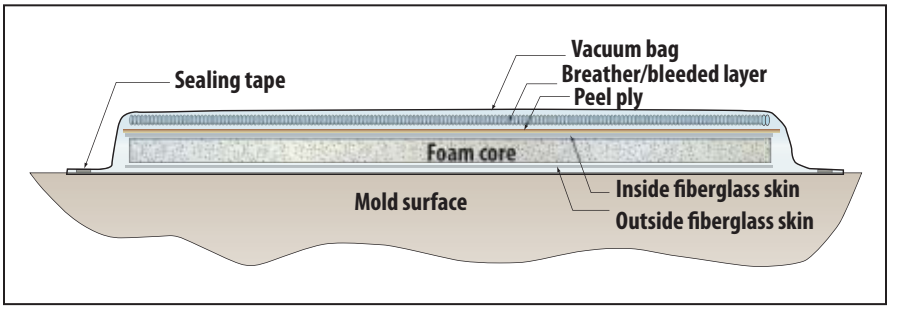


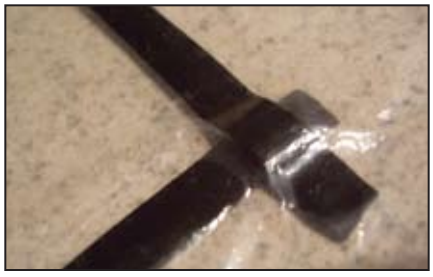
Diagram of laminate stack and vacuum bagging materials.

(top) A panel under vacuum. The red fabric is peel ply; the quilted white polyester breather/bleeder material is on top. (bottom) Another flat panel under vacuum. The excess resin is coming through the laminate stack and is being absorbed by the breather/bleeder material.

Next, we laid the outside skin against the mold table. While most people use a first layer of 3/4oz (225gm/m²) mat against the mold to prevent print through of the reinforcing fabric layers, we used a thinner mat "surface veil" to minimize weight of the panels. Next, we added the primary reinforcing fiberglass, a stitched 20oz (666gm/m²) triaxial E-glass. The triaxial fabric was wet out by pouring a large amount of mixed resin directly on to the fabric, which was spread out with a plastic squeegee. This was much faster than brushing or rolling with a roller.

We then precoated the core with resin, to seal the open pores. We did this well before placing it on the wet resin of the outside skin; otherwise the core could absorb excess resin from the lay-up and leave us with a resin starved fiberglass skin. When using polyester, an additional layer of mat is required before the core but, because we used epoxy, with its superior bonding ability, this was not required.

For these flat panels, we found it possible to laminate the outside skin, core and the inside skin in one operation. We used a resin with a long working time and ensured that the ambient temperature wasn't too hot. Alternatively, we could have vacuum bagged the outer (mold side) skin and core in one operation and used vacuum or hand layup for the inner skin, after the outside skin and core had cured.



Common vacuum bag leaks are due to (top) bag not pressed against the sealing tape; (middle) leaks at top of pleat and (bottom) and a leak point at corner.

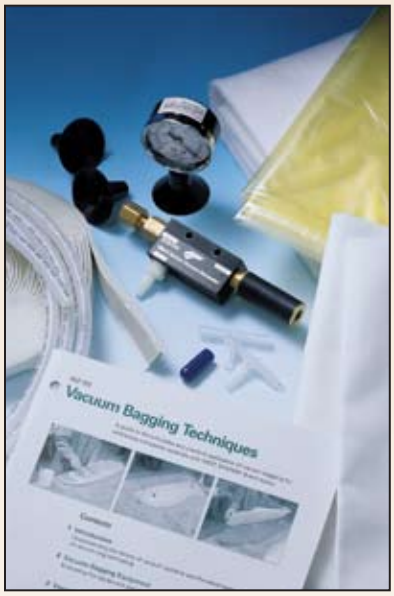
The first layer against the core or inner fiberglass skin must be peel ply or perforated plastic film. We used peel ply because it was easier than punching a lot of holes in a plastic film. Then, we unrolled the breather/bleeder layer on top of the peel ply, putting an extra layer of this material where the vacuum hose would attach in the middle of the part. Parts larger than 30 sq.ft (3 sq.m.) require additional vacuum connections.

Next, we removed the protective masking tape around the perimeter of the part and unrolled a strip of mastic sealant tape onto the mold where the masking tape protected it. We placed the vacuum bag over the part. Starting at one corner we removed the backing paper from the sealant tape in short sections and stuck down the vacuum bag, pressing down the vacuum bag firmly onto the mastic tape and putting in pleats along the edge. Pleats are required with a polyethylene plastic bag because the flat plastic has to form a three-dimensional surface over the thicker part.

We made an "X" shaped incision in the middle of the bag about 1" long with a utility knife and affixed the vacuum suction cup with more sealant tape.

Now, we were ready to apply pressure. We turned on the vacuum pump and checked for leaks by listening carefully. While leaks almost always happen at the pleats, other places we found them were where a single fiberglass fiber was caught under the sealant tape, as well as at the vacuum suction point.

Starter Kit Makes Vacuum Bagging Easy



When used with a conventional air compressor, the West System 885 Vacuum Bagging Kit (US$181.30) contains everything needed to complete repairs or laminate projects up to 13 sq. ft. (1.2 sq.m). The kit includes a venturi vacuum generator, vacuum gauge, tubing, connectors and three vacuum cups, release fabric, breather fabric, vacuum bag film, sealant tape and an instructional booklet. The venturi generator develops more than 20 inches (mercury) of vacuum (10 psi) and has an operating range of 40 to 100 psi. Contact: West System at tel: 866/937-8797; web: www.westsystem.com.

We fixed all the leaks. Since we had a bigger vacuum pump, we could have ignored a small leak, but it was easier to try to get them all. Locating the vacuum pump outside the workspace can make it easier to find leaks because it will be quieter. Some vacuum pumps are oil lubricated and give off an oil mist. We used a hose connected to the exhaust port on the pump to vent the mist to the outside air.

Once all the leaks were found and fixed, we monitored the vacuum level, with 12" to 15" (0.4 to 0.5 bar) of Mercury about optimum. Too much vacuum sucks out excess resin from the part; too little is insufficient to create a good bond with the core. We adjusted the vacuum level using a tee connection to a bleed air valve. This allowed the pump to suck in a little extra air to reach the desired vacuum level. As the vacuum level increased, we often saw resin coming through the peel ply into the breather/bleeder layer in small spots. This was extra resin from the outside laminate coming through the holes in the core.

After the part cured overnight or longer, we removed the vacuum bag, breather/bleeder layer and peeled off the peel ply. The peel ply layer would occasionally stick firmly to the part and required pulling on it quite hard to allow it to release. To release the part from the mold, we used thin wooden shims that we taped between the part and the mold. The parts would often release all at once with a loud sound.

When all locker pieces were completed they were transported to the boat. The old lockers had been cut away as part of a larger project and the boat was located on the hard.

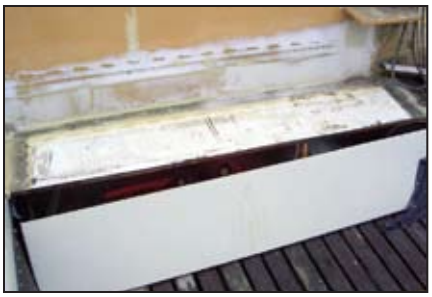
Assembly

The anchor lockers run between the hulls and attach to the front face of the mast support beam. First, we attached two long panels that formed

Installing new panels with 2x4 props holding them in position.

the bottom of the locker to the mast beam and sides of the hulls. We temporarily supported these panels in position with 2x4 props.

After grinding off old paint from the hulls and wiping down the surfaces to be fiberglassed, we filleted and taped the inside seams of the lockers to the hull and the mast beam with two or three layers of 12oz (340g) biaxial fiberglass tape. When the epoxy had cured, we removed the props and fiberglassed the external seams. Each fillet was formed with a mixture



Lockers under construction. (top) The vacuum bagged panels have been taped to the existing cabin structure and some fairing compound has been applied to the seam. (bottom) New locker panels and partitions fiberglassed in place.

of epoxy thickened with microballons and colloidal silica. We used a plastic squeegee cut into a 1/2" (12mm) radius as a tool to form the fillets into a smooth shape before applying the fiberglass.

Once the bottom panel was solidly glassed, we fiberglassed three internal, vertical dividers to the 13' (4m) long locker. This divided up the locker into spaces for the propane tanks, two separate anchor rodes and a fuel tank. The locker top forms the base of new forward seating.

New fuel tank being installed in locker.

About the authors: Evan Gatehouse is a naval architect and mechanical engineer, with extensive experience in composite boat design and boat mechanical systems. Diane Selkirk is a freelance writer and sailor with stories and photos published in a variety of magazines. Together they are completing a total rebuild on "Ceilydh," a Wood's Meander 40' (12m) catamaran.

Composite Materials at a Glance

Mat: A random collection of short glass fibers held together with a binder. Conforms well to tight curves and also provides a smooth resin rich surface for the outside skin of a molded part. Usually available in 3/4oz and 1.5 oz/ft^2 (225 gm/m^2 and 450 gm/m^2).

Cloth: Tightly woven fiberglass that is light and also drapes well. Often used as the last layer of a laminate. Available in weights from very light 1.5 oz/yard^2 (50 gm/m^2) to the more common 6 to 9 oz/yard^2 (200 to 300 gm/m^2).

Woven roving: More loosely woven heavy fiberglass to add strength and thickness to a layup.

Stitched fiberglass fabrics: Available in unidirectional, biaxial, triaxial and quadraxial construction. Layers are stitched together with thin threads. Since the fabric is not crimped by the weaving process, the resulting fabric is considerably stronger than plain woven fiberglass types. These fabrics are the best choice for boats where weight is important. Biaxial weaves are very effective for taping pieces together.

Kevlar/Aramid: Where impact resistance is important, Kevlar is often used. This golden colored fabric is very strong but is difficult to work with. It tends to float in resin due to its low density, requires special scissors to cut and, when sanded, it forms a fuzzy surface. It is also quite low in compressive strength compared to fiberglass and is expensive.

Carbon fiber/graphite: Where high strength and stiffness is important, carbon fiber can be an excellent choice. This black colored fabric can be worked similarly to fiberglass. Its primary drawback is high cost but small amounts can be integrated into a structure where strength is most important.

Core Choices:

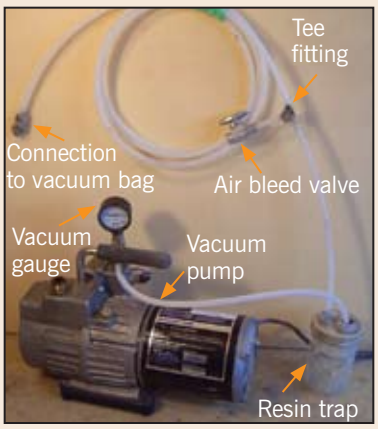
- SAN foam (e.g. Corecell) is most costly but very tough and resistant to impact and easily worked with woodworking tools.
- PVC foam like Divinycell, Herex and Airex are often about 20% less costly than Corecell and still a good choice for most applications.
- Balsa, the cheapest option and a good choice where compressive strength is important but is also the heaviest option. Where hardware will be through bolted, builders should use higher density cores.

[Ed: DIY recommends installing hardware in cored laminates using the potting technique as outlined in DIY 2005-#2 issue.] Builders should not use styrofoam or polyurethane insulation foam because their shear strength is not sufficient.

Resin Options:

- Ortho/iso polyester resins are the commonest type of fiberglass resin available. Offering low cost and working ease, these are the best choice where material properties do not have to be high.
- Vinylester resins are a nice compromise between the low cost, low material strength of ortho/iso polyester resins and the high cost, high strength of epoxy resins. They have similar working properties to polyester resins.
- Epoxies have the highest costs but the best material strength. They are the best choice for bonding to already cured and properly prepped fiberglass parts and are the best choice for vacuum bagging where weight is critical. Epoxies are much stiffer and have a higher elongation to failure ratio, both qualities that make them a better choice for high strength and stiffness parts. They also offer very long working times.

DIY Materials List and Costs



Vacuum pump equipment.

- Central to the vacuum bagging process is the vacuum pump. The size of the laminate pieces and the amount of material being laid up will determine requirements. We were able to purchase a 6 CFM, 29" Hg, HVAC technician type used for $150 from eBay.
- Airtight mold surfaces need to be built in the shape of the pieces to be made. The mold surface can be Formica, melamine-covered particleboard, glass, smooth metal, etc. We purchased old, discounted sheets of Formica and glued them to a plywood substrate. We also used melamine-covered particle board and found that gave an acceptable surface finish with less expense and preparation. Cost: $22 for a 4' by 8' (1.2m by 2.4m) sheet of melamine-coated particleboard.
- We chose flat Corecell foam core because our parts were not curved. You can purchase predrilled core but the cost premium is often enough to make it worth doing yourself. Knife slit cores, used for curved parts, have air passages that allow air to escape as well and do not require drilling. Cost: 1/2" (12mm) thick Corecell core, 4' by 8' (1.2m by 2.4m) sheet for $125.
- Specialty mold release waxes are available from fiberglass supply houses. Car waxes can contain silicone, which will contaminate the surface and hinder future painting. Cost: $18.
- The vacuum bag is the final layer in a vacuum bagging operation and forms an airtight seal against the mold. We used rolls of 4-mil lightweight plastic sheeting that are available from hardware stores. Cost: $10 per roll.
- The breather/bleeder layer performs two functions: it absorbs excess resin that bleeds through the peel ply and it also doesn't compress fully so vacuum pressure is distributed evenly to all parts of the part. Common breather/bleeder layers used are bubble wrap and polyester batting quilting material. We used polyester batting because we have seen bubble wrap leaving small dimples in the finished part of other vacuum bagged projects. Cost: $2 per yard.
- Peel ply prevents the other layers from sticking to the part. We used sale priced Ripstop nylon from a fabric store. We used many different types and never found any release issues. Commercial peel ply is more costly and is essentially the same material, though it may be treated to release more readily. Cost: $1 to $2 per yard.
- We used stitched triaxial 20 oz (666 gm/m^2) E-glass from V2 Composites (web: www.v2composites.com), as we were also using it elsewhere on our boat project. However, it only sells whole rolls so other vendors should be consulted if you need smaller amounts. Cost: $8 per yard.
- We used Jeffco 1310-L6 resin and 3155 slow hardener. This had a working life of a few hours when mixed in one gallon (3.78L) batches and, with an ambient air temperature in the 60F (15.5C) range. It's only available in 5 gallon (19L) pails so you'll need to contact suppliers for slow or extra slow hardeners if using smaller quantities. Cost: $50 per gallon.

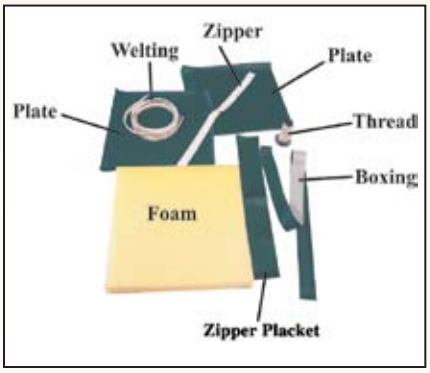
Note: Prices in Canadian funds. Divide by 1.10 to convert to U.S. dollars.

Sewing With Sailrite

Make your Own Cushion Covers

Part 2: The DIY 2006-#1 issue discussed making cushion patterns and selecting and cutting foam. Here you'll learn you how to assemble and sew a small stadium cushion.

By Jim Grant



Parts and pieces of a cushion cover.

Now that you've made your cushion pattern and cut the foam the next step is to fabricate a cover. The cover serves two functions: it is decorative but it also helps protect the foam from sunlight and abrasion that can harden or tear it.

Almost any fabric can be used for cushion covers but a synthetic fabric provides the best resistance to rot and mildew. Some synthetics offer better abrasion resistance than others. Naugahyde marine products (Naugahyde Bellingham, Naugahyde Oakwood, Naugahyde Southampton, Naugahyde Universal, NaugaLeather, NaugaSoft), outdoor acrylic furniture fabrics (Ultraleather, Ultrasuede, Sunbrella, etc.) or the Designer Phifer line of upholstery mesh are all recommended. The latter uses a vinyl-encapsulated polyester yarn in a weave that is designed to allow the free passage of moisture and air. The final selection from among all of these materials depends upon personal preference and budget. Samples are available from Sailrite (for a small charge) to help refine your selection.

Making an 18" (45.7cm) square stadium cushion cover requires the same construction steps as a much larger, irregularly shaped cushion. You'll need enough fabric to provide for the two "plates," the top and bottom of the cushion, for the "boxing" placket that encircles the thickness of the foam and the zipper placket. You can make a paper pattern (craft paper works well) to calculate how much material you'll need. Measure the foam surfaces (top, bottom and all around the depth) and cut the paper to these measurements and lay out the pattern pieces to measure for the material needed.

Besides the fabric, you'll need a nylon or plastic zipper that is closed at both ends (not separating) and is about 8" ((203mm) longer than one side of the foam. I suggest a #5 zipper for foam up to 3" (76mm) thick; a #10 for 4" (101mm) thick foam. I like a welting on all seams. Welting is cord wrapped in fabric that is sewn into a seam for a more finished look but it's not a required detail for this project. I use prefabricated welting that is available at any fabric store. Finally, select a quality polyester thread for your project since it holds up very well in a marine environment.

Step 1 Cutting Fabric Cushion Cover Pieces

Cut the two plates for the upper and lower cushion covers exactly the same size as the foam. If you followed our advice in the last issue you cut your foam 1/2" (12mm) larger than the desired final size all round. Cut the zipper placket as a rectangle 1.5" (38mm) wider than the depth of the foam to allow for zipper installation. It's roughly the same length as the side of the cushion plus about 6" (152mm). Finally, cut the boxing that goes round the rest of the cushion to the length of the circumference of the cushion, less the placket, with 1" (25mm) or so of extra length to allow for seaming. Boxing should be exactly the thickness of the foam. There should be no extra allowance for seaming as the seaming will reduce the size of the finished cover just enough for a snug fit. As you cut, be sure to mark the inside surface of the fabric if there is a right or wrong side for the exterior. Note that the boxing and the zipper placket may require cutting two or more pieces that will be seamed together (more about this later).

Cut all fabrics with scissors or hot blade, such as a soldering iron or gun with a narrow blade or use a specially designed tool that cuts and seals the edge at the same time, an advantage with synthetic fabrics that fray easily. This is not a serious problem with cushions where all raw fabric edges are inside the cover and any raveling goes unnoticed. With this cushion, scissors work satisfactorily. Vinyl-coated materials don't ravel at all so the hot blade offers no advantage there.

Step 2 Preparing the Zipper Placket

Fashion the zipper placket from a strip (or strips) of fabric 1.5" (38mm) wider than the thickness of the foam. If the

Figure 1
A placket end-to-end seam.

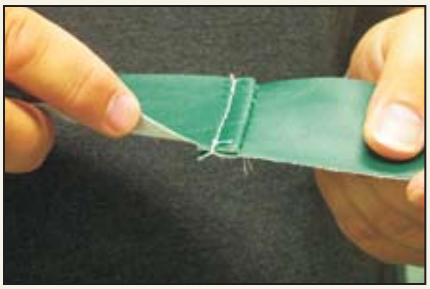


Figure 2
Topstitch on an end-to-end seam.

Figure 3
Creasing the placket tape down its center.

zipper edge of the foam is beveled, it's necessary to build this bevel into the placket by cutting it into three pieces: one piece the length of the beveled edge plus 1" (25mm) to allow for a seam at each end. Cut the ends of this first piece at right angles to its length. The short pieces to be sewn in place at each corner should be angled to match the bevel of the foam. To join separate pieces (with or without a bevel allowance), simply lay one on top of the other with the edges flush and put a row of straight stitches 1/2" (12mm) inside the matched edges (**Figure 1**). Then, spread the two panels to their full length and use a row of straight or zigzag stitches (**Figure 2**) to hold the seam allowance up against one or the other side (this is often called a topstitch).

The zipper placket should be roughly 6" or so longer than the corresponding cushion side. The longer the zipper placket, the easier it is to insert the foam but the placket tends to bulge so you don't want to make it any longer than necessary. While you are at it, trim the zipper with scissors to a length about 2" (50mm) longer than the placket. Fold the placket in half down

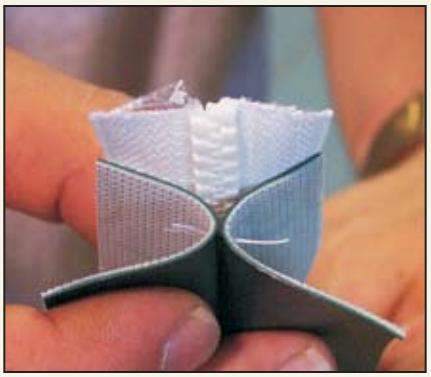
Figure 4
Sewing the placket shut with a row of straight stitches.

its length keeping the right side of the cloth inside (**Figure 3**). I like to crease the fold over a table edge to make it more distinct. Run a row of straight stitches just 3/4" (19mm) away from the fold all along the length of the placket (**Figure 4**). Cut the placket on its fold. This results in two pieces of cloth sewn together 3/4" (19mm) from

Figure 5
Cutting the placket on its centerfold.

one edge (**Figure 5**). Splay the placket out flat with the 3/4" (19mm) side up (the right side will be down). Press the two 3/4" (19mm) edges down away from the stitching so that the parts

Figure 6
Splaying the sewn placket.



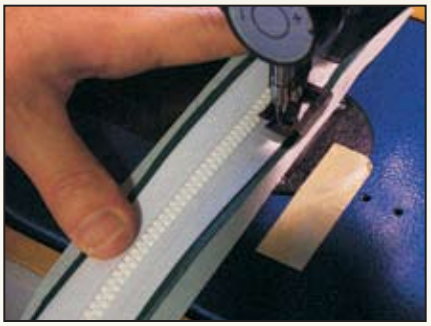


Figure 7
(top) Matching the zipper to the placket. (bottom) Sewing along the zipper teeth.

touch only where they are sewn (**Figure 6**). Place the closed zipper on top of the border with the teeth centered over the stitches. You can remove the zipper slider from the tape completely at this point and replace it shortly. Note that zippers have no right or wrong side. Nor is there a right or wrong direction for opening and closing the zippers (**Figure 7**).

Sew both sides of the zipper to the placket tape with a row of straight stitches. You may want to baste everything together with a stapler before you sew. Remember to remove the staples when the stitching is finished. Start sewing with about 1" (25mm) of the zipper tape extending out over the end of the placket. Note that the zipper is secured to the wrong surface (side that doesn't show on the completed piece) of the placket in Figure 7. A zipper foot helps with this task, although the stitches should be about 1/4" or so from the teeth and this normally can be accomplished without a special foot. When both sides of the zipper are secure, rip the stitch that joins the two halves of the zipper placket down its center (**Figure 8**) and pull out the broken stitch remnants.

Figure 8
(top) Cutting the temporary seam in the placket. (bottom) The finished zipper placket. Note that the zipper teeth are centered along the seam and covered by material.

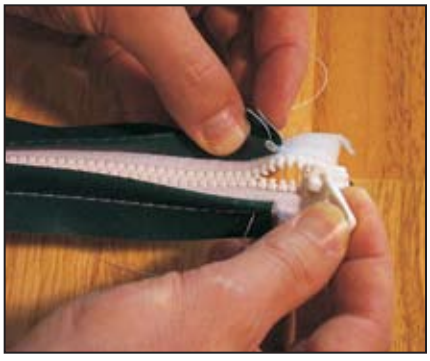


Figure 9
(top) Starting the zipper slider with the pull-tab on the right side of the placket. (bottom) While feeding the slider the zipper opens up ahead of the slider.

Now, reinstall the slider on the zipper tape (assuming it was removed as directed above). Pull the zipper teeth apart on one end for 3" or 4" (76mm or 101mm) and push the lead end of the slider onto the separated sides at the same time so the teeth mesh together. Be sure to install the slider so the pull-tab is on the right side of the placket (**Figure 9**). Run the slider about half way into the zipper's length. As the slider runs up the tape it closes the zipper while opening it in front as it should.

Check the width of the finished placket now. It should measure exactly the width of the cushion foam. If it's too wide, simply cut it down to size. If it's too narrow, take this into account by reducing the seam allowance when joining it to the plate and the welting (**Figure 10**).

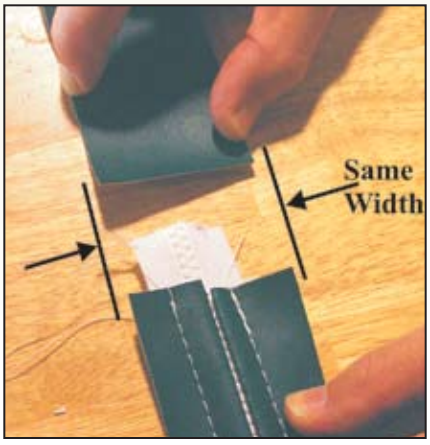


Figure 10
Attaching the boxing to the placket.

Step 3 Sewing Welt to the Plates

The welt attaches to the plates and then the boxing to the two plate and welt assemblies. Breaking the tasks down means that there is less likelihood of error. Using a stapler or double sided basting tape to hold things in place as they are sewn makes things more manageable. I don't find this step necessary but it is, nevertheless, one more aid to use. Using a welting foot (built into Sailrite Ultrafeed sewing machines) is a big help since it allows placing the presser foot directly on top of the welt to keep everything aligned (**Figure 11**). If not available, use a zipper foot and sew a stitch alongside the swelling bulge in the welt.

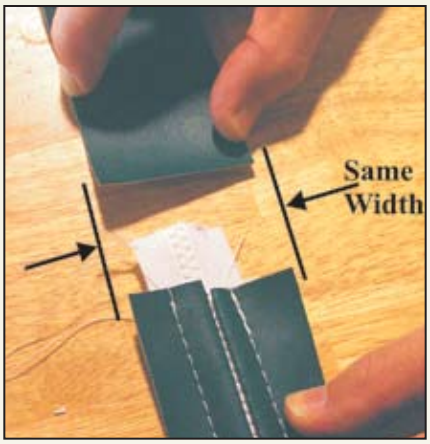


Figure 11
There is a groove on the underside of the Ultrafeed presser foot so the foot can actually sit on top of the welt and thus ensure a straight stitch accurately placed along the cord. This fabric is Sunbrella and it was cut with a hot knife.

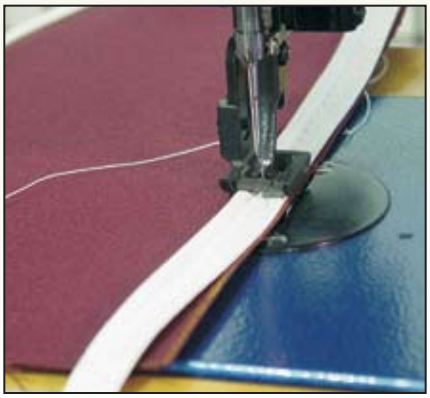


Figure 12
Sewing the welt to the right side of the first plate. By sewing in a clockwise rotation keeps the bulky material to the outside.

Lay the welt flat on the right side of the first plate. Line up the "tail" of the prefabricated welt (it looks like a tadpole from the end, hence the "tail" reference) with the edge of the plate. Begin sewing the welt near the center of the side that eventually has the zipper placket (**Figure 12**). Leave about 2" (50mm) of welt unsewn at the start of your stitch. It's always a good idea to sew clockwise round a cushion. This keeps the bulk of the material outside of the machine. Everything that follows assumes this routine.

Sew to the first corner and stop with the needle down about 1/2" (12mm) short of the corner. Cut notch-

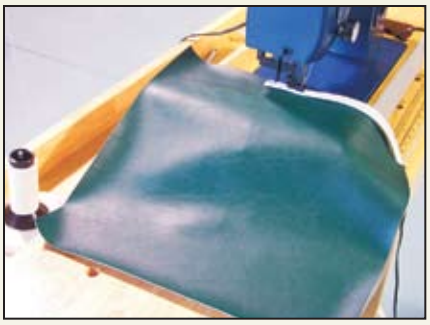


Figure 13
Rounding the first corner.

es ("eases") into the tadpole tail of the welt if necessary so it can be bent around the corner. A prefabricated welt already has eases that may be enough to permit a smooth turn as shown in **Figure 13**. At this point, it's a good idea to operate the machine manually while slowly turning the fabric. With each stitch, bury the needle and lift the presser foot of the machine to turn the work 30˚ or so. Once turned, drop the foot and manually produce another stitch. Stop with the needle down and continue on in this manner to complete the corner. Make 90˚ turns as cleanly as possible. Don't be discouraged if your turn has a small radius. As long as it's consistent, the finished product will look fine.

Figure 14
(top) The crossover technique to finish the welt circle. (bottom) Trimming the crossover ends.

Continue all round the plate. Stop sewing 5" (127mm) or so short of the unsewn welt at the beginning point of your work. Trim the ends of the welt so they cross over one another and overlap about 1" (25mm). The two ends should extend over the edge of the plate (**Figure 14**). Now finish sewing the welt. At the crossover point, just continue sewing right up and over the two thicknesses of welt. This crossover point continues for a 1/2" (12mm) or so. It may be necessary to hand turn the machine's balance wheel to get the needle through the bulky material. If the machine absolutely refuses to do the job, hand sew the last bit. Note that some sewers prefer to simply cut the welt ends flush with each other, creating a small break in the cord instead of the crossover in the welt cords. It's also possible to actually pull the prefabricated welt apart and insert one cord into a mating cover so a neat, continuous seam is produced but this requires much extra effort.

Attach a second length of welt to the other plate in exact-

Figure 15
The plates with welting attached to the right sides.

ly the same way. **Figure 15** shows the completed plates with welting installed.

Step #4 Sewing the Boxing and Placket to the Plates

Join the boxing and the zipper placket end to end. Secure the boxing to the left end of the zipper placket. The placket has a "left" end only if it's for a beveled edge, otherwise it will be symmetrical. Be sure to close the zipper along its length except the small opening in front of the slider, which should be somewhere near the center of the placket. Place the two strips of fabric right face to right face on top of one another. Run a row of straight stitches 1/2" (12mm) inside their flush narrow edges. The zipper tape actually extends beyond the sewn edge. It's a good idea to hand turn the machine when going over the zipper teeth so the needle can be guided to relatively open places. Hitting a zipper tooth directly can easily break a needle. Reverse stitch over the zipper so there are at least two stitches holding everything together (**Figure 16**).

Figure 16
The seam that joins the boxing to the left end of the placket.

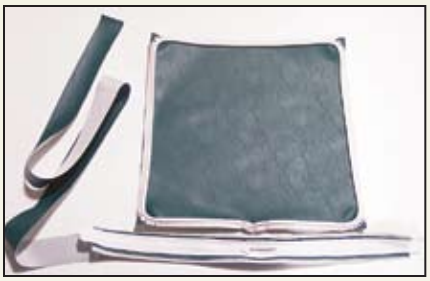


Figure 17
Lay out components in preparation to secure the placket and boxing assembly to the first seat plate.

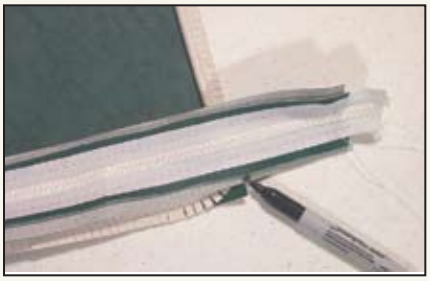


Figure 18
Mark the first corner point then each corner in succession as you sew.

Now lay one plate flat, right side up, with the welt crossover forward. Center the zipper placket portion of the boxing assembly (right side down) over the side of the plate with the welt crossover and on the back side of the cushion so it's less visible when finished. Extend the zipper placket about 3" to 5" around the cushion corners on both ends. Be sure that the boxing and placket joint is on the left hand side where the boxing continues on with enough length to encircle the plate (**Figure 17**). Keeping the boxing to the left allows pushing the assembly through the machine in a clockwise circle. Just prior to the corner on the right, where the placket begins,

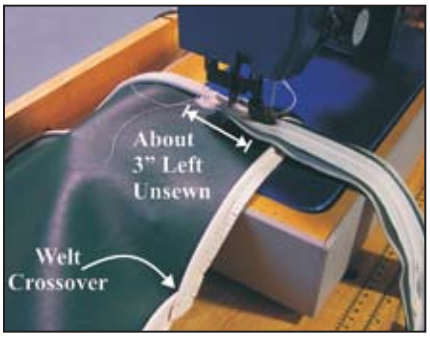


Figure 19
Initiating the stitch that attaches the placket and boxing to the first plate with its welt in place.

Figure 20
Notches ("eases") cut into the boxing at the corners.

Figure 21
The boxing and placket closure point.

start sewing about 3" (76mm) from the placket end. Mark the placket where it turns round the right hand corner of the plate (**Figure 18**) and be sure that mark lines up as you sew (**Figure 19**).

Proceed to the first corner and stop with the needle at the turning point. Clip eases into the boxing and placket strip so the plate turns and the boxing is eased around the corner (**Figure 20**). Again, a small radius is okay here but try to make the corner as sharp as possible. Place a mark at the next corner and continue sewing down the next side (along the length of the zipper placket), checking the mark position at intervals to make sure everything is feeding evenly top and bottom. Move on the same way to the next (third) side where the boxing/placket joint is found. When you get to the seam allowance for the boxing and placket joint, just continue sewing so the boxing and placket seam allowance is folded down against the boxing side. This makes for a very neat finish on the zipper tape.

Continue to the next corner and the next one beyond that until you are 5" (127mm) or so from the starting point. Stop now and remove everything from the machine (**Figure 21**). Cut

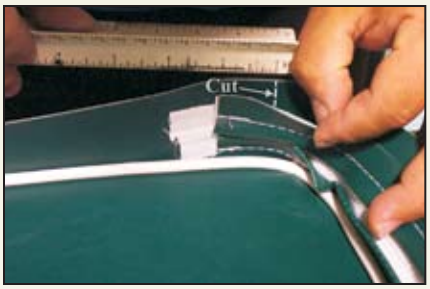


Figure 22
Cut the boxing to close the circle accurately.

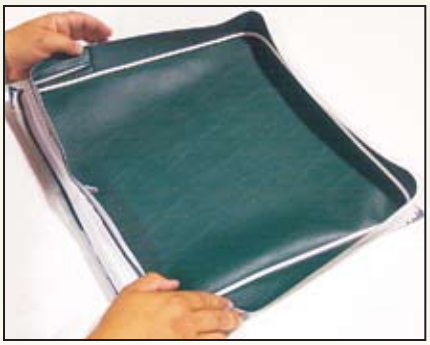


Figure 23
The completed boxing and placket and welt and plateassembly.

the surplus from the boxing strip so there is exactly 1" (25mm) of overlap between where the placket starts and the boxing ends. Be sure to cut squarely across the tape so there should be no angle in the cut (**Figure 22**). Put the boxing and the zipper placket right side to right side and sew them together with a row of straight stitches 1/2" (12mm) inside their flush edges. Once again, hand stitch over the zipper teeth where necessary and make at least two passes over the closed zipper to lock it in place. This seam allowance quite naturally lays toward the point where you stopped sewing because the zipper is rather stiff. Let it be that way and finish the stitch all round the boxing and placket assembly and the welt/plate assembly. **Figure 23** illustrates the finished assembly.

Step 5
Sewing the Final Plate in Place

The attachment of the second plate is perhaps the most error prone process in cushion construction. It's easy to get this plate misaligned, which results in wavy stress lines along the boxing. There are a couple simple tricks that will avoid this problem.

First place the cover assembly as it is now, inside out flat on a table. On both sides of each corner, press the boxing flat and pinch it up in a triangle with a 45° angle to the corner (this assumes a 90° corner). Hold the triangle while

• TIP •

Firmer Cushions

To make the finished cushion surface smooth and firm, it's my practice to cut the foam 1/2" (12mm) larger in all directions than the intended size of the finished cushion. Fabric plates are then cut to the same size as the foam while the boxing is cut to the foam thickness. Since roughly 1/2" (12mm) is required along the edges of the plates and the boxing for seam allowance, the foam is actually stuffed by hand into the cover. — *JG*

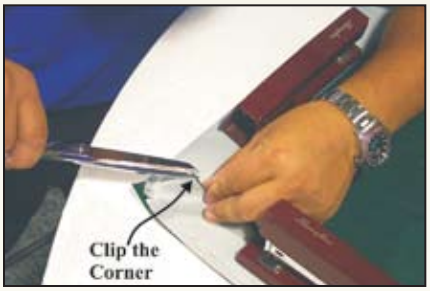


Figure 24
(top) Staplers serve to hold the boxing in place while the corner is pinched to find its center. (bottom) Cutting the corner notch.

cutting a 1/4" (6mm) notch out of the apex. The four resulting notches mark the location for the corners of the new plate and also provide for easing around those corners at the same time (**Figure 24**).

The second trick it to staple each corner in place at these notches before sewing. Lay the assembly (plate with boxing and zipper placket attached) right side down over the right side of the unattached plate (**Figure 25**). Place staples on each side of each of the four corners of the unattached plate so those corners are centered right under the notches cut above.

Figure 25
Matching the final plate to the boxing, placket and plate assembly. Everything is wrong side out.

Start sewing 4" or 5" (101mm or 127mm) from one corner. Starting at a corner opposite the zipper placket makes it a little easier to get an accurate match up since the assembly is not so thick there. When a corner is reached, make sure that the notch is located accurately and add additional easing cuts as necessary to make a smooth turn. Check the location of the next notch. Separating the zipper makes it easier to match the placket since its bulk will be reduced. Eventually, it may be necessary to pull or push the boxing and placket assembly to ensure that the corners match the notches. This is perfectly okay so long as the corrections are limited to less than 1/4" (6mm) or so per 24" (609mm). Where the inaccuracy exceeds this, you'll need to determine what the problem is then rip out stitches and start over.

Figure 26
Opening the zipper in preparation for turning the cover right side out.

Figure 27
The finished cushion.

Step 6
Foam Insertion

Pull the zipper halves apart and slide the slider down to the bottom (**Figure 26**). Now, turn the cover right side out through the zipper opening.

Fold the foam in half and insert it into the open cover. Once partly in place, flatten the foam and reach inside to tug on the far corners and the far edge to nudge the foam deeper into the cover. Be patient. It may seem that the foam just doesn't fit but, once the job is done, the cushion covering is properly filled (**Figure 27**). To facilitate insertion, use silicone spray to "lubricate" the foam or cover the foam with lightweight plastic (e.g. dry cleaner bags) and slide it in place, if necessary. Pull the plastic film out once the foam is in place. Close the zipper and admire your work!

About the author: Jim Grant founded Sailrite (www.sailrite.com) in 1972 to supply specialty marine fabrics, component hardware and tools, sewing kits and sewing machines for boaters to build or repair canvas and sails. Headquartered in Indiana, the company has satellite stores in Fort Lauderdale, Florida and Annapolis, Maryland.

• BOOK REVIEW •

The Practical Encyclopedia of Boating

by John Vigor, 350 pages, Hardcover
(McGraw-Hill, US$29.95, CDN$42.95)

This book calls itself "An A-Z Compendium of Seamanship, Boat Maintenance, Navigation, and Nautical Wisdom," which "informs, entertains, enlightens, and amuses." From abandoning ship to zinc anodes with latitude/longitude in between, this concise reference book covers traditional nautical wisdom and vital techniques for such things as reading the weather, recovering overboard crew, using a disappearing light to fix your position at sea and how to navigate locks. While not an exhaustive or in-depth guide, The Practical Encyclopedia of Boating gives sound guidance for practically any boating situation you might encounter.

POWERBOAT RIGGING

Cool Running

Regular maintenance to the cooling system is the essence of life expectancy for an outboard motor. Follow these tips to minimize the risk of engine overheating and maximize your time on the water.

Story and photos by Steve Auger

A healthy cooling system telltale water stream.

From a little 2 hp on an inflatable to a supercharged 275 hp on a bass boat, all outboard motors require special attention to their cooling systems to ensure trouble-free operation and avoid the dreaded overheat condition. Outboards, when subjected to a major overheat, usually suffer serious internal engine damage typically to pistons and cylinder walls resulting in very expensive repair bills.

The powerhead of an outboard engine is constructed of specialized marine application aluminum-based alloys. This provides a lightweight but structurally sound platform into which are installed a lightweight steel crankshaft and cylinder liners, forged connecting rods and alloy pistons to produce an engine that has an excellent power-to-weight ratio. It's the exotic alloys used in modern outboard engines that makes them very expensive to repair.

10 Dos and Don'ts

How well do you maintain your engine's cooling system? Below you'll find the facts to dispel the most common myths, some of which, I'm certain, you've heard from "expert" dockmates or bar buddies.

1 Never remove a used water pump impeller and reverse its rotation on the drive shaft. Always purchase a water pump repair kit, not just the impeller, when servicing water pumps. If the impeller needs replacing, so do the gaskets and seals. As for brands, always purchase OEM parts. While these are, as a rule, more expensive than generics, OEM parts' warranties cover subsequent damage from failed parts, such as an impeller failure causing cracked heads, whereas an aftermarket warranty doesn't usually cover damage resulting from a failed impeller. Also, OEM parts are date coded for quality tracking purposes.

2 Do not remove a thermostat as a cure to an overheating problem. The thermostat is an integral part of the cooling system and affects its ability to maintain the correct water flow and block temperature. Removing the thermostat and then running the engine results in a power loss, cylinder wash down and eventually expensive internal engine damage.

3 Never run an outboard engine without a water supply to the seawater inlet. Never, not even for a second. Never. Got it? Without a lubricant, in this case water, impeller vanes burn and damage the water pump. Period.

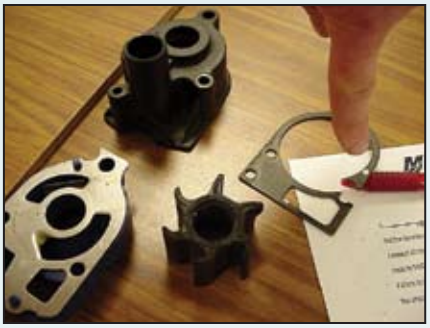
4 Never run an outboard on a flusher above idle speed (600 to 800 rpm). Maybe you've heard someone in a boatyard or maybe you have run your outboard on a flusher in the driveway and

(top) Remove the poppet valve cover and inspect (middle) the cover and (bottom) valve and seat for debris.

you give it a 3,000 to 4,000 rpm rev to clean it out. You're killing your water pump! A 1/2" (12mm) 75' (22.8m) garden hose cannot provide the volume of water required to supply the water pump on an outboard run above idle. A 115-hp outboard, for example, run for 60 seconds at 3,000 rpm requires 24 gallons (91L) of water. A garden hose outputs 30 psi or around 2 to 3 gallons (7.5L to 11L) or nowhere near enough water, resulting in a damaged water pump. Use a flusher at idle to flush salt or contaminated water out of the engine block and cooling system to ensure long engine life. No where in the instructions of any flushing device does it say you can use it to road test your boat in the driveway.

5 Try not to dry store the outboard in direct sunlight. If you must leave it in sunlight, it's best to cover the engine. Small outboards should be stored

Keep water intake ports clean. A plastic bag usually drops off the gearcase when the engine is shut off. Use a boat hook or deck wash brush to remove algae, seagrass and other obstructions. If the boat is trailered, inspect and clean water pickups after each use.



Broken gaskets and worn impellers cause overheating.

indoors in a cool dry area. This reduces the drying effect of the sun on impellers and seals of the cooling system and other engine components.

6 If your boat is moored at a slip, do not store the engine with the gearcase out of the water (in the tilted up position.) The sacrificial anodes on the gearcase must be submerged to protect against corrosion. If you must store the outboard in the full up position to avoid fouling marine growth, the gearcase must be completely out of the water or the corrosion protection system will be rendered inoperative. It's an "either/or" position; fully in or fully out. A benefit of keeping the gearcase submerged is that immersion eliminates UV and air dry damage to the impeller.

7 If your engine is equipped with a cooling system telltale, make it a habit to verify that it emits a steady stream of water at a temperature of no more than 120F (49C) or about the same temperature as the hot water in your

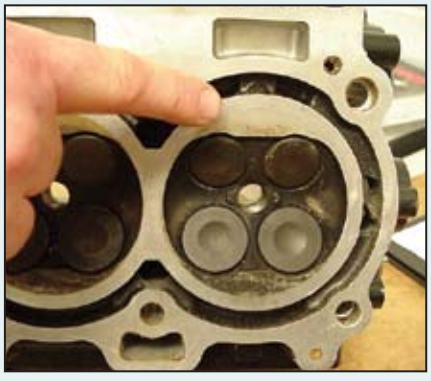
Location of thermostat on a modern outboard.

home. Very hot water or steam (vaporized water) being emitted from the telltale indicates a cooling system problem, such as an obstructed water inlet or failed component. One-step better for remote steering and control outboards is a dash-mounted water-pressure gauge or temperature gauge that allows you to monitor the performance of the cooling system at all times while underway. [Ed: For step-by-step instructions on installing a water pressure gauge refer to DIY 1997-#1 issue.] Know your engine's normal operating temperature and if you cannot remember, mark the dial with paint or permanent marker.

8 Modern, large displacement outboards often employ a poppet valve system to maintain water pressure in the cylinder block. If sand and other debris are noted when servicing the water pump, it's advisable to inspect the poppet valve for debris.

9 A plastic bag picked up by the engine's gearcase can block the water pickups located in the strut of the gearcase. This means a major overheat and, by the time you get the engine shut down, chances are that a water pump kit alone is not likely to get the engine running again. Damage to cylinder heat gaskets, exhaust cover and adaptor plate gaskets and exhaust system components is not uncommon. When cylinder compression or exhaust leaks into the cooling system, the water flow becomes static. This means while the new 5 psi impeller looks fine it cannot overcome the 150 psi that the cylinders are leaking into the cooling system and the engine continues to overheat,

Retrofit a water pressure gauge to monitor the water pressure in your engine's cooling system.



Head gaskets that leak will cause overheating that can cause major engine damage.

especially at speed.

10 Want to be sure you're prepared for a cooling system emergency? Get a spares kit. Purchase a water pump kit and a thermostat (if so equipped), spare spark plugs, manual recoil rope and fuel filter. Toss them in a plastic tub and store them on the boat. Chances are, if you did your routine maintenance, you won't need them but, if you do have a problem, you can perform the repairs and then restock your spares kit. This means no waiting for parts to be ordered and more time for you on the water.

Maintenance and Manuals

I cannot emphasize enough how important regular cooling system maintenance is to the life expectancy of an outboard. Most outboards are neglected for some months a year (a state referred to as "in storage"), and "parked" outdoors in the sun while their gaskets, seals and impellers dry out and take a permanent set from UV damage. Once boating season comes along we expect the

(top) Old: This 1960 outboard still runs well as it has never suffered an overheat. (bottom) New: This 2006 fly-by-wire, state-of-the-art outboard still requires cooling system maintenance.

engine to fire up and take us safely to our destination. The fact is that the potential for a soft part failure (gaskets, seals, impellers) climbs dramatically with each season that maintenance is not performed. Water pump impellers should be inspected every 100 hours of operation or annually as regular maintenance.

If you are planning to perform your own engine maintenance and repairs, purchase an OEM service manual. If that is not available, then purchase the generic version. Follow the maintenance guidelines in the service manual for all the different systems. Regular maintenance is the least expensive and most effective way to ensure your day on the water is a safe and pleasant experience.

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

Flipped Out Over Flipper

This fan of a popular '60s TV show tracked down the Thunderbird boat that starred in the original series and then restored it to Flipper livery.

Story and photos by Keith Oram

When I was a youngster back in the '60s, I was a great fan of the original "Flipper" TV series. My fascination was not so much with the dolphin but more so with the very cool boat that the park ranger character used in every episode. I just loved that boat! Over the passing years, I would occasionally wonder, "What was that boat on Flipper?"

An Internet search on "Flipper" 35 years later took me to a great website, www.fiberglassics.com, which is dedicated to classic fiberglass boats from the '50s and '60s. It was all there, including promo stills from Flipper and a Thunderbird brochure from the time. I discovered that the boat of my dreams was actually a Thunderbird Iroquois cuddy.

For a normal person, it should have ended there with a few dozen years of curiosity salved and the itch scratched. Problems start if, like me, you're a fan of old boats. The next thing I knew I'm on the website's bulletin board asking if anyone knows of one for sale. Insane behavior, for a number of reasons, not least of which was that any still around were pretty much certain to be in the U.S., some distance away from Johannesburg, South Africa, where I live. The bulletin board hooked me up

A seasick Flipper arrives in author's driveway after a nearly 10,000-mile (16,093-km) journey.

with Mike Cole, son of the boat's late designer. By fabulous luck, he knew of one of the boats actually used in the series. After a few emails and telephone conversations with the owner, I owned the boat from Flipper, which, for me, was just too cool for words. All I had to do now was get it home to restore it. The boat was shipped from Baltimore, Maryland, to Durban and that's a whole story on its own. In January, I did a 1,000-mile (1,609km) round-trip drive to tow it home.

Assessment

With the boat now safely in my yard, the next task was to prepare a plan and budget for the restoration. After my initial panic (I'd bought the boat pretty much sight unseen), I saw a lot of work in just cleaning the boat. Job one was to empty the boat of hundreds of gallons of water (the electric bilge pump still worked) and all the miscellaneous stuff left onboard. The previous owner must have given the keys to the shipping company and walked away because, along with the to-be-expected rusty tins of paint and broken screwdrivers, we found tons of useful gear. The rubbish filled three bags and the keep and use stuff another three.

For a 42-year-old boat, the hull gelcoat looked okay, a few dings, but mainly just dirty. The superstructure, however, looked liked it had been painted by a blind monkey with a broom. Even worse, it had been painted pure white rather than the original speckled white. I added a spray paint job to my to do list but, for now, a thorough cleaning would have to do.

The cabin wasn't bad, just dirty, but the overall appearance down below

The cockpit was full of water and loaded with junk.

Original fusebox made of scrap wood.

After the clean up: (top) view of cockpit forward and (bottom) aft.

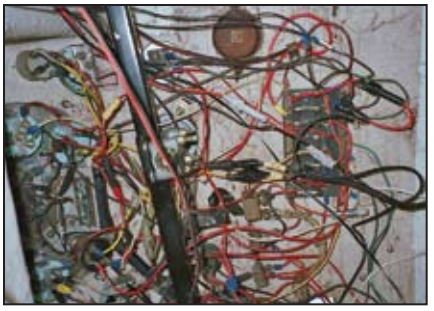
was completely ruined by the spaghetti junction of wires hanging everywhere and the "fusebox" that, best as I could tell, was made of driftwood. Awful woodwork, a tatty carpet and seats and an engine box with odd and superfluous bits of scrap wood nailed to it similarly ruined the cockpit appearance. These were all just cosmetic jobs that would take effort but very little money to put right.

I opted for the old-fashioned method of elbow grease, a bucket of soapy water and a sponge as the way to clean the boat. Even the awful white paintwork looked better after the scrub. I steam cleaned the engine and engine compartment.

With the outside looking less like a tramp steamer, it was time to get cracking with the cockpit and cabin. The cabin was very simple as built, just v-berths and a chemical toilet between the aft ends of the berths. There was no nasty smell to signal the full holding tank but, once emptied and cleaned, the unit was ready for duty. The rest of the cabin required a once-over with a heavy-duty cleaner. The boat was clean. Wiring was next.

Wiring Disarray

I'd already established that the electrics worked so I decided to tidy up the wiring rather than rewire at this stage. I replaced the twisted-together-wires-with-tape-over joints with proper marine grade connectors and terminals as required. In the process, I discovered that half the wires were attached to nothing and getting rid of those made a huge difference.



A wiring mess!

Deck Options

Getting the deck hardware into shape, reviving all the aluminum fittings and sorting out the rubrail and its insert were next on the list. This, at least, would go a long way to improving the exterior appearance.

A nice anchor roller came with the boat but it was unfortunately attached to what appeared to be half a railroad tie that was bolted to the foredeck. Job one was to remove that structure. The six bolts came out without much hassle and my crowbar and I persuaded the wood to separate from the sealant and off came 62lb (28kg) of wood and paint. I built a smartly varnished pad for anchor stowage. The Danforth anchor now sits on this pad and is secured to the main forward cleat while the anchor chain and line comes forward in a bucket when needed.

The perished and faded rubrail and its insert strip were hurting the boat's

(top four photos) Before: Removing the hunk of anchor roller took some persuasion. (bottom photo) After: Anchor now mounts on a nicely varnished pad.

appearance potential. Getting the old insert out took only a good tug, leaving the less-than-perfect aluminum section looking pretty shabby. I used a wire brush and wet and dry sandpaper to clean away the oxidation and most of the pitting but that left the metal dull, even after an attack with metal polish. In my search for a solution, I came across Super Chrome, a metallic spray paint. Testing on a spare bit of aluminum confirmed that I had discovered a grand way to restore all the aluminum, including the shabby cabin windscreen

(top) Aged rubrail insert is replaced with (bottom) a black plastic insert that slips in easily after heating with a hair dryer.

frame and portholes that were really depressing the boat's appearance. It took two hours to mask the metal but only 10 minutes to spray it. The end result was great. Now, I just needed the new rubrail insert.

Boats here don't usually have a complicated extrusion but rather are fitted with just a 1/8" (3mm) thick plastic strip with a slight bend in its longitudinal axis to clip it into the rubrail. Easing the new insert into the aluminum strip was difficult until I realized that a hairdryer in an extra pair of hands was needed. With wife Jane moving ahead of me, warming the strip slightly forward of where I was clipping in, we got the whole 59' (18m) fitted in about 20 minutes.

Paint in a Can

Replacing the cabin door with a new one was a simple job. While I was at it, I removed the wood doorjambs for a good sanding and painting. The lower trim piece was beyond redemption in terms of refinishing but I didn't want to remove it, as it seemed to be semi-structural. The answer was to clad it in white melamine sheeting, capped with a quarter-round wood molding. This was varnished and the small gap behind closed with a bead of sealant. Nice stainless-steel screws gave a finished look to the job.

(top) Before: original woodwork and cabin door visible in bottom right foreground. (bottom) After: new cabin door capped with aluminum U-channel. Instrument panel received a coat of satin black paint to reduce glare.

With the forward area of the cockpit now looking spiffy, I looked aft. Most of the problems here could be fixed by new upholstery and carpet but the outboard lockers and the fuel tank enclosures also needed attention and there was a general need for organization, especially the wires drooping from under the gunwales.

The general appearance was much improved after an hour with cable ties and some cleaning rags. Before I could go further, I needed to make a decision: to paint or not? When the boat first arrived, I obtained a quote to spray the superstructure; cheap enough actually but still more money than I could afford to spend so I decided that I might be able to do it myself, using off-the-shelf paint in aerosol cans. The results I'd had with small experimental areas were pretty good and, at any rate, a huge improvement over what it had been. Based on the sampling, I calculated how many spray cans I'd need to do the rest of the white painted area. Obviously, not the most economical way to do things but I calculated a likely cost of US$100, less than 10% of the quote for a professional spray job. I figured that, even if this DIY job only lasted one season, at least I'd have a boat I could use for that time without wearing a paper bag over my head to hide my embarrassment. I bit the bullet and attacked the superstructure with the orbital sander. There was no going back now! As with my earlier test area, I used two coats of primer and four of topcoat and the end result was pretty good.

I also sprayed the instrument panel in satin black as well as the original trim. This was much more attractive and much easier on the eyes in bright sunlight.

Trim Choices

I replaced the wood on the outboard lockers with some tongue and groove I had on hand that, once varnished, resulted in a pleasing look. I capped the edges of the upright end frames with aluminum U-channel. This looks great and will be harder wearing than wood. After doing this, I noticed in the brochure that the lower edges of the cockpit sides of the boat were originally trimmed in aluminum. This was easily retrofitted with some "L" section, which made a surprising difference in the overall look of the cockpit and tied in beautifully with the lockers and door trim.

The built-in fuel tanks live behind port and starboard wood panels. Bordered with varnished wood, these were easy to refinish but the main panel inserts were made of a plastic veneer with a well-faded finish. I experimented, using both clear and colored varnish, both of which looked awful, to restore the color and then tried white gloss paint, which looked great. So white gloss it was and, with dark varnished trim, it looks good.

Back to Original

Upholstery took my attention next.

Author's wife transfers the stern panel onto the new vinyl.

Recovering the engine compartment hatch.

Recovering the seats was a priority but I had already decided this was a job for a pro. The independent upholsterer we found did a great job for less than US$75 complete.

The removable seats rested on two-part wood pedestals, basically open-topped boxes covered in horrible blue vinyl. All that was needed to make them look good as new was recovering with the cream vinyl leatherette I had chosen to match the original factory upholstery. The top half of the pedestals lifted clear, so I did these first as they could be done off the boat. Recovering these two upper sections went easily, which gave me confidence to do the larger bottom sections that were still secured to the deck. The newly upholstered engine compartment cover, aft bulkhead panel and a matching cushion on top of the engine box pulled the new look together nicely.

(left) Before: Original horrible blue vinyl. (right) After: cream vinyl leatherette covers seats, engine compartment hatch and cushion and stern panel and is a near-match to the original factory upholstery. Note new wood slats along side compartments.

Carpet Substitute

New carpet was the last task in the cockpit. I'd found some industrial-grade carpet tiles and figured that it would be easier to work around all the odd corners and angles using carpet tiles instead of a single piece of carpet or vinyl. Carpet tiles are usually marked on the back to show the direction the nap of the fabric lies. In a house installation, one lays the tiles with

Dry-fitting the carpet tiles.

these at alternating right angles to get a checkerboard effect. Since I didn't want that look on the boat, I had to make sure the nap marks all pointed in the same direction. Particular care is needed when you start cutting tiles, as they tend to just have one arrow mark. Once the tile is cut, it's easy to lose track of which way the piece without the directional arrow is supposed to lie.

Cabin Frills

The cabin now just needed new bunk cushions. It was to be a simple place for rest and storage of overnight gear. We purchased two foam mattresses for a quarter of the cost of custom-sized foam and trimmed them ourselves to the desired size with a bread knife. [Ed: An electric carving knife works best for cutting foam.] We stuck the off-cuts together with contact glue, which gave us another piece large enough to cut two more cushions: a square one to go

Finished cabin with DIY cushions.

over the toilet cover and a triangular filler piece for the vee space between the bunks.

Custom tonneau, stretched taunt and supported with tent poles.

We'd chosen light denim for the covering and sewed the cushion covers together. I've learned that there are only two tricks to upholstery: allow plenty of material for hemming and seams and measure twice, cut once. [Ed: For complete details on sewing cushion covers, refer to page 46.]

A Custom Tonneau

All through this project, the boat had been covered with a tarpaulin but now it needed a proper cover for protection at the mooring and we decided to make this ourselves. The boat already had a line of dome fasteners around the windscreen and we felt that the stern pulpit would give good support and shape at the transom. To hold the aft end of the cover in place, we used the stern cleats to give a stronger anchor point than just snaps. We sewed giant buttonholes with three rounds of reinforcing stitching that fit over the cleats. With the material held in place in the corners, we started a process of trial and error to get the proper shape while we pinned the hems. With the cover attached at about half the final number of fastener points, we were then able to make final adjustments and be sure the cover was tight when all snaps were attached. Based on bitter experience, I know that rain will pool on a cover given half a chance, causing either tears or leaks, so we also built

Close to original decal of the marine park depicted in the TV show.

Modified police light completes the original look. Note refinished aluminum port frames in cabin coaming.

in three leather reinforced sockets to support three tent poles to prevent any pools from forming.

Finish Touches

To complete the Flipper look we needed decals for the mythical Coral Key marine park, the Florida registration letters and the red police light for the cabin roof. During my many sessions watching the Flipper tape in the VCR, I'd found a number of good close-ups of the Coral Key logo and was very pleased with my replication. Using my artwork, a local sign maker made a pair of decals in self-adhesive vinyl that went on without a problem. The faux Florida registration numbering is stock, off-the-shelf stick on characters. The police light doesn't need to work and I found an orange lens cover from a road worker's vehicle at a scrap yard and sprayed it with red paint. The look of my dreamboat was now complete. The final hurdle was getting the engine and sterndrive in shape.

Mechanical Overhaul

The sterndrive looked terrible, even after the major scrub down when the boat first arrived. The whole unit and

(top) Removing the tarry black mixture on the sterndrive proved challenging but, (bottom) after applying primer and paint, it looks like new.

the prop seemed to have been painted in some kind of bitumen. A day of work with an electric wire brush finally removed all the coating, now in the form of horrible black dust. I then sprayed the drive with three coats of aluminum primer followed by three coats of black enamel and the sterndrive looks almost good as new.

When I bought the boat, I was told that the starter motor would occasionally stick and that the steering had recently become erratic "probably due to a stretched cable." In fact, the starter was jammed solid. I also discovered that the alternator was seized and I replaced both units. Other than that, the engine, which had only 120 hours since a rebuild by a previous owner, received a minor tune up and ran just fine. On examining the steering, I eventually figured out the splines were stripped on the steering shaft that connects to the gimbal ring. As I explored the steering problem, I saw

After a steam clean and tune-up and, except for some minor corrosion, the engine ran well.

that the exhaust bellows were split and the U-joint/driveshaft bellows looked a bit dodgy and I replaced all. I already knew that the drive was missing its trim and tilt cylinders, hoses, etc., when I bought the boat. I found a complete set of cylinders, hoses and all, on eBay for US$50 as well as the replacement steering shaft I needed. It was a bit of a mission to sort out the steering but eventually we fitted the new shaft and had everything working fine.

Three months after towing the boat home, I took the helm of the boat I'd dreamed of owning for 40 years. All I need now is a pet dolphin!

Three months after arriving in South Africa, the refurbished Flipper boat awaits launch.

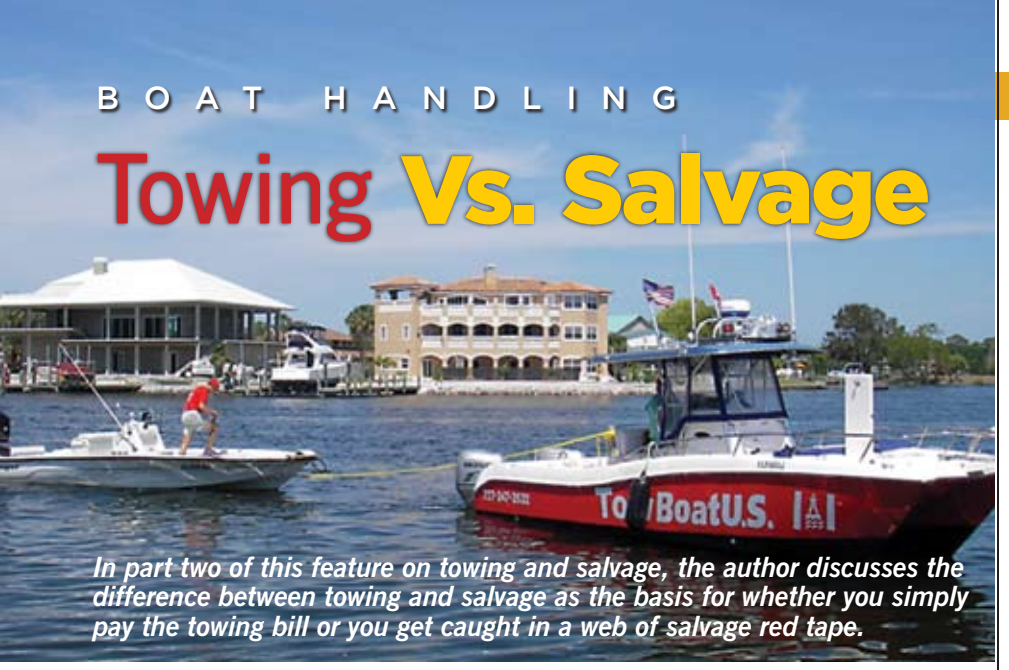
About the author: Kevin Oram is an expat British businessman, currently living in South Africa. He's been messing about with boats for 30 years, sometimes power, sometimes sail, but always ones in need of TLC.

DIY Repair Bill

Cost to purchase the boat and trailer, ship to South Africa from the U.S., and refit parts in U.S. dollars.

Boat and Trailer	$2,000
Shipping, South Africa port costs and transport	$9,223
Refit Components	
Fabric, Velcro, etc.	$100
Carpet	$68
Paint (all)	$114
Replacement stainless-steel pulpit rail (fabricated)	$17
Hydraulic trim cylinders, used	$40
Aluminum trim and miscellaneous wood	$40
Replacement rubbing strake	$15
Miscellaneous fittings (dome fasteners, screws, etc.)	$100
Other miscellaneous (glue, brushes, etc.)	$50
Outsourced Work	
Seats	$100
Engine and outdrive servicing	$600
Total Refit	**$1,244**
Total Boat, shipping and refit:	**$12,467**

Towing Vs. Salvage



In part two of this feature on towing and salvage, the author discusses the difference between towing and salvage as the basis for whether you simply pay the towing bill or you get caught in a web of salvage red tape.

By Scott Croft

When your car breaks down on the road, calling for a tow truck is an accessible remedy. On the water, you have the option of accepting help from a Good Samaritan or, better, you have a towing service plan that can send your local on-the-water tower to assist. The Coast Guard is the superhero of search and rescue but it does not send its resources to deal with dead batteries, empty fuel tanks or non-life threatening groundings. Depending on the circumstances, this is where the auto and boat stories diverge.

The tow truck driver simply hooks up your car and presents you with a bill when you've reached the repair shop. That bill is most likely based on the number of miles towed. The commercial on-the-water towing company, however, could present you with either a towing bill, much like the tow truck driver or a salvage claim. Potentially hundreds or even thousands of dollars can separate the two, so knowing the differences between towing and salvage is key. Who pays the bill? You? Your towing plan? Your insurance company?

What's the confusion? This requires a look back to the age of tall ships when crossing oceans was a perilous job. There were no weather forecasting services, emergency position indicating rescue beacons (EPIRBs) or Coast Guard. Commercial sailing ships had only themselves or other cargo ships to rely on if something bad happened. The problem rested with the willingness of another boat to go out of its way to render assistance, potentially placing itself into peril with its own crew and cargo. To alleviate that concern and to provide an incentive for other ships to invest capital and risk lives to render aid, the salvage award was created. For salvage to take place, it had, and continues to be, any voluntary effort leading to the successful rescue of a boat, its cargo and/or passengers from peril at sea.

Legal Aid

No longer did captains have to forego compensation for taking valuable time and risking peril to their own ship and crew. Under the salvage rules, a percentage of the distressed ship's cargo and/or the stricken ship's post-casualty value could be awarded. Countless lives were saved and valuable cargo prevented from going to the deep because it was in everybody's interest to keep a stricken ship afloat. With ships hailing from many different countries, however, disputes arose over who had jurisdiction over salvage awards. The cure was the one thing most vessels had in common. Lloyd's of London was their insurer.

It was Lloyd's who developed the first Standard Open Form Salvage Contract, which stated where disputes would be settled (London, England) and set forth salvage award criteria. This form remains today as the recognized document for salvage awards in the international shipping community. The factors used to determine the amount of a salvage award today are still the level of peril involved, the experience of the salvage crew and the disabled vessel's post-casualty value. A more recent factor added to that list is the prevention of damage to the environment.

Minutes can make the critical difference in the saving or sinking of a boat and taking time to negotiate while a gale is about to drive your boat on the rocks is not in anyone's best interest. So, a key element that was included in that first Salvage Contract was that it allowed the price of the award to be left open while a salvage operation took place.

Local Support

As recreational boating grew, the Lloyd's form wasn't practical for boaters in North American waters. Having to travel to the U.K. to arbitrate a salvage dispute, the difficult-to-understand British-based vernacular of the form, paying substantial fees to Lloyds to hear a case and the form's foundation based on English law greatly hampered boater's efforts on this side of the pond to resolve salvage disputes.

As a result, the Boat Owners Association of The United States stepped into the fray in 1989 with the simplified Boat U.S. Standard Form Salvage Contract that steers both parties to binding arbitration in the U.S. and keeps a dispute out of the expensive legal system. Today any boater can download the free, easy-to-read form at www.BoatUS.com/salvage.

Towing Vs. Salvage

When compared to a towing job, salvage awards are steep. Your boat's insurance policy is most commonly the source of funds for a salvage award. The greater the peril; the greater value of your boat or, in the presence of environmental circumstances, the greater potential for a large salvage award. Often a salvor negotiates directly with an insurer for the reward. If conditions permit, many marine specialty insurers encourage boaters to contact them immediately upon learning that salvage will take place.

If you don't have insurance, you could be facing a big bill. Keep in mind that it's perfectly legal for salvors, under some circumstances, to arrest your boat if they believe any salvage award is in

jeopardy. If you are uninsured or present some other risk, you may be required to post a bond, in lieu of getting your boat arrested, to provide some type of security to a salvor until arbitration is completed.

Today's commercial towing services got their start in the mid-'80s when the U.S. Coast Guard and Coast Guard Auxiliary stopped providing all but emergency assistance to recreational boaters. While salvage is all about the existence of some degree of peril to the boat and the risk to the salvage crew, towing assistance services serve for the opposite, when very little or no peril exists. [Ed: Part 1 of this topic discusses how to avert a tow and what to do if you need one and appears in DIY 2006-#1 issue.] Since the level of peril can often be subjective, this is the most common source of confusion in distinguishing between towing and salvage.

For example, salvage can include a boat taking on water while tied up safely in its slip on a calm, sunny day. In this case, however, it's usually a "low order" salvage job. The potential for a much greater salvage award exists, for example, if your boat was going down fast and a salvor had to come to your assistance offshore while it was blowing 30 knots and 8' (2.4m) seas running.

Another example of salvage is recovering a boat that's hard aground or is stranded on a federally protected coral reef. Salvage also involves efforts to prevent or mitigate damage to the environment, such as preventing fuel from leaking from a sunk or stranded boat.

BoatU.S. towing service providers, TowboatU.S. and Vessel Assist, are required to inform the boat's captain, before beginning any work, whether the procedure is salvage or towing. If this isn't possible due to sea conditions or absence of the owner, the towing company shall tell the captain as soon as possible. However, boaters should not assume they would always be told, so ask before accepting a towline.

To further protect boaters, BoatUS requires its service providers to distinguish between a simple towing/soft ungrounding job and more expensive salvage job. Conditions that are usually defined as towing, not salvage, include when just one towboat is used with lines attached to a softly-grounded vessel or a grounded boat that can rest without peril until the tide returns to refloat it or a manned boat that is drifting in calm conditions after losing power. Some clear indicators of salvage include when multiple towboats and lines are required or the use of special equipment such as pumps, air bags or the need to deploy oil booms or other containment measures are required.

Value Limitations

The good news is if you need to call for on-the-water assistance, chances are it will be for a simple towing job. BoatU.S. reports that 98% of all calls for assistance to its 24-hour dispatch centers are for towing, not salvage.

Water towing services, like automobile clubs, are either paid through an annual pre-paid towing plan or by the hour from the time the towboat leaves its home dock until its return. Without a plan, you're looking at rates from about US$200 to US$250 per hour depending on the location.

BoatU.S. reports that the average "per incident" cost for towing last year was around US$600 for non-members. That's why pre-paid plans, usually costing no more than around US$140 annually for an "unlimited" plan, could make sense for you. Generally, this means you pay one annual price and there is no cap on the dollar amount when towed by one of the boats in its fleet. You simply sign the towing invoice and go, leaving your wallet in your pocket.

Don't buy more coverage than you need. If you boat on an inland lake, for example, you most likely can't be towed very far. A less expensive annual plan that has a cap of US$350 or US$500 per incident may be wiser. Also, be sure to check online service area maps before you purchase any plan. You can also call your local tower directly for details on its capabilities and offshore distances.

There may also be limits on towing from dock to dock. For example, TowboatU.S. and Vessel Assist fleets provide 100% payment, up to your plan's dollar level, when towing from a restricted use dock, such as a restaurant pier or fuel dock. When getting a tow from a home slip and other non-restricted docks for the purpose of making engine repairs these towers provide 50% payment. Failing to keep your boat in serviceable condition, or perhaps running out of gas five weekends in a row also can jeopardize a towing plan.

If you're ever confused about whether you're about to buy towing services or a salvage job, keep the BoatU.S. Standard Form Salvage Contract aboard. This way you and your towboat captain can sign it immediately, take care of business and arbitrate later when there is less stress on all parties.

We are all going to run aground or have a breakdown someday but, because towing and salvage needs aren't always black and white, the best advice is to prepare yourself for that inevitable bad day on the water by having a pre-paid towing service plan as well as an insurance policy that includes full salvage coverage.

About the author: Scott Croft recently sold his sailboat for a 28' (8.5m) power cruiser in order to take advantage of the "great" fuel prices. He is an assistant editor of BoatU.S. magazine and director of public affairs for the 640,000-member association. He currently cruises on the lower Potomac River in Maryland.

Boat Insurance Tips

When shopping for boat insurance, consider buying a separate insurance policy for the boat, rather than adding it to your homeowner's policy as the latter often limits certain marine-related risks such as salvage work, wreck removal, pollution or environmental damage.

Whatever amount the boat is insured for, your policy should have a separate but equal amount of funds available for any salvage work. This means that you're compensated for the loss of your boat and you won't have to pay additional, out-of-pocket costs to have a wreck removed from a waterway or land. If your insurer can't clearly explain your policy's salvage coverage, it's time to find a new one. [Ed: For comprehensive information on the marine insurance "rules of the road" refer to DIY 2003-#4 issue.] – *SC*

Additional Reading

Tow Sense	*DIY 2006-#1 issue*

Technical CD-ROM Library for Boat Owners

MRT Series

CDs contain articles from past issues of DIY Boat Owner Magazine

$19.95 EACH

Building With Starboard

22 Projects and Fabrication Techniques: The ideal choice for replacing wood components onboard – won't delaminate, rot or splinter and requires no paint.

UPDATED

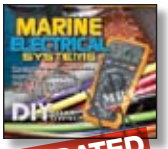
Plumbing 101

A boat owner's guide to the inspection, maintenance, repair, troubleshooting and upgrading of onboard plumbing systems.

DIY Mechanic

Gasoline and diesel engine service. How to maintain, troubleshoot and repair outboard engines, sterndrives and diesel inboards.

AC/DC Electrical Systems



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

UPDATED

Painting & Refinishing

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

Launch & Haulout

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.

UPDATED

Marine Equipment Installations

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.

UPDATED

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.

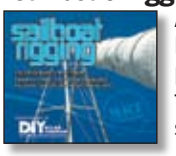
Nautical Necessities

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



A practical guide to deck layouts, equipment repairs, performance upgrades, rig tuning, sail controls and steering systems.

1995 – 2007 52 Issues of DIY:

A technical reference library for powerboaters and sailboaters. The editorial archives of DIY from 1995 to 2007, organized by year and issue from cover to cover.

$99.95

MRT BOX SET

12 of the MRT Series in a custom vinyl case. Power version has Powerboat Rigging and Sail version has Sailboat Rigging.

$119.95
(Specify power or sail)

Making the Electronics Connection

NEW

Provides the information you need to consider when purchasing, installing, operating, and troubleshooting marine electronics for most any layout or equipment and budget in a step-by-step approach.
$19.95

Powerboat Rigging

NEW

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

To order call 1-888-658-BOAT or Shop Online at www.diy-boat.com

PROJECTS

6

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

Give Your Dock a Face-Lift

Easy-to-build custom dock facings protect your boat from pilings and provide an accessible handle to make boarding safer and easier.

By Rich Odato

Jeff King

Dock facings protect your boat and when made of StarBoard, they are environmentally stabilized and the surface never needs refinishing.

DIYers have come up with hundreds of ways to use King StarBoard, a maintenance-free polymer, to improve their onboard experience. King Plastic president, Jeff King, an avid DIY boater himself, devised this simple, yet effective dock facing for his own dock in southwest Florida.

"Polymer facings offer less friction than the wood pilings themselves, so when a passing boat's wake rocks your boat there's less stress and fewer marks on your boat's rub rails," says King. "It also gives your dock a more finished appearance, especially if you're already using StarBoard blocks on the dock surface to protect lines and reduce chafing."

(left) Countersink your bolts so they don't scratch your gelcoat. (right) Details of backing block (standoff).

For each facing, you'll need a 15" by 8' (381mm by 2.43m) piece of 1" or 1-1/2" (25mm or 38mm) thick StarBoard, available through your local chandlery or boatyard as well as two pieces for the standoffs, approximately 7" by 6" (177mm by 152mm). StarBoard sheets come with a mat finish on both sides, so no finishing is required. It's environmentally stabilized and never needs painting or maintenance other than routine cleaning. Adhesives are not recommended when fastening. Instead, always use mechanical fasteners or polymer welding rods. One 4' by 8' (1.21m by 2.43m) sheet makes two facings (US$520 for 1"/25mm) and these are fastened with four stainless-steel lag bolts with washers. Begin by cutting the patterns. This is made easier if you have access to a CNC router but it's certainly within reach of anyone with quality woodworking tools. Allow three hours or less to produce two facings.

Draw the first pattern on a piece of inexpensive wood or plywood at least 3/8" (10mm) thick and then carefully cut out the shape using a jigsaw or Rotozip. Sand and shape the wood piece until you are happy with the edge outline. Note that any imperfections here will be transferred onto the StarBoard. Now, attach the plywood to the top side of the 8' (2.43m) block using either double-sided tape or screws through where the predetermined mounting holes are located. Cut the StarBoard using a router and carbide router bit with two to four flutes and a guide bearing following the edge of your wood pattern. You may need to make partial cuts through the thickness as cutting through 1" or 1-1/2" (25mm or 38mm) with one pass may not be possible.

When each facing is complete, finish the edges using a router equipped with a round-over bit and bearing to break the hard edges. Then, mark fastener location and attach your standoffs to the back side of your fenders using two wood screws. Installation will be easier if these are not loose as the screws keep parts from spinning out of position. Next, counter-bore a hole with a bit deep enough (leave at least 3/8" /10mm of material) and large enough so that the bolts are tucked safely inside the material and away from your gelcoat. Next drill a 3/4" (19mm) hole the rest of the way through the StarBoard and standoff blocks. Note that all holes in StarBoard should be slightly oversized (1/32"/.8mm or more) to allow for the material's natural expansion and contraction.

Each facing attaches to its piling using a 5/8" (16mm) lag bolt. Drill a proper sized pilot hole in each piling. Run a stainless-steel bolt loosely through a washer, the facing and the standoff and fasten it securely into the wood. Test the installation thoroughly to make sure it holds up to repeated use.

— Rich Odato is president of Odato Marketing Group. He cruises Florida's Gulf Coast aboard his family's 36' (11m) Carver, "Kobayashi Maru," and fishes the local flats in his Boston Whaler Dauntless.

Access Full Size Drawings

A dimension drawing of this dock facing is available by clicking here. For readers with access to a CNC router, you can download a .dxf file to feed into the machine and cut the parts automatically at: www.kingstarboard.com/pdf/dock.zip

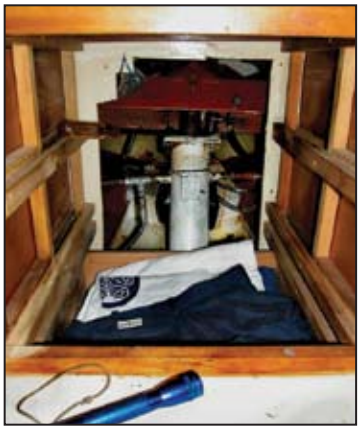
Rudder Stuffing Box Repair

When water squirts in through the rudder stuffing box and fills the bilge, familiarity with their construction helped this voyager to seal a steady leak.

By Michael Batham

7

Stuffing boxes are precocious. Either they leak or they are too tight. The latter, particularly on the propeller shaft, causes them to over-heat, burning the packing. Once this happens, the packing becomes glazed, greatly reducing it's efficiency to seal out the water. Have you ever looked closely at a rudder or propeller shaft stuffing box? Do you know what squeezes against what to keep the water from leaking around the shaft?

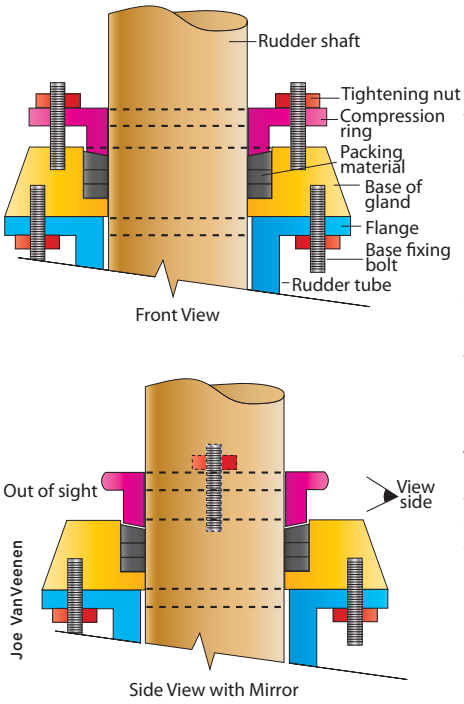


View of the rudder trunk and stuffing box as seen through the drawer space under the bunk.

Stuffing boxes are often hidden away behind the engine, deep under a bunk or in the lazarette. Invariably, as in our boat, just one side is visible and can only be reached with an out-stretched arm. Prior to our departure on a month long passage to French Polynesia, I made a routine check of both engine and rudder stuffing boxes. I decided the rudder needed tightening and could first use another turn of packing material. I slacked off the two nuts and slid the compression ring up. Working mostly by feel in the confined space, I inserted another coil of square-woven, greased packing before reseating the compression ring. From what I could see, the ring had begun to slide inside the base housing, as it's designed to do. So, I tightened down the nuts just enough to allow for the occasional drip when the stern dipped in a swell.

Off the coast of New Zealand, during a three day gale, I found some water in the bilge the first night out and a small weep became a steady flow. The rudder stuffing box, buried deep out of sight under our double bunk, was the apparent source. Without dismantling the bunk, I could only reach it through the back of a drawer space. Thinking the new packing might be a bit dry, I gave the remote grease cup another turn. However, as conditions worsened so did the leak. I had taken the precaution, as I do with many fittings around the boat, of writing the required wrench/socket size in permanent marker on an adjacent, easily visible place. Knowing I had the right sized tool in hand, I reached in and by feel alone tightened the packing nuts.

For the next 48 hours we were buffeted by a deepening low and associated cold front. The bilge water continued to rise. Alarmingly, surging water now flowed into our separate



Schematic of stuffing box shows what was visible from (top) the front and (bottom) the side view as seen with the aid of a mirror.

engine room bilge. I knew the rudder shaft leak was getting worse. The problem had started with the installation of the new packing, so therein must lay the cause of the flooding. In my mind's eye, I visualized the stuffing box from all angles. There is the fixed base of the gland bolted to the stern tube, through which passes the rudder shaft. The rings of packing material are placed in this base, coiled around the shaft. The compression ring fits snugly on the rudder shaft and, as its name implies, it compresses the packing material. Two opposing studs pass through and tighten this ring down against the base. As this happens, the compression ring slides tightly into the fixed base, squeezing the packing material down to evenly compress it around the shaft. This keeps the water out but still allows the rudder to turn.

Detail of stuffing box shows (left) the screwdriver holding up the compression ring and (right) the socket over one of the tightening bolts.

There had to be a simple explanation for so much water coming in. Was it that, when I tightened down the nuts on the two studs, only half of the compression ring had seated into the fixed base of the gland? Had the other edge of the compression ring, out of sight on the aft side, become "hung up" on the lip of the base? This would have resulted in only one side of the packing material becoming compressed. If so, the more I tightened the nuts, the more the packing would deform, thus increasing the leak. I could think of no other plausible reason for the ever increasing flow of water. In the early hours before dawn, when my wife Tere came on deck to relieve me at the helm, I dove below and pulled the bunk apart. With the help of a flashlight and mirror I peered at the gland, now seen at 90° to my normal line of sight. From this perspective, it was obvious that the aft side of the compression ring was cocked up at an angle.

I loosened the nuts, then inserted a wide-bladed screwdriver under the forward side of the compression ring that I could see. As I tightened down the nuts again, this wedge ensured that the out-of-sight side of the ring slid into the

base. When I then pulled out the screwdriver, the visible side slipped neatly into position, the pressure of the two nuts once again being evenly distributed around both the compression ring and the packing material. The non-alignment of the compression ring stemmed from my inability to see it properly and not realizing it had hung-up at the time of assembly.

With the stuffing box properly sealed, we both felt mightily relieved. With water no longer sloshing in the bilges, the seas around us looked less menacing. Somehow, my stomach was still not quite ready for breakfast.

— Michael Batham and his wife Tere have lived and cruised for 14 years aboard their 47' (14.3m) steel ketch, "Sea Quest." They have crisscrossed the Pacific from New Zealand to Japan, from French Polynesia to the jungles of Borneo.

Bridging the Classic Gap

A well-executed teak deck looks striking, offers good skid resistance and enhances the resale value of a boat. If you own a modern yacht but like the traditional look and have time to spare, follow these steps to lay sawn teak planks over a fiberglass deck.

By Andy Pitt

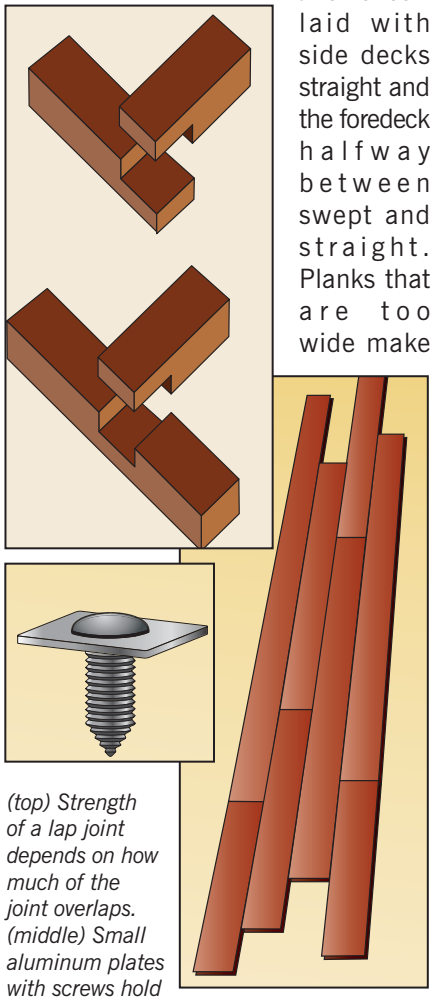
The days of building classic yachts with varnished brightwork, teak decks and caulked wooden hulls are rare and there are very few qualified craftsmen left to undertake such work. For better or worse, the efficiently designed, factory-built fiberglass yacht is the practical option. There are traditions of classic yacht building that many boat owners will not give up and some even taken to an art form. The well-designed and executed teak deck is perhaps the best example of this.

Teak is one of the most stable and durable woods. It's hardwearing, less prone to rot than most all other timber and it's heavy. At 60lb (27kg) per cu. ft (.9 cu. m), it doesn't need to be thick when laid over a fiberglass deck or coach roof when its purpose is strictly decorative. Thickness is related purely to the fastening method. Modern sealants and epoxy glues allow the teak to be reliably fastened to the fiberglass without screws, a saving on weight, labor and the cost of the teak. Still, some boat owners prefer the teak planks fastened with screws and plugs for the authentic classic look. If using screws and plugs, the minimum thickness is about 3/8" (10mm) as the grain plug needs to cover the screw head and have enough wood over it to allow for wear.

The cost of sawn teak for an average 35' (10.6m) sailboat is about US$3,500 plus about US$1,900 in adhesives. One person with reasonable skills and basic hand tools can fit a teak deck.

Plank Arrangement

Planks can be laid parallel to the outside rail (swept), straight or a combination of both. By far, the most attractive is the swept deck but, on motoryachts with large flared foredecks, the planks are often laid with side decks straight and the foredeck halfway between swept and straight. Planks that are too wide make the deck look heavy and ungainly so a 35-footer (10.6m) has planks of about 1-3/8" (35mm) wide. Caulked seams that seal the gap between the planks must match the plank width and the overall length of the yacht. Teak decks with excessively wide caulking seams look ugly so, if in doubt, make the seams narrow. A 35-footer has seams of 5/32" (4mm).



Joe VanVeenen

(top) Strength of a lap joint depends on how much of the joint overlaps. (middle) Small aluminum plates with screws hold planks in place. (bottom) Stagger the joints, allowing a distance of 9' (2.7m) to the next joint.

The covering board is the first wide board at the outboard edge of the deck, running parallel to the toerail. It's wider than the other deck planks and this accentuates it. On some boats, a waterway, 3" to 4" (7.6cm to 10cm) wide, is left at the edge and painted white, a nice contrast to the teak. The covering board is cut and fitted first, followed by the margin boards around the main superstructure and fittings.

It's often difficult to find really long pieces of teak so deck planks have to be joined. The ends of planks, margins or covering boards, are joined by a plain, half lap joint where one overlaps the half thickness of the next by 1-5/8" (40mm). The planks must have the same run or layout on both sides of the boat; a butt joint at a point on the starboard side deck must have the same joint at the same point on the port side deck. Planks must not butt at the same place across the boat unless there are at least two, preferably three, planks between them before using the same point again. A distance fore and aft must be at least 9' (2.7m) to the next plank butt.

The center fore and aft plank is called the king plank and this runs parallel to the centerline. It's much wider than deck planks and usually tapers slightly at the bow and stern. All deck planks that meet the king plank are notched into it.

Fastening the Teak

It's best to adhere the planks, margins and covering boards to the deck and coach roof with marine adhesive or good quality epoxy resin glue. Clean the teak and fiberglass deck with acetone or other degreasing agent before gluing. Apply a primer to the teak and allow it to dry. Now, apply Sikaflex 221, 3M 5200 or epoxy glue to the deck to about 3/32" (2mm) thickness. Fit the

Additional Reading

"Teak Deck Care: A guide to maintaining, refastening and recaulking teak decking," in DIY 2002-#4 issue.

"Teak 101," in DIY 1999-#2 issue, reports the results of teak cleaners.

These articles and more are available on DIYI's MRT Series "Painting & Refinishing" CD-ROM — how to apply antifouling to aluminum, fiberglass and steel boats and underwater running gear, to oil or varnish brightwork, to paint bilges, to apply modern polyurethane paints to decks and topsides, and to get professional results every time.

planks one at a time and hold each in place with heavy weights like lead, iron or concrete cones. Alternatively, make small aluminum plates about 2-3/4" (70mm) long and 1-3/16" (30mm) wide with a #10 screw hole in the center. Screw these into the plank seam bridging, about 8" apart (20cm), and compress the planks either side. To prevent bonding, coat the screws and plates with mold release.

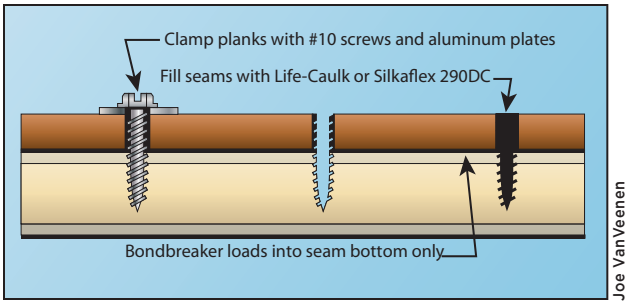
Grain Plugs

Grain plugs, if you have to use them, are cut and tested to find a firm tight fit. Choose an off-cut of teak from the same piece as the plank or the same color and density. Cut a number of plugs in a strip. Fit each grain plug with epoxy resin glue with the grain running in the same direction as the surrounding timber. Drive them home and allow the glue to dry. Cut off the excess plug with a super sharp wood chisel along the grain, about 3/32" (2mm) above the deck and then shave down carefully with the chisel or sand off.

Preparation and Caulking

When all the deck planks have been laid and the plank seams cleaned and made equal in width, plane and sand the deck until smooth and level. Clean and vacuum the complete deck until dust free. Clean caulking seams with soft rags dipped in acetone to remove the surface natural oil from the teak. Apply a primer, Sika 290DC/215 in this case, to increase the bond between the teak and the rubber compound. When dry, fit bond breaker or release tape, such as 3M Fine Line masking tape or 3M 233+, into the bottom of the seams. [Ed: Available in 1/8" and 5/16" widths, BoatLife Bondbreaker is sold in the DIY Store at www.diy-boat.com.] This prevents the caulking compound from bonding to the bottom of the caulking seam but to the side only. When the teak deck moves with moisture and drying, the rubber seam moves, connected only to the sides, and doesn't break. The caulking compound, Life-Caulk or Sikaflex 290DC, is filled into the seams from the cartridges or sausages. The usual practice is to have a 1/8" (3mm) wide hole in the cartridge tip placed in the bottom of the seam. By pressing and moving the cartridge towards you the seam fills from the bottom up. Generally, there are no air bubbles but, if these appear, take a wet spatula or finger and gently press down on the caulking while pulling it toward you. When dry, usually after two days, the complete deck is sanded with a belt sander.

Screws are removed, seam bottoms are filled with a bond breaker then the gaps between seams are packed with caulking.



Joe VanVeenen

Care and Upkeep

Prior to launching, it's a good idea for the completed deck to be sealed with a suitable, no gloss, invisible sealer, such as Hemples Teak Sealer. [Ed: Commercial sealers are a watered down version of varnish. You can make a sealer by thinning a single-part varnish, such as Epifanes, by 50% with the recommended thinner.] This will keep the dirt out of the wood grain for many months. Depending on your location and air pollution levels in your area, decks need cleaning at least once a month. Teak decks must not be cleaned with high-pressure cleaners or wire brushes. Heavy scrubbing with

Note covering board and plank layout around cockpit locker hatches, cockpit sole and cabin top.

(left) Same diameter teak planks are notched in a matching king plank on the deck hatch. (right) Note plank details around skylight.

• TIP •

Installing Teak Decks

1 Planks will be 5/16" to 3/8" (8mm to 10mm) thick and about 1-3/8" (35mm) wide for a 35' to 40' (10.6m to 12m) yacht. Most boat builders recommend using quarter sawn teak, which means the grain of the wood is 90° to the deck. This is the most stable and hardwearing timber. In fact, boat builders cut and fit as best possible. It's important the teak is dry, reading 10% to 12% moisture on a moisture meter (the kind used for lumber, not fiberglass). If the teak is too wet, cut the planks and lay them in the sun for a week or so. Keep the wood dry and clean.

2 Apart from basic joinery tools like wood chisels, a hand plane, saw, electric drill, jigsaw and small router plus a small workbench are all that are necessary. A small band saw can be put onboard or next to the boat. An electric screwdriver is a big help if using hold-down plates.

3 It's worthwhile to draw up the centerline on the deck and pencil in some of the deck planks. Any deck faults will be readily apparent. There may be a difference (port and starboard), for example, in the distance from the centerline to the covering board and the same number of planks must fit and meet at the same point. If the distance is not the same, the smaller side can have all the planks planed by a small amount (say 1/64"/.25mm). After fitting all the planks, the eye won't detect a difference.

4 Glue planks with Sikaflex 221, 3M 5200, epoxy resin glue or other adhesive. Ask your dealer for a user brochure, which gives all the information you need plus many tips. Sealant cartridge guns are available and often provided free by the sealant supplier.

stiff brushes will remove the softer wood fibers leaving a rough and uneven surface. The best cleaner is brown soap, which has natural oils.

It's difficult to quantify the value of a teak deck as beauty is indeed in the eye of the beholder. Teak decks have good slip-resistance value but some say they are hot in the tropics and require too much maintenance. This is for the individual owner to decide but wood is a natural product and most agree wood is beautiful. The resale value of the yacht may increase but, for most owners, this is not the main goal. A production boat that incorporates some individuality and some of the traditions of classic yacht building is a choice without much compromise.

Completed deck prepared with teak sealer is strikingly beautiful.

— Andy Pitt is skilled in building and refitting yachts, fishing boats and small ships and currently is project manager at Concordia Yachting in Thailand.

Blueprinting Hull Bottoms

Hook, chine and rocker — these lines tell a lot about how your boat performs.

By Roger Marshall

Next time your boat is out of the water, stand back and carefully examine the hull from one side. Notice the line of the chine, where the topsides meet the hull bottom and the hull bottom on the centerline, known as the keel. What do you see?

Look at the chine first. It probably sweeps down from the bow to the stern and straightens out horizontally as it nears the transom but look at it carefully. If it sweeps up high at the bow, the vee part of the bow sections become very knife-like. This hull shape excels when hammering into big seas. It's also a very wet shape, so boats that have a high chine line forward often have flared bow above the chine to keep the deck dry. A good example is a Carolina skiff.

Where the chine doesn't sweep up high at the bow, the bow sections likely have a shallow vee. Such boats are designed to run in flat water and they also have a fairly low transom deadrise angle. A flats boat, for example, has a fairly low vee-shaped bow, usually because the boat operates in shallow water so there's no need for a bow that slices into waves. Deadrise angle at the transom probably runs only 3° to 8°, if that, and a wide beam keeps it stable.

Now, look at the chine at the stern. On most high-speed boats, the chine runs in a straight line from about amidships to the transom, a typical shape of a boat intended to plane. On slightly slower, semi-displacement hulls, you might see the keel turn downwards slightly as it nears the stern. Some people call that hook; designers call it a wedge. A wedge helps to control the trim of the boat as it accelerates onto a plane and while it runs on semi-plane. If you've ever seen a semi-planing boat at speed, you'll notice that it has a high trim bow angle, often obstructing visibility forward. Adding a wedge or hook to the underbody aft reduces the trim angle. At the design stage, however, extreme care must be taken to determine exactly the right amount of hook. Too much can make the boat run really flat and squirrelly; too little has the same effect as having no hook at all. Usually the amount of downward curvature is determined by tank testing a model. A wedge operates most efficiently at one speed, usually cruising speed. For hull trim to be balanced across the entire range of speeds, adjustable trim tabs are strongly advised.

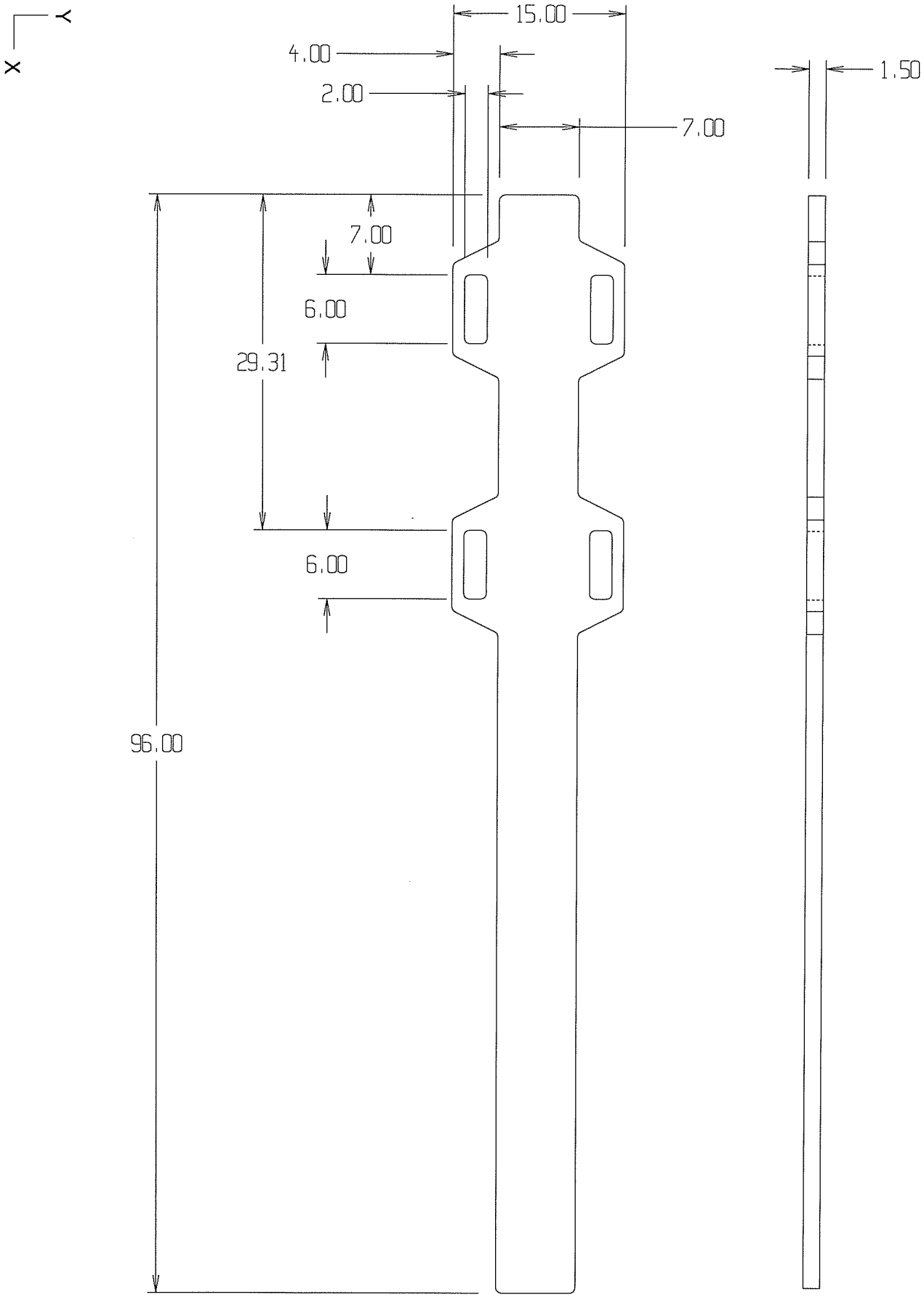
Albeit this trawler has a flared bow, mounting strakes near the waterline further reduce spray.

Chine on this boat runs in a straight line from amidships to the transom, a typical shape of a planing boat.

Now look at the hull's centerline. A sweet curve from bow to stern turning upwards at both ends is called rocker. The best example of rocker can be seen on a canoe. Long, seagoing canoes have little rocker so they move in a straight line as the paddler digs the paddle in on one side and then the other. Slalom canoes that need to turn quickly have a very rounded bottom from stem to stern. When thinking of rocker, think of a soup bowl. It's rounded on all sides and can easily be pushed through the water in any direction. That's the ultimate in rocker. Rocker allows a boat to turn easily. Lack of rocker helps the boat track straight. Generally, boats with a lot of rocker are not intended to plane. Rather, they are intended for optimal maneuverability.

So the next time you look at a boat when it's out of the water, think about the hook, chine and rocker. They'll give you some clues about the performance of the boat's hull.

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 he is the president of Boating Writers International.

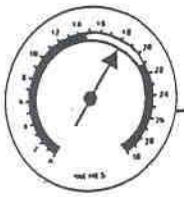


CONTENTS/ BACK TO ARTICLE

Troubleshooting with a Vacuum Gauge

Most Engines Will Have a Normal Gauge Reading of 15 to 21 Inches of Vacuum. Before Using Vacuum Gauge, Engine Must Be at Normal Operating Temperature. Distributor Advance Must Be Working Properly and Ignition Timing Set to Specifications. Use Tachometer To Be Certain That Engine Is Running at Specified RPM. Vacuum Gauge Must Be Connected to Intake Manifold.

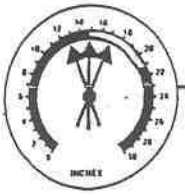
Following Chart Indicates Possible Malfunctions of Various Vacuum Readings.



Average and steady at 15-21 inches	Normal

Extremely low reading with indicator holding steady	Air leak at intake manifold or carburetor; incorrect timing; underpowered boat; fault in boat hull

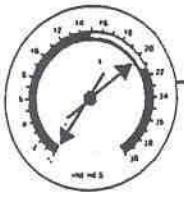
Indicator fluctuates between high and low reading	Blown head gasket between 2 adjacent cylinders (check with compression test)



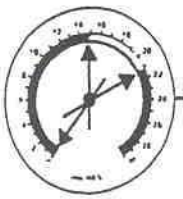
Indicator fluctuates very slowly, ranging 4 to 5 points	Carburetor needs adjustment, spark plug gap too narrow, valves are sticking

Indicator fluctuates rapidly at idle – steadies as RPM is increased	Valve guides may be worn

Indicator continuously fluctuates between low and normal reading at regular intervals	Burned or leaking valve



Indicator drops to zero as engine RPM is increased	Exhaust system is restricted



Indicator holds steady at 12 to 16 - drops back to zero and back to about 21 as throttle is engaged and released	Possible piston ring leak (check compression)

CONTENTS/ BACK TO ARTICLE