2001-#1

DIY boat owner

the MARINE MAINTENANCE MAGAZINE

ODE-to-CO

What is carbon monoxde? How does this deadly gas get into your boat? How can you protect yourself and others? Read this article than follow our guidelines to minimize the chances of CO's intrusion in your boat

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A Wet Start; Premium Junkyard Oil Changer; Storage Steps

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Drilling Stainless: Tricks of the trade when alterating or adding to stainless-steel components.

By Wayne Redditt

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Solar Solutions: Determine how much solar power is right for your onboard power needs, then use one of these mounting solutions.

By Kevin Jeffrey

SAILBOAT RIGGING

Steering Tune-Up: Here's how to troubleshoot, maintain and service cable wheel steering systems.

By Nick Bailey

GOOD BOATKEEPING

Custom pet doors; Easy-to-make pedestal guard.

By David & Zora Aiken

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Tech Tips A collection of boat-tested hints and tricks.

DIY MECHANIC

RETROFITTING FRESHWATER COOLING

Converting an engine from seawater to freshwater cooling is simplified with a custom cooling kit. With these instructions, you can add a heat exchanger system that is properly sized for your engine at minimal cost.

By Robert Hess

Removing Engine Scale

This product effectively removed all lime and rust deposits and marine growth from the seawater cooled passages in this 30-year-old engine.

TUNE UP

INSTALLING DECK HARDWARE

Step-by-step how to install deck hardware when a cabin headliner is in place.

By Nick Bailey

FITTING OUT CHECKLIST

A personalized guide to inspecting your boat's exterior, interior, onboard systems and boating gear.

By Susan Canfield

CUSTOM PAINT JOB

Not commonly seen on boat hulls, a fading paint job looks stunning and is easy to do, especially on lapstrake hulls — just count the laps, do the math and paint!

By Seward Owen

PROBLEM SOLVING

Of all the maintenance problems boat owners face from time to time, these 9 seem to be the most common.

By Nick Bailey

ELECTRONICS

PLUGGED IN

Here's the latest in power and sailboat electronics packages for staying in touch, navigating, handling emergencies and onboard entertainment.

By Charles Husick

MAINTENANCE

ALL ABOUT INFLATABLES

A professional tells you how to maintain your boat to ensure longevity, improve it and effect repairs when necessary.

Currents

Fuel Pump Found

Imagine our surprise when the DIY 2000-#4 issue had a drawing of the very fuel pump we have been searching for. Our 1986 Endeavour 42 center-cockpit sailboat that we purchased two years ago has been refitted for an extended cruise. After a fuel-water problem with the boat's Perkins 4154 diesel, we replaced the fuel lift pump and filter. Duplicates could not be found as the pump bears no marking, so we installed another brand, but it doesn't work well. "Getting to Know Your Diesel," in the 2000-#4 issue has a picture on page 26 of an exact match. I'm an employee of West Marine and have ample access to many sources but no one in the "business" can identify this pump. Could you please provide the supplier's name? Thank you for your excellent articles. *Donna Cass, Warwick, Rhode Island*

This pump sells for US$225 and is available from Vetus (tel: 1-800/G0-VETUS; website: www.vetus.com; email: vetus@aol.com).

Hands-on Westerbeke

I always look forward to receiving DIY magazine, and I have been a faithful subscriber. Regarding Phil Primm's question in "Talkback," 2000#4 issue, page 8, titled "Tips for No Starts," and your answer, I'd like to share my experience with other Westerbeke owners. I had similar problems with the Westerbeke 33 in my CS36. The "clicking noise" he hears is likely the hourmeter on the engine panel that commences ticking when turning the key to the "On" position. After applying the glow plugs, he should count four or five ticks, around 20 seconds, then dwell (let the glow plugs heat the air in the cylinders), then repeat this cycle. Glow plug leads need to be properly sized, and if so, they will not have any voltage drop across them. The one item that you overlooked, and should have warned Primm about, is the damage that unspent diesel fuel can have on the bearings. This unspent fuel ends up in the sump and lowers the viscosity of the lubricating oil. My engine was misdiagnosed with ring problems to the tune of $5,000. Instead, a qualified and trusted diesel mechanic rebuilt the injectors and reset the valve lash to the spec of 0.010" for $700. The engine purrs like a kitten now and it's easier to start, even when cold. The Westerbeke is a quality diesel, but the injectors are a weak link. With #2 diesel having next to zero lead, the injectors aren't lubricated sufficiently, so it's necessary to rebuild them more often and use a good quality additive to increase lubricity. *Don Donaldson, "Leighway II," Scarborough, Ontario*

A4 Info Wanted

I would like to review all articles on Atomic Four engines. *Robert Bell, "Casper," Anacortes, Washington*

There are two DIY issues covering these engines. A step-by-step rebuilding appears in 1997-#4, and the 1998-#2 issue has a complete list of all technical bulletins and product cross-referencing. You can order these issues by calling us toll-free at 1-888-658-2628 or order in DIY ONLINE at www.diy-boat.com and click on "Subscriber Services," then "Back Issues." The cost is US$7/CDN$9 each plus $2.50 each for shipping and handling.

Solution Searching

Is there an archive for previously asked questions? It would save time if an already answered question was viewable or searchable in an archive of questions. Many boaters have the same problems or will soon experience them. It would be helpful to know about other's experience, or, if having once read about a problem, one could revisit the issue in the archives, and recover the solution. *Doug Wade, "Reel Action," Vancouver, British Columbia*

You can search the Q&A and Techtips from the past 5 years on DIY ONLINE by clicking on "Search" from the home page. It's not a great search engine, and will be upgraded soon, but it works and brings up all occurrences for a particular keyword. If you don't find an answer to your question, email us and we'll get you an answer.

More Bird Poop

There are three methods I use to dislodge birds. Using monofilament line, hang CD discs at different heights from the deck. They reflect and turn in the wind, causing the birds to keep moving. On the swim platform, deck and other flat surfaces, I place large rubber snakes, bending them several times. Birds, like humans, don't like snakes.

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Although this last method isn't very attractive, it works really well. Wrap your wire lifelines with silver-colored tinsel. This stops birds from landing, as they can't see the thin wire and don't like the look of the tinsel. *William Myers, Racine, Wisconsin*

A solution we use to rid our 10.6m (35') Chris-Craft of nesting swallows is to cut blue plastic (we use the bags our newpapers are delivered in) into 2.5cm (1") lengthwise strips. These are then tied at the center at about .9m (3') intervals on the lifelines and left on for two to three weeks. *A.E.Burr, "Fancy Lady," Brechin, Ontario*

Winners of DIY Draw

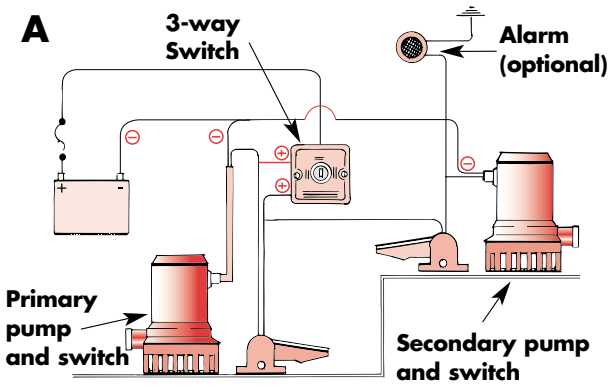
Winners of DIY's 2000-# 3 Product Information Card Giveaway who received a Clymer Engine Maintenance and Repair Manual are: Curtis House, Delray Beach, Florida; Harold Balch, Springfield, Massachusetts; and T. Pedersen, Surrey, British Columbia.

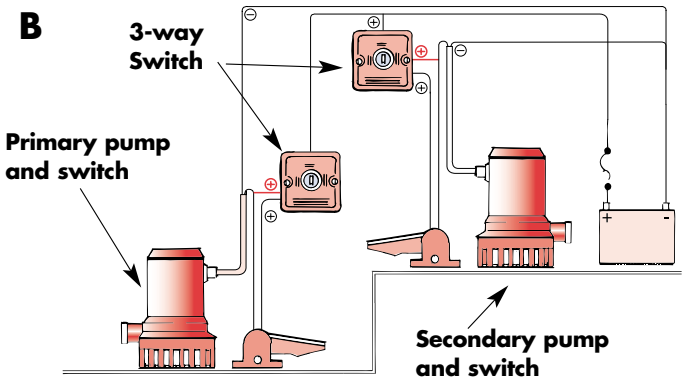
Bilge Diagrams Revised

In the bilge pump article in DIY 2000 #1, on page 16, wouldn't a three-way switch have two positive leads coming from it? Hence the name three-way switch. One lead directly to the pump for the manual side and the other to the float switch for the auto side. And furthermore, in diagram 4A, what is that ground lead doing coming off the three-way switch? Am I hallucinating?

Scott Hamilton, "Our Calm," Napa, California

Nick Bailey responds: You're correct on all points. The three-way switch must have two positive leads, one for manual "on," which is missing in both drawings, and one for automatic "on." The ground lead in diagram 4A does appear to connect with the positive power lead going into the three-way switch. The usual convention for electrical drawings is to show it "hopping" over a circuit to which it's not connected. Worse than that, the drawing shows a ground coming off the switch, which gives a dead short when the switch is closed. All switches live entirely in the positive circuit. [Ed: Below are amended drawings (revisions are in red), for you to photocopy then paste into the corresponding page in the 2000-#3 issue.]





Talkback Q+A

Search past Q&As for answers to hundreds of boat, engine and gear problems @ www.diy-boat.com

Spare Power

Q: My new boat has a 24-volt DC system consisting of four, 12-volt batteries, two in series on each side of the switch. I would like to increase the capacity of the banks. How would you suggest putting eight batteries into two banks in this system?
Mark Carey, "Assassin," Freemantle, Australia

A: You can put another battery in parallel with each bank (for a total of 6 batteries), or two batteries in parallel with each bank, for a total of 8 batteries. For best performance, however, you should only combine batteries of similar age, size, etc. in a bank. You can accomplish this by putting the four older batteries in one bank in a series/parallel configuration, and the four new batteries in the same setup. I prefer to minimize the number of individual batteries (and therefore cells) in a bank, so I usually recommend getting larger batteries to create the required bank.
— Kevin Jeffrey

Alarming Alarm

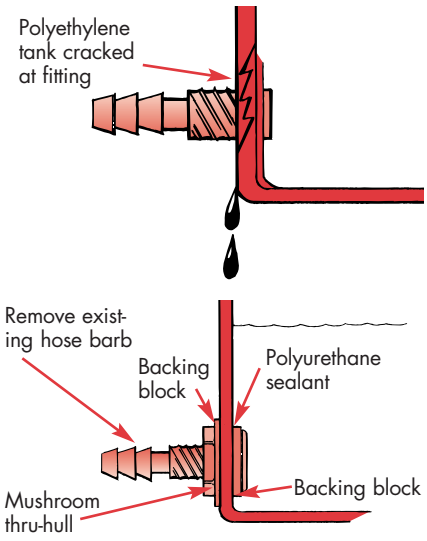
Q: An alarm on my 1994 180CC SeaPro sounds every time the key is turned to the "On" position. I assume it's the alarm on the 90-hp Mercury outboard, because no other equipment is on. I have plenty of oil in the reservoir. The engine feels cool to the touch and is discharging a steady stream of water. What causes this alarm besides the lack of oil or an overheat condition?
Paul Kaus, Severna Park, Maryland

A: Overheat and lack of oil are the only items the audio alarm module on your engine recognizes. If the problem is oil-related, the audio alarm signals an intermittent beep, while a steady beat indicates an overheating problem. Check the float switch (open/closed switch) in the fuel tank, oil level, oil warning module and the overheat sensor, also an open/closed switch, on the block. If all checks out, it's likely the audio alarm module. We had a similar problem with a 1990 150-hp Mercury on one of our test boats. The alarm's ground wire is fed a constant 12 volts and can short to ground, or it may be a pinched wire. To check, use a multimeter, starting at the horn on the harness at the panel and working back following the ground wire. The repair manual for your motor outlines testing of the audio alarm system. In our case it was a faulty alarm.
— Jan Mundy

Band-Aid for Tanks

Q: My Northern 25 has a plastic water tank that has cracked at the fitting. Is there an easy fix that doesn't involve removing the tank?
Joe Sancroft, Pickering, Ontario

A: It's possible to repair polyethylene tanks, but it requires special tools and techniques. A cracked tank is usually repaired by welding with molten polyethylene. The tank will need to be removed and taken to a specialist shop. Although a proper repair cannot be done with the tank in place, I have seen a tank repaired while in place. That tank



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was cracked where a fitting threaded into it. The original threaded fitting is removed and replaced by a mushroom-style thru-hull of the same thread size. This is not guaranteed to work simply because sealants don't bond well to polyethylene, but it may be worth a try.
— Nick Bailey

Power Away from the Dock

Q: We purchased a 14.6m (48') 1983 Hilburn houseboat last year and have been restoring it to a livable condition. I plan to install a power source to handle the refrigerator, lights, TV and VCR; we don't plan on running the air conditioning while away from the dock. I am considering an inverter and a 4 kW generator to recharge the inverter batteries, if needed, and as a power backup, if necessary.
Larry Davis, "Coming Home," Wichita Falls, Texas

A: You are definitely on the right track. If your battery bank is large enough, or your load small enough, you can easily run your loads on the inverter while away from the dock. Battery bank size and type of electrical loads determine how long you can do this before needing to fire up the generator, or initiate some other charging source. [Ed: Turn to page 12 for solar panel selection and mounting options.]
— Kevin Jeffrey

Keel Fairing

Q: I'm trying to find an article that will give me step-by-step instructions on how to fair a lead keel. Is there a DIY article on the subject?
Robert Thomas, "Whisper," Rock Hall, Maryland

A: Lead keels are relatively easy to fair to the correct profile with accurate templates and the proper procedure, unlike cast iron keels, which are rarely symmetrical or fair, because they are molded in a horizontal position. The easiest and most widely used approach for fairing keels is what some people call the sheet-rock-taping approach. This is accomplished by covering imperfections with fairing material. Smoothness can be quickly achieved with this process. The fairing process involves first getting the keel to the correct thickness, and then getting the shape right. The key is getting a symmetrical, well-shaped keel of proper size and thickness. This is nearly impossible without a template. Divide one side of the keel into horizontal "stations" and make half templates of 1/4" plywood of the required curve sections at these measured stations. Make an epoxy fairing compound of 50/50 microspheres and colidical silica with slow cure epoxy resin mixed to a peanut-butter consistency, and apply by trowel. Lay your templates over the correct elevation on one side of the keel to obtain your starting profiles, then run a flexible batten laid on edge over the compound to fair the surface between stations. Continue placing the template in position and fairing with the batten. Do this on both sides of the keel. Once cured, sand with 80-grit paper. Recheck the profile with the templates and batten. Sand the high spots or fill the low spots. To find the high spots, rub colored chalk on the template and batten edges. Ideally, the profile on both sides should be equal for your boat to be equally happy on either port or starboard tacks. When faired as desired, cover with three coats of unthickened epoxy resin, or use an epoxy primer, followed by antifouling paint. Fairing a keel with a half template takes a great deal of effort to get the keel the correct thickness and shape. An option would be to purchase full-size templates from Computer Keels Company (612/829-5670, email: Compukeel@aol.com). The company offers templates for the more popular production boats.
— Jan Mundy

Rod Rigging Repairs

Q: We have a 21-year-old traditional CS36 with Navtec rod rigging. The boat is raced and cruised about five months each year and has never been in saltwater. Other than visual inspection, is there any other way to determine potential rigging failure? Does rod rigging need replacement after a certain number of years? Do you have any information about a two-part dye system designed to look for "hairline cracks" and would this be appropriate as a diagnostic tool?
Joe von Heymann, "Syndrome", Port Elgin, Ontario

A: Navtec recommends doing a visual inspection of rod rigging at least annually and before any long passages. Testing by a dye penetrant, X-ray, ultrasonic and other means can cost more than replacing the rod. Instead, clean the rod and fittings, then use a magnifying glass to inspect for cracks. One of the first areas to

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crack is at the rod head where it's terminated. Look for corrosion, pitting and rust, all of which is accelerated in a saltwater environment. Replace any bent rod. Any bends or kinks are cause for concern and result in local stress and possible failure. Though some riggers recommend replacing all rod rigging after 10 years, it's not uncommon for older boats to have rigging that's 20 years old. Obviously, if your mast hasn't fallen, or a shroud hasn't broken, replacement may not be a critical issue. As a rod package for 36-footer costs about $8,000, budget-conscious boaters often replace a few shrouds every year. Navtec's web site (www.navtec.net) has an excellent Q&A section on rod rigging along with maintenance tips.
— *Jan Mundy*

How Not to Boil Batteries

Q: Is leaving a battery charger on all the time recommended? I inspect and check the water level in boat's wet cell type batteries every 45 days, usually adding a little water each inspection. *David Sanderson, "Cruzan," Newark, Delaware*

A: Some battery chargers have high-performance charging characteristics and shut off completely when the batteries are fully charged. The TrueCharge models (formerly Statpower now Xantrex,) and most inverter-chargers operate this way. This type can be left plugged in indefinitely without harm to the batteries (barring a malfunction). Ferro-resonant chargers, and less efficient or unregulated models (auto type) should definitely not be left plugged in longer than the time it takes to bring the batteries back to full charge. I suspect that more batteries have been damaged with these types of chargers than any other single cause. The fact that you have to add water so frequently tells me that the batteries are regularly, even if mildly, overcharged. My advice is to get another charger or only use it when needed.
— *Kevin Jeffrey*

Merc Cooling

Q: I plan to convert the 5.7L MerCruiser Alpha 1 in my 1991 Searay 185 to a closed-cooling system. Do I need a separate seawater pump to supply enough water to the heat exchanger? *Gordon Kachmarski, Spruce Grove, Alberta*

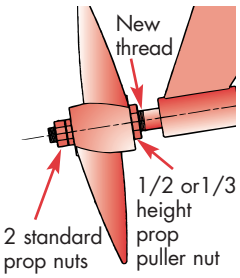
A: MerCruiser recommends installing a belt-driven seawater pump on V-8 Alpha stern drives to supply the needed water volume to the water-pump impeller, except if boating in water temperatures below 15°C (60°F). Most often the belt-driven pump is fed via a thru-hull with a seacock. This allows you to perform maintenance on the seawater pump without hauling the boat. In a raw-water cooled engine, the water supply hose connects from the pump on the stern drive to the thermostat housing. When converting to closed cooling, the belt-driven water pump now supplies the thermostat housing. You can either discard the existing water-pump impeller in the drive, and plug the outlet at the transom assembly so your boat doesn't sink, or reroute the hose as the pros do so it sprays water over top of the driveshaft housing to keep it cool when underway. Refitting your engine, requires the closed-cooling kit, part number 91036 Alpha1, and costs CDN$1,388 plus applicable taxes. The recommended pump is part number 46-72774A56 and costs CDN$532. Both are available from an authorized MerCruiser dealer.
— *Jan Mundy*

Tip — Don't Trash Your Wrap. Recycle it!

Heaps of plastic shrinkwrap fill the boat yards every spring awaiting transfer to a local landfill. Dr. Shrink, the Michigan-based supplier of shrinkwrap, installation equipment and supplies, offers an alternative. For US$8.95 you can ship your used shrinkwrap cover and scraps to Dr. Shrink for recycling. You purchase the company's self-contained Rebag kit, consisting of a large clear bag imprinted with cover removal and packaging instructions, and a prepaid UPS return label. When full, deliver the bag to a UPS drop-off center. One Rebag holds a cover from a 8m (26') powerboat, or about 55.7 sq. m. (600 sq. ft.). Rebags are available at marinas or contact Dr. Shrink at 1-800/968-5147; web: www.dr-shrink.com, or email: drshrink@dr-shrink.com.
— *Jan Mundy*

Tech Tips ✓

BUILT-IN PROP PULLER: Instead of carrying a prop puller onboard, permanently attach a puller nut to the prop shaft. Thread on a half-height or one-third height nut forward of the propeller, and then attach the prop and retaining nuts. Don't forget to secure the installation with a cotter pin through the shaft. To remove the most stubborn prop, loosen the prop nuts, then back off the puller nut. *Dave Gerr, Gerr Marine, New York, N.Y.*



DRIP CATCH: Tie a rag around the paintbrush handle to prevent paint running down the handle of a brush when in use.

SURGE CONTROL: Use slow-blow fuses with an inverter and windlass to avoid nuisance tripping.

FILTER OUT RUST: To eliminate rust buildup that clogs the carburetor and fuel pump in the integral steel fuel tank of a small outboard, it's common to clean the tank by rattling loose nuts and bolts around inside with mineral spirits. This loosens some of the rust, but not all. Here's a better idea. Purchase a small fuel filter with hose barbs of the same ID as the fuel hose. You can get the filter from an automotive supplier for about $3. Cut the fuel hose midway, and connect the filter with hose clamps. Fuel flows readily through the filter and you won't need to rebuild carbs or pumps. *Bruce Colman, "Solaro," Ottawa, Ont.*

SWEEP THEN WASH: Give an old dust mop head new life and wear it as a mitten for washing your boat.

CUE CARDS: Photocopy and laminate the operating pages of your electronics manuals and stow them near the helm. *Goerge Van Nostrand, Keswick, Ont.*

ONLY IN EUROPE, PITY: If you're continually misplacing your deck plate key, either a slot or two-prong type, needed to remove open deck plates, a better design, and one that gives a more positive grip is opened with a standard winch handle, a common fitting on European-made sailboats.

HOSE FLUSH: Flush sanitation hoses with a solution of 30% water and 70% vinegar to remove sewage odors.

DRAIN TRAP: Since all sink and shower sump drains should be fitted with a trap, a quick fix for drains lacking this feature is to make one by cutting twice the length of hose required and coiling it into a single loop before attaching it to a sea-cock.

LOCKING NUTS: Dab some nail polish, paint or varnish on bolt threads, and then screw on the nut. Once cured, the nut can't back off, yet is easily removed by a socket wrench if necessary.

STICKING PARTS: To momentarily hold a nut, washer or other parts in place when reassembling, apply a dab of thick grease, such as Mercury Triple Guard.

SEND YOUR TIPS

If you have a boat-tested tip you'd like to share, send complete information along with your name, boat name and home port to: DIY Tech Tips, P.O. Box 22473, Alexandria, VA 22304
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Projects

A WET START

Many Chrysler V-8 inboard engines, especially 318ci models, have the seawater pump mounted high on the engine. It's often positioned above the waterline causing the pump to loose its prime when the boat is hauled for servicing. This can result in a burned out impeller on the next engine start-up.

After loosing two impellers, I found a solution. Purchase a check valve of the same ID as the engine water hose and install it on the hose at the water intake thru-hull fitting. After a quick two-day haul out, water pump prime was fully maintained.

— George Van Nostrand, "Dreamweaver," Keswick, Ontario

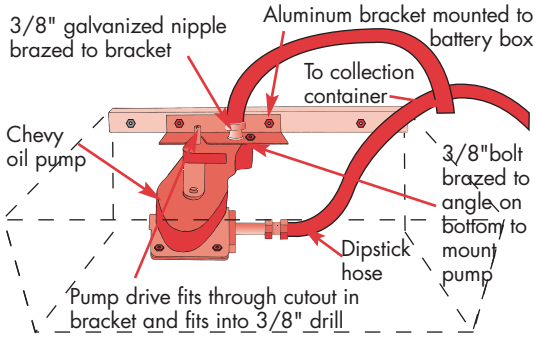
PREMIUM JUNKYARD OIL CHANGER

With two 350ci engines, two transmissions and a gen-set all requiring regular oil changes, I needed a good oil-change system. After sampling different models of the inexpensive, rubber impeller oil change pumps, I decided to make a real pump.

From the local junkyard I bought a big block Ford oil pump. This is driven by a hex-shaped shaft easily chucked into a 3/8" variable speed, reversing drill (don't forget to get the driveshaft, too). Then to the hardware store for some fittings and small diameter suction hose to fit into the various dipstick holes on the engines and a short length of garden hose. An old, plastic battery box served as a platform for the pump, since the pump weeps oil during the process. It makes a nice carry box for the unit and coiled hoses.

The pump worked as planned, except when running, it gyrated badly, so holding the pump and drill was a two-hand affair. A yoke-shaped aluminum bracket was cut and bolted to the pump with the yoke fitting around the drill to hold it in place. The whole apparatus cost about $25.

Evacuating some 13L (3.5gal) of oil now takes less than 15 minutes from the time I open the hatches until all the oil is in the collection container. Carry the old oil to your local Jiffy Lube for recycling (a call to the local EPA informed me of this convenient option), or to your nearest oil recycling station (see "Dial to Recycle Oil" on page 23).



You can also make one using a Chevy small block oil pump, but as it's driven by a slotted connection from the distributor, you need to make a driveshaft of 3/8" rod with a screwdriver-shaped end ground into the end, and add a collar (plastic tube works) on the shaft to keep the slot from wandering out of the pump.

— Michael Myers, "Wendy Lynn," Baton Rouge, Louisiana

STORAGE STEPS

My boat is a 6.7m (22') 1940 U.S. Navy wooden lifeboat converted to a pocket cruiser, and has a 66cm (26") drop from the cockpit into the cabin. For several years I used a two-step plastic stool but was never satisfied with its appearance, which was not very nautical and a mismatch for the teak and mahogany interior.

Since space is always at a premium on any small boat, I designed new companionway "stairs" as a storage box. Hinged steps double

Removable storage "stairs." (bottom) Assembly details showing placement of cleat stock.

as lids for access to storage compartments that provide about .2 cu. m (2.5 cu. ft) of additional space.

Sides, front and back are built of 19mm (3/4") fir plywood, glued and fastened with stainless-steel wood screws through 2.5cm (1") solid wood cleat stock to reinforce edges and corners. Lids are made of solid 2.5cm (1") solid teak, 2.5cm x 25cm (1" x 10"). Iron-on wood veneer finishes the plywood edges on the fronts and sides.

As the unit is free standing, the addition of two teak grabrails gives it a boaty look, and makes it easier to lift the structure out of the boat when required. It was then stained with a teak tone, followed by a few coats of a clear finish, such as Epifanes Woodfinish. For safety, I was careful not to finish the step treads to a high gloss. *— Bert Small, "Sea Eagle," Salt Spring Island, British Columbia*

-Tip- Breathe Easy

Shop Tested

We should all wear a respirator when sanding, grinding or buffing, but few of us do. Here's a lung protector that removes all objections. The 9211 N95 particulate respirator from 3M is the Cadillac of "masks." A three-panel design conforms to different face sizes to fit snugly against the chin and nose so it doesn't creep up on the face. A valve reduces heat and humidity build up inside the respirator; when particles adhere to a wet mask, it becomes plugged so the wearer can't breathe. It's comfortable, feels good on the face, and is designed for long wearing. Now what's your excuse? *— Jan Mundy*

ShopTalk

DRILLING STAINLESS

Drilling stainless steel poses a major challenge. Here are some tricks of the trade for the do-it-yourselfer dealing with alterations or additions to stainless steel components.

Story and photos by Wayne Redditt

Stainless-steel hardware is ubiquitous on boats built in the past 30 years. Unlike wood and some other materials, it's unlikely to be supplanted by another alloy anytime soon. Stainless finds service in bolts, rivets, shafts, bearings, rails, stanchions, wire rigging, cleats, barbecues and just about any other application requiring a corrosion-resistant metal.

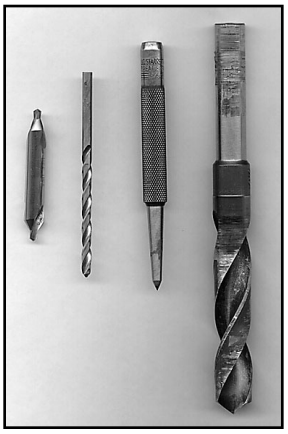
What is "stainless" steel? All stainless steel is primarily iron with smaller percentages of chrome and other corrosion-resistant elements. No steel qualifies as "stainless" unless it contains a minimum of 10.5% chromium. Generally speaking, corrosion resistance increases with increased chromium content. Stainless steel must also exhibit a characteristic known as passivity. The chromium in the alloy has an affinity for oxygen and creates a passive surface layer on the steel. The most common alloys used for boat hardware and components fall into the 304 and 316 designations. These numbers distinguish the percentage of alloying components within the steel. The 304 type has approximately 18% chromium and 8% nickel as major alloying elements, hence the commonly heard 18-8 designation. The 316 type has approximately 17% chromium and 13% nickel.

As stainless steel is worked by cutting, drilling, bending, etc., it exhibits a hardening or strengthening, a characteristic known as cold working. In other words, as you drill, the material may get harder as you go through. Commonly a drilling operation will start out smoothly, then part way through the drill gives up and will no longer cut the material. Edge destruction of the drill usually occurs soon thereafter. Did the drill become dull first causing the failure, or did the material become hard, causing the drill to fail? Either effect requires a solution.

The general rule that cannot be ignored when drilling stainless is low speed, high feed. Whenever possible, drill stainless on a drill press. The force applied on the drill press is greater and more controlled than that applied with a hand drill. Set the spindle speed to the lowest speed the machine is capable of achieving. If hand drilling, set the machine on its low speed range.

Center punch the material prior to drilling. This prevents the drill from wandering off course when starting the hole. Apply coolant lubrication in the form of a tapping/cutting oil, available from most machine tool suppliers. Very little is needed, but it's highly recommended, particularly on larger sized holes. Once the cutting has started, don't stop or slow down until you are through. On larger holes, slowing the cutting action sometimes allows the material to work harden and become difficult to cut.

According to John Bamford of

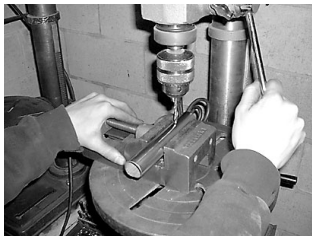


Tools for drilling stainless steel: center drill, a small pilot drill, center punch (actually a prick punch), reduced shank drill (9/16" to 1/2").

Stainless Outfitters (tel: 705/725-1779; web: www.stainlessoutfitters.com), a custom marine fabrication shop, the best drill bits to use are the HSS (high speed steel) jobber types. These provide the best value for the money. Avoid the titanium-oxide coated bits. The surface coating that gives these the fancy gold color quickly wears off and does nothing to enhance drilling stainless. Similarly, the special tip grinds that are available are not recommended for cutting stainless steels. Just plain old fashioned, general-purpose jobber drills are the tools of choice. They will wear out and even break frequently if you drill enough stainless. Tip regrinding is fairly straightforward, and many simple machines are available for drill pointing. If you drill infrequently though, they are not worth the investment. Drill bits are like files in that regard. Just

discard worn out tools and replace with new sharp ones.

Bamford recommends first drilling pilot holes. This means that you begin drilling with a smaller bit than the final hole size. For example, if you are drilling a 12mm (1/2") hole through 6mm- (1/4"-) thick stanchion base material, you should not start with the 12mm (1/2") drill bit.



A small section of pipe drilled in a press.

To drill stainless steel, begin with a center punch mark. Drop a small droplet of tapping oil on the mark. Chuck a 1/8" general-purpose bit into your drill. If hand drilling press down hard on the mark with the drill bit and then trigger the drill. You have to press hard enough to actually flex the bit. Any less pressure than this and the material will work harden. Once the drilling has started, complete the cut as quickly as possible. This means pressing heavily on the bit. If a nice curl starts to come off the bit, try to maintain that cutting speed and feed. If you get through the material without breaking the bit, congratulations!

Follow this with a 6mm (1/4") drill bit. Dab on some oil. Press hard. Flexing a bit of this size will almost always break it, so be careful. Next use the 12mm (1/2") drill bit. Most hand drills will not accept bits of this size. There are bits made with turned shanks that allow chucking in a 3/8" chuck. This whole operation is simplified on a drill press. I never change from the slowest speed my machine can run, regardless of the bit diameter. This method applies to stainless only, as other alloys require quite different strategies.

If the drill turns blue while drilling, it's almost certainly turning too fast or is damaged in the tip area. HSS drill bits are not ruined if heated to blue, and can be repointed, and put back into service. It's not at all unusual to see lots of smoke created when drilling through stainless, as the oil burns in the hole. Stainless steel is a very poor thermal conductor and the heat doesn't travel far from the hole. If there is heat discoloration though, buff the stainless back to a shiny condition. Generally, the shinier the surface, the better the corrosion resistance.

The easy way to buff out discoloration.

About the author: Wayne Redditt has 20-years experience in design, construction and repair of small craft built of wood, composite and metals and teaches engineering technology programs at Georgian College of Applied Arts and Technology, Barrie, Ontario.

Electronics

SOLAR SOLUTIONS

Once you establish how much solar power is right for your onboard power needs, a little creativity can help you find practical mounting solutions for a functional yet visually pleasing installation.

By Kevin Jeffrey

Photovoltaic (PV) solar panels are a great way to charge batteries on any power or sailboat. These technological marvels are able to convert light into electricity with no noise or moving parts, and they do it with greater efficiency (over 16%) than standard incandescent light bulbs can change electricity into light (10% efficient). Their advantages are becoming well known, but boat owners still face the sometimes-daunting task of finding suitable places to mount solar modules.

Boat types and the owner's preferences impose limits to how much solar power to include onboard. There are several ways to determine the right number of solar panels for your situation. One approach is to simply include one or two medium size solar panels (50 to 100 watts of total power) in your battery charging mix. This gives you a good introduction to solar panel operation, as well as an opportunity to see how solar panels affect your battery charging needs and the appearance of your boat. You can always add more panels later. This is particularly easy if your charge control is sized to handle additional current (see "Key Components" on page 17). Another approach to determining how much solar power to have onboard is to put as many solar panels on your boat as you have space and money for. You could also estimate your total electrical load, and select a panel to match your consumption **(Figure 1**). Though more scientific, this method doesn't guarantee a perfect match as there are so many variables, such as mounting location, geographic area, time of year. Whichever approach you take, the first step is to review the various types of solar panels on the market and their mounting options.

Selective Options

There are three basic types of panels: standard models with glass cover and aluminum perimeter frame (Kyocera, Siemens, BP Solar, Solarex); semi-flexible marine panels with a polymer cover and rigid backing plate (Solarex MSX-L panels); and fully flexible models (Unisolar). When planning for solar panels, keep in mind that, for best performance, the panels should have good average exposure to direct sunlight throughout the day. Unlike home solar installations, there is usually no "south" side to a boat, so your best option for permanent mounting is to install the panels horizontally, facing up. You can increase performance substantially if your panel mounting allows you to pivot the panels into the sun, but be aware that getting those extra amps can become tedious, and you can actually decrease solar performance if you forget and leave the panels pivoted in one direction. Another consideration when mounting panels is that thick, dark shadows can diminish solar output dramatically, although fully flexible panels have blocking diodes between strings of cells that minimize this effect.

With this in mind, let's look at the various mounting options.

Deck Mount

The classic solar panel mounting location is on an unobstructed area of the boat's cabintop or deck. Semi-flexible marine panels, such as the Solarex MSX L-series, are best for deck mounting in areas where the crew may walk. These panels can be stepped on without harm, although I recommend you avoid mounting them in areas of high foot traffic. Since these panels are thin and can assume a slight curve, they are fastened directly to the deck, passing the fasteners through rubber grommets in the corners of the panels (**Figure 2**). The grommets protect the deck and keep the panels just above the deck surface, allowing for some necessary airflow. Fully flexible panels are also mounted on the deck, although they are put to better use on soft surfaces such as biminis and dodgers. You cannot step on rigid solar panels. If you do deck mount them, it's best to do so on hardtops or other places well away from normal foot traffic. When mounted on sailboat hardtops, leave ample space on either side of the boom for access to the

Electronics

mainsail and to prevent the panels being shaded by the boom and sail cover.

The best way to deck mount a rigid solar panel is to provide two parallel rails (**Figure 3**). Fashion the rails from teak and secure to the deck with screws. You can build up fiberglass rails, and fair them into the glass deck surface. Either way, construct the rails so the panel is recessed yet still has airflow underneath. Fasten the panel to the rails with screws or pivoting clips that allows easy removal of the panel when in port so you can keep it faced into the sun. [Ed: "Good Boatkeeping" in DIY 2000-#1 describes how to make a combination teak handrail and support rail for solar panels.]

Hatch covers seem like a conve-

Figure 1

POWER CONSUMPTION WORK SHEET

To estimate your daily power consumption, make a chart with four columns. You can also download a system sizing worksheet from Siemens Solar website at www.siemenssolar.com/marine.

Column 1: List all DC appliances (lights, radios, fans, clocks, etc.) and all AC appliances (microwave, computer, etc.)

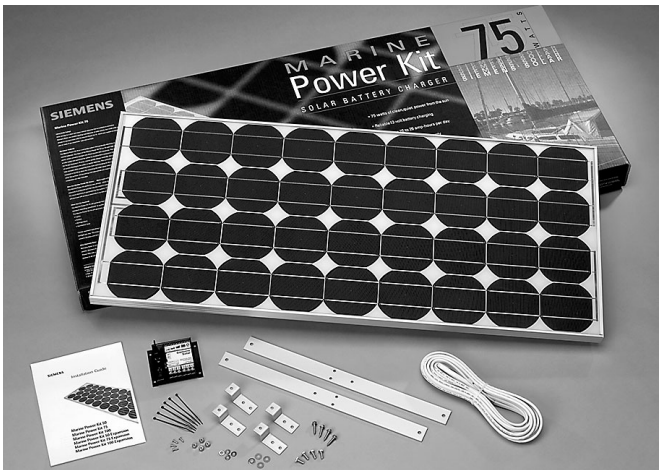
Column 2: List the power usage in amps for each appliance.

Column 3: Write down the number of hours each appliance is used every day.

Column 4: Multiply the number of amps for each appliance times the number of hours and write the value in this column. This represents the power consumed for each appliance (amp-hrs/day). Total this column.

To determine the size of solar panel(s) needed, divide the total power consumption obtained from Column 4 by the power output from the solar panel(s).

Note: Manufacturers' power output specs are usually based on "ideal" light conditions and vary greatly with mounting location, time of year and geographic area.



Siemens rigid solar panel kits available in 10, 50, 75 and 100 watts, include charge controller, mounting hardware and 7.6m (25') of wiring.

nient place to mount solar panels, but there are several drawbacks. Hatches are usually located along the centerline and any above-deck obstructions (i.e. a sailboat boom) shade the panel. It's often difficult to find panels of exactly the right shape, and if the hatch is transparent or translucent, the panel tends to block the light and view, and may restrict hatch operation.

Rail Mount

Stern rails provide a convenient mounting location for standard or semi-flexible marine solar panels. Solar panel manufacturers supply rail mount kits that consist of plastic rail clamps, either 19mm or 25mm (7/8" or 1") in diameter, attached to aluminum mounting struts sized for the width of the solar panel. The panel attaches to the struts (**Figure 4**). Panels mounted in this manner can be rotated about the rail to increase performance or tilted out of a passageway. Rail mounts also allow solar panels to be easily removed. There are four variations on the rail mount theme.

To mount to a stanchion, some solar suppliers offer an angled piece of stainless-steel tubing that attaches to a stanchion with a double set of rail clamps (**Figure 5**). Solar panels are mounted to the outer part of the tubing using a regular rail mount clamp set. In this arrangement, the panel can be rotated about the tubing, and the tubing can be rotated about the stanchion, allowing the panel to face directly into the sun regardless of boat position or time of day. This rig is especially useful when in port.

Another clever rail solar panel mounting system is stanchion-to-stanchion mount. Sold as a kit, it creates a rigid section of rail tubing at the top lifeline between two stanchions (**Figure 6**). The lifeline passes through the tubing that attaches to each stanchion with special adapters. This arrangement allows you to mount even large solar panels where they can be rotated to seek the sun or tilted outboard in a passageway.

Davits are a convenient place to mount standard solar panels. A davit mount kit features a piece of stainless-steel tubing installed between the davits (**Figure 7**). This tubing not only allows a solar panel to be mounted with a standard solar rail mount kit, but also gives the davits better resistance to lateral movement.

Mounting solar panels on a stern arch can be a variation of a deck mount or a rail mount, depending on your method of attachment. The simplest approach is to weld or bolt horizontal struts, the width of a solar panel, onto the top rail of the arch (**Figure 8**). The solar panel bolts directly to the strut in a fixed position. Another approach is to weld a smaller diameter rail 19mm or 25mm (7/8" or 1") over the top bar of the arch. The upper rail provides a convenient place to attach standard rail mount hardware, which allows the panel to pivot into the sun, yet easily removed if necessary.

Bimini/Dodger Mount

Biminis and dodgers are great places to attach fully flexible solar panels. Fully flexible panels are less efficient, which means they take up more space for a given power output, but that extra space is often available on large areas of canvas overhead. Fully flexible panels are attached using their corner grommets or by actually sewing them onto the bimini or dodger fabric. When choosing a mounting location, make sure that the panels will not be directly shaded by the boom or other overhead obstruction.

For those trying to maximize solar charging potential, rigid panels can be mounted on a separate metal tube frame installed over a conventional bimini. Alternatively, you can skip the soft bimini and simply create a "solar bimini" consisting of two arrays of standard solar panels, one on each side of the boom. For additional weatherproofing, a

MOUNTING OPTIONS

Figure 2 *Semi-flexible panels mounted directly to a catamaran deck with corner fasteners.*

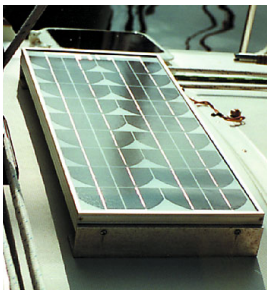


Figure 2 *Rigid panel mounted on top of companionway hatch roof on raised aluminum brackets allow airflow underneath.*

Rigid panel mounted to tube arch on stern.

PAUL SHARD

PAUL SHARD

Panels securely mounted to tube supports that fasten to bracket on stern tower.

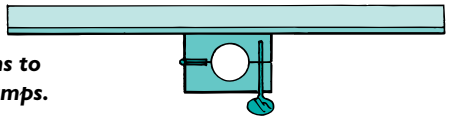
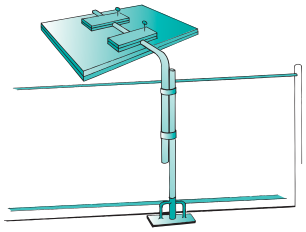


Figure 4 *A rigid solar panel fastens to the boat's stern with rail mount clamps.*



DAVID AIKEN

Figure 5 *Stanchion mount kit consists of a curved pole that pivots outboard or inboard and fastens to a stanchion with rail mount clamps so the solar panel tilts up or down.*

Figure 6 *A pivoting stanchion-to-stanchion mount secures the solar panel on a rigid piece of metal tubing secured between stanchions with rail mount clamps.*

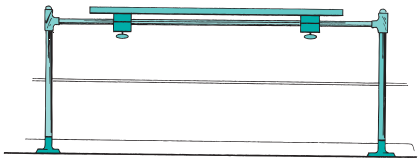
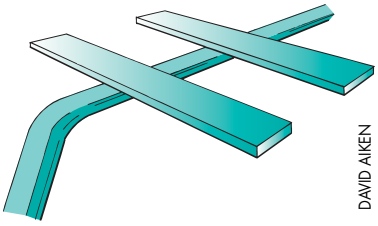


Figure 7 *Panels mounted on metal frame suspended between davit arms.*



DAVID AIKEN

Figure 8 *Two metal struts bolted to a stern or radar arch make a convenient place to fasten a solar panel.*

strong yet lightweight rigid hardtop can complement, or even replace, the metal tube frame. This arrangement is especially practical on catamarans or beamy monohulls. A healthy dose of ingenuity can help you find practical mounting solutions that don't detract from your boat's appearance while allowing the panels to have good average exposure to the sun.

About the author: Kevin Jeffrey is an independent electrical power consultant, and is the author of the "Independent Energy Guide" and the publisher of "Sailor's Multihull Guide," now in its second edition.

KEY COMPONENTS

To make your solar installation complete, you'll need the following components.

Wire. Properly sized two-conductor wire rated for marine use. Even though the current is relatively low, the length of a run can be substantial. Size the output wire for no more than a 3% to 5% voltage drop.

Deck plug. A high quality deck plug to lead the solar output belowdecks to the charge control. Make sure the plug is rated for the maximum amperage expected.

Charge Control. A charge control sized for the maximum amount of solar current for present and future needs. New solar controls on the market have pulse-width-modulated (PWM) circuitry for efficient charging, and either analog or digital monitoring of solar current. Some type of current monitoring — a simple analog meter with a full scale close to the full rated output of the panel(s), a digital ammeter, or a complete system monitor such as the Link 10 from Xantrex, the BTM1 from Mastervolt, or the TM500 from SALT — is essential for accurate tracking of solar performance.

Diodes. Only a few panels on the market have built in blocking diodes that allow unshaded portions of the panel to keep working near full capacity, or a main diode to prevent reverse leakage at night. Most charge controllers supply reverse leakage protection, but you may need additional diodes, especially if you have panels mounted port and starboard wired in parallel. Diodes allow an unshaded panel(s) to produce full power if the other panel(s) becomes shaded.

Fuse and disconnect or circuit breaker. A properly-sized fuse or circuit breaker should be placed as near the battery being charged as possible; some convenient method of electrically disconnecting the panels — a fuse or circuit breaker rated slightly above the rated output of the solar panel(s) — makes for a good installation.

DIY COOLING MECHANIC

RETROFITTING FRESHWATER COOLING

Converting an engine from seawater to freshwater cooling is simplified with a custom cooling kit. With these instructions, you can add a heat exchanger system that is properly sized for your engine at minimal cost.

By Robert Hess

Many modern marine engines are fitted with a freshwater or closed-cooling system that recirculates an engine coolant (a 50:50 solution of antifreeze and water) through the engine instead of seawater (**Figure 1**), which is the engine coolant in raw-water cooling systems (**Figure 2**). In a freshwater system, seawater cools the engine coolant in a separate heat exchanger. Since the coolant never comes in contact with the engine block, it never has a chance to corrode or build up scale in the engine water jackets. This eliminates the main drawback to the raw-water system.

Because raw water, especially saltwater, precipitates out salts and minerals when it reaches a temperature above 66°C (150°F), raw-water cooled engines usually use a 60°C (140°F) thermostat. Although this reduces scale buildup in the engine water-jacket cooling passages, it also causes increased engine wear, valve and ring sticking, and poor fuel economy. (Most engines are designed to run at a temperature of at least 82°C (180°F). Fitting a heat exchanger allows the use of an 82°C (180°F) thermostat, which provides all the benefits of hotter running, as well as allowing the addition of an engine coolant water heater (heats water via engine heat exchange).

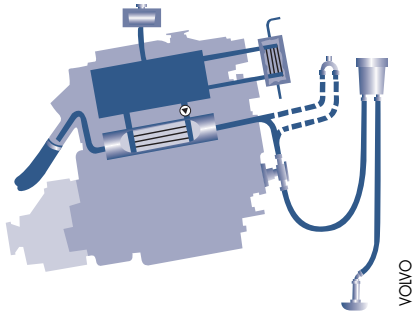
Marine engine heat exchanger design, theory, corrosion protection and pressure testing was discussed extensively in "Water Cooling Systems," DIY 2000-#1 issue, and step-by-step maintenance procedures in "DIY Mechanic," DIY 2000-#4 issue. This article discusses the specification, purchase and installation of a heat exchanger system in a boat fitted with a raw-water cooled system.

Contrary to what the name implies, a freshwater cooling system doesn't mean all the raw-water components have been replaced. Actually two separate sub-systems are created in the engine cooling system that include a seawater (or raw-water) system and an engine coolant (or freshwater) system (**Figure 3**). On an engine purchased with a freshwater cooling system as standard equipment, the engine manufacturer fits the required heat exchanger and extra water pump. When retrofitting a freshwater cooling system to a raw-water cooled engine, you install a similar heat exchanger and water pump. Difficulty and cost of this procedure varies depending on the condition and configuration of the engine and boat, and your mechanical skills.

Choosing a Kit

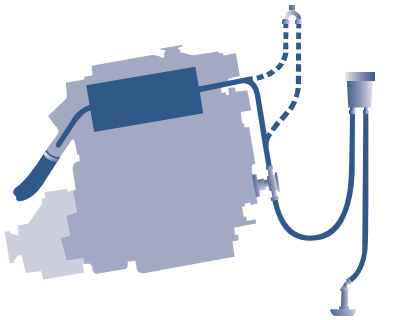
All major marine engine manufacturers, Caterpillar, Cummins, Detroit, Kubota, MerCruiser, Volvo Penta,

Figure 1



Freshwater (closed) cooling.

Figure 2

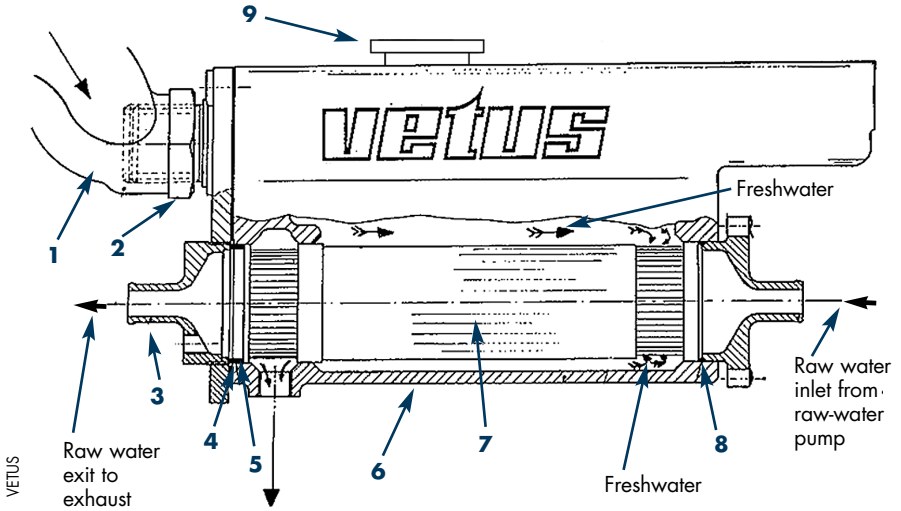


Seawater (raw-water) cooling.

Yanmar and Westerbeke, sell freshwater cooling kits or individual freshwater cooling parts for their engines. Such kits come with all components necessary to retrofit raw-water cooled models with freshwater cooling. Purchase a complete kit (US$970/CDN$1,500 plus thermostat), if available, to obtain the correct heat exchanger, water pump and other parts properly sized to your engine.

Manufacturers usually discon-

Figure 3

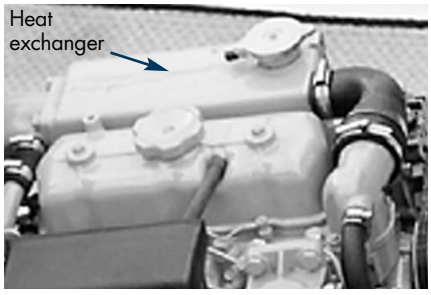


Cutaway of a combination heat exchanger and exhaust manifold illustrates raw water and freshwater systems. 1 Injection elbow; 2 Nut 1" BSP; 3 End cap; 4 Gasket; 5 Rubber O-ring; 6 Aluminum housing; 7 Tube stack; 8 O-ring; 9 End cap.

tinue stocking kits for older engines after sales drop off, and don't stock complete kits for engines that were freshwater cooled originally, just individual replacement parts. Volvo Penta, for example, only stocks kits for 6- and 8-cylinder gas engines sold in the last 10 years.

When ordering a kit, you'll need to supply detailed engine information such as year, model and serial number. This is important since engine manufacturers modify kits as engine specs change. MerCruiser's accessory catalog, for example, lists pages of kits by engine year and serial number range. When it's not possible to obtain an engine manufacturer's freshwater cooling kit, for size and type recommendations consult an independent heat exchanger manufacturer (Sen-Dure, San Juan, SeaKamp, Monitor, Orca) or a marine engine dealer experienced in installing heat exchangers.

Figure 4



Horizontal heat exchanger unit mounted close to exhaust manifold.

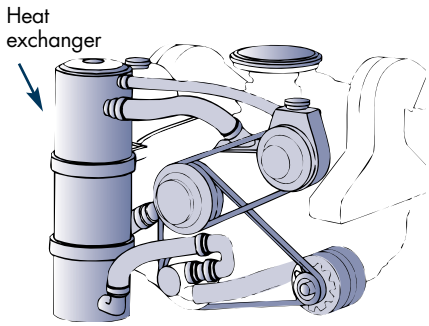
Configuration and Location

There are two basic heat exchanger configurations: a horizontal heat exchanger unit mounted on the engine, usually close to the exhaust manifold as shown in **Figure 4**; and a vertical heat exchanger unit mounted remotely from the engine on an engine compartment bulkhead (**Figure 5**). Many engine-mounted freshwater systems use the exhaust manifold as the heat exchanger header (a.k.a. expansion or surge) tank (**Figure 6**).

Before deciding whether an engine-mounted or remote heat exchanger should be installed, you need to confirm the size of the heat exchanger. Engine cooling systems dissipate the waste heat generated by the engine, which is approximately 1/3 of the energy of the fuel consumed. Roughly another 1/3 of the energy is released as heat in the exhaust gas, and the remaining 1/3 is transformed into useful work to move the boat and charge the batteries. Extensive calculations can be done to determine the correct size of the heat exchanger cooling tube size and coolant capacity, however, in practice, the size required for any common engine is obtained by asking the engine manufacturer or a heat exchanger supplier.

Most conversion kits include an engine-mounted heat exchanger. In some cases, it may be necessary to determine whether there is actually room to fit one before ordering a kit. If there isn't room on the engine due to the configuration of the engine compartment, you'll need to substitute a remote heat exchanger or modify the engine compartment. Select a mounting position, keeping in mind not only heat exchanger size, but also location of the header (or expansion) tank fill cap which must be at the highest point of the system and easily accessible for filling and checking the coolant level. If the heat exchanger has an integral expansion tank-fill cap, it must be located so that the cap can be removed for filling the system and checking the level. If the tank-fill cap is a separate piece, it must be mounted slightly higher than the heat exchanger.

Figure 5



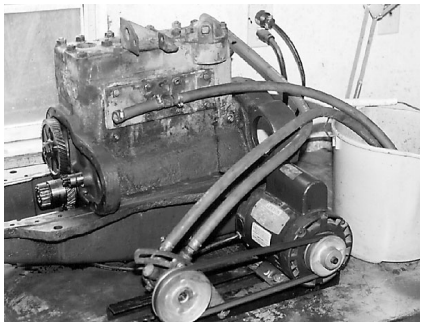
Volvo Pre-'94 cooling kit for V6 and V8 gas engines with remote-mounted vertical heat exchanger.

REMOVING ENGINE SCALE

Shop Tested

MarSolve effectively removed all lime and rust deposits and marine growth from the seawater cooled passages in this 30-year-old engine.

How convenient that marine engines are cooled with water, but there is one drawback to this arrangement. Because both fresh and salt cooling water contain salts, minerals and dirt in suspension, when it's circulated through a hot engine or heat exchanger, the salts and minerals gradually precipitate out onto the surfaces of the water passages, especially when water temperature exceeds 60°C (140°F). As deposits build up they form a rough coating



Test equipment: old A4 engine, electric-driven pump, automotive coolant hose and a bucket.

called "scale" that eventually begins to restrict water passages. As water passages become blocked, engine operating temperature increases, which in turn accelerates the creation of scale, which further increases the temperature, and so on.

Many different methods have been used to remove this scale, including flushing with weak acid solutions or high-pressure water, partial disassembly and steam cleaning, vacuuming and flushing with the engine in the boat, or engine removal and complete disassembly followed by immersion in strong industrial hot acid, then in alkaline solutions. Many boat owners flush their engines when the engine operating temperature starts to increase, usually by circulating a weak solution of muriatic acid through the engine with the engine water pump while running the engine at slow speed. Though some report success with muriatic acid, even weak acid solutions can be very unsafe and environmental hazards, as well as damaging to hoses, gaskets, or other components.

MarSolve is an aqueous organic salt solution that is touted as a non-toxic, non-hazardous, non-corrosive, non-flammable, fully biodegradable solvent sold to dissolve all water scale and lime deposits, calcium, barnacles and zebra mussels that accumulate on the water side of your equipment.

Does it actually work? To find out, we conducted a test on a rusted, raw-water cooled Atomic Four engine that had been run in saltwater for 30 years. We rigged the engine's water pump to an electric motor, then used automotive coolant hose to connect the pump to the bottom of the engine block, and from there to the engine thermostat housing, and into a bucket to hold the MarSolve. This allowed the solution to circulate from the bottom of the engine to the top.

MarSolve International (tel: 203/834-8728,info@marsolve.com) supplied 2 jugs (4L/2gal) for the test. The instructions recommend that it not be used with aluminum, magnesium and most alloys of stainless steel, and must be diluted with water at a ratio of 1:1 to minimize electrolytic plating and discoloring of some types of stainless steel. After completing the MarSolve flush, clean water is circulated through the engine before putting the engine back into service.

Following the instructions, we mixed MarSolve with equal parts of water, giving a total mixed solution of 16L (4gal). Since one jug of MarSolve apparently dissolves 900grams (2lb) of lime and rust scale at room temperature (21°C/70°F), our solution was supposed to be capable of dissolving 1.8kg (4lb) of sediment at room temperature. The recommended procedure is to circulate the solution through the engine for 2 to 4 hours. Very heavy rust deposits can take up to 8 hours. The manufacturer recommends that they first be consulted before it's circulated for more than 4 hours. In order to work properly, the solution should be kept under a temperature of 82°C (180°F). If circulated by the engine water pump while running the engine, the engine coolant must be kept as cool as possible. You may need to remove the thermostat and spray cold water on the side of the engine block to cool the engine. Good ventilation is important as MarSolve releases bubbles of carbon dioxide when dissolving lime or scale. MarSolve doesn't bubble when dissolving rust. If it stops bubbling, either it's saturated with lime or scale or it's removed it all, or there is only rust left in the engine. You can test to see if the MarSolve is saturated by holding a small seashell or antacid tablet in the solution. If it starts to bubble vigorously the MarSolve is still working.

To determine how well the MarSolve solution actually worked, we removed the engine thermostat housing and block water jacket inspection plate before the test to examine the deposits



Before: Hard scale and rust deposits on the (left) block water jacket inspection plate, (above) cylinders and (bottom) thermostat housing.

we wanted the MarSolve to dissolve. The deposits were a mixture of hard scale and rust about 3mm (1/8") thick.

After reassembling the engine, we started the pump to begin the test. As the solution circulated through the engine it bubbled slightly, and gradually became darker and thicker. We circulated the solution for 2 hours, until the MarSolve stopped bubbling, and then circulated it for another hour to make sure it had a chance to work on the rust deposits, too. Then we stopped the pump, and disassembled the engine to inspect the engine parts.

Remarkably, the block water jacket plate was clean down



After: (left) Water jacket plate, (above) cylinders and (bottom) thermostat housing were cleaned of rust and scale after circulating a 1:1 MarSolve-water solution for 3 hours.

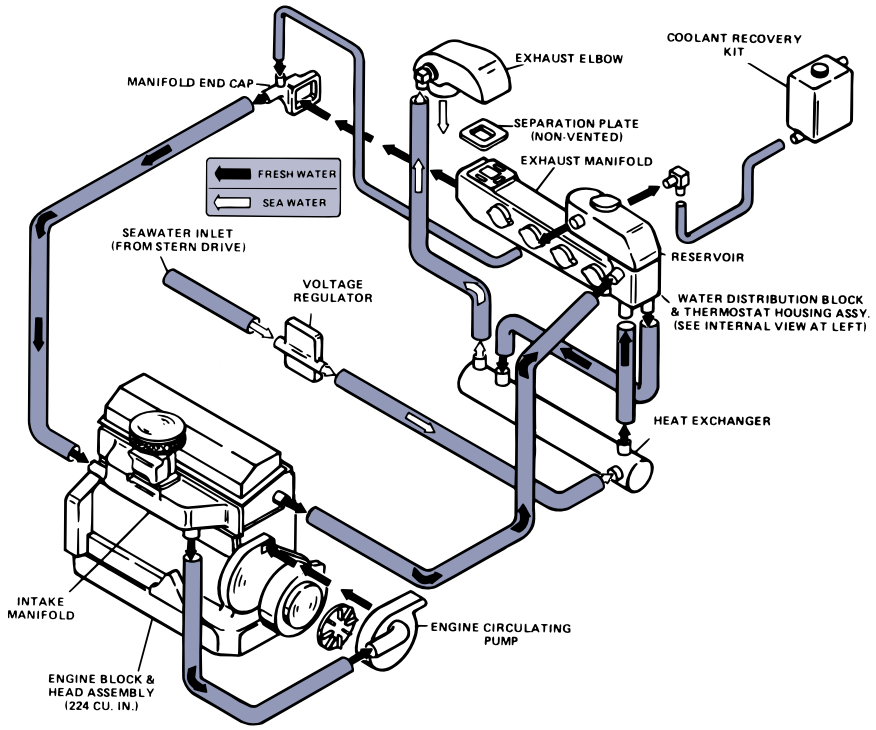
to bare metal over nearly 50% of its area. The thermostat housing was completely clean, although the metal was stained black. Rust deposits on the cylinders were completely removed, and the remaining deposits were reduced about 50%. The deposits that remained were soft, and easily scraped off with a spoon, suggesting that either we hadn't used enough MarSolve or that we hadn't circulated it long enough. The used MarSolve solution in the pail was very thick and black as pitch, presumably from the engine deposits it absorbed.

It was obvious that using more MarSolve for a longer period of time would have completed the job of cleaning the engine. Since the instructions suggest that the average engine flush takes about 2 hours, it's possible that the engine we used for the test had more deposits than most engines, which is quite likely since it probably had never been cleaned in 30 years.

MarSolve works, and it works well, as long as sufficient product is used and the instructions are followed carefully. It costs $24.95 per gal and is sold in 1, 5, 30, 55 gal containers.

— Robert Hess

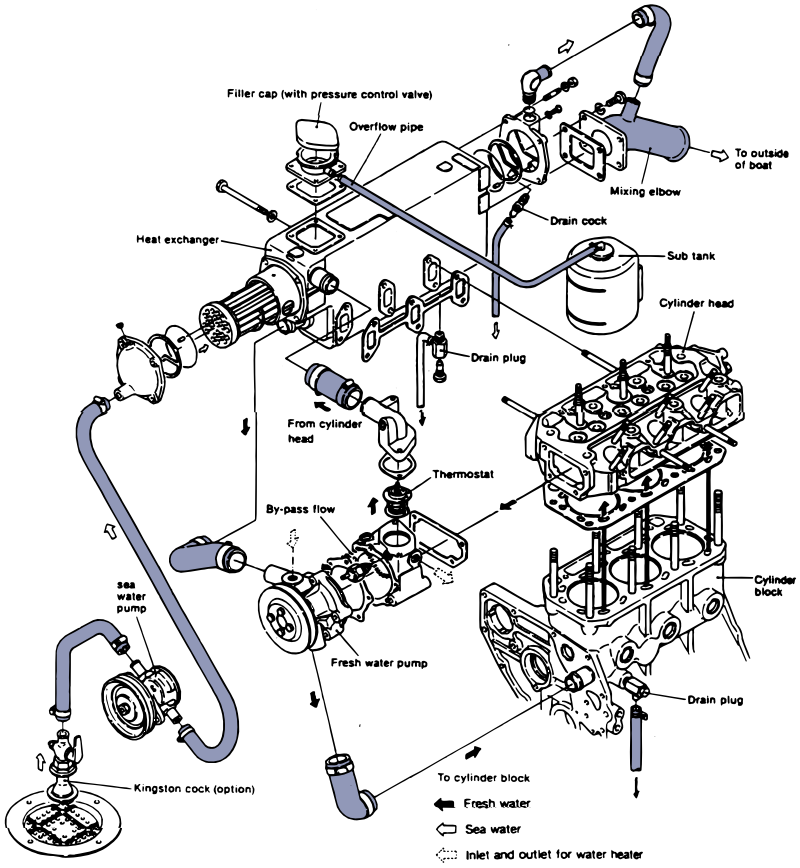
Figure 6



SELOC, NICHOLS PUBLISHING

MerCruiser freshwater coolant system uses exhaust manifold as the heat exchanger expansion tank.

Figure 7



Typical "full system" on diesel engines includes both the engine block and the manifold with integral heat exchanger and expansion tank in the freshwater system.

Mounting Bracket

The heat exchanger mounting bracket and mounting fasteners must be strong enough to hold the heat exchanger, which is heavy when filled with coolant and seawater, and prevent it from breaking loose in heavy seas. Mount the bracket to prevent vibration and flexing which, over time, can crack the heat exchanger housing. If using rubber mounts, they must be rigid enough to prevent excessive movement that could weaken hoses or allow components to rub or strike each other.

Pump Selection

The seawater pump fitted to a freshwater cooling system is usually a low-pressure, rubber impeller-type designed to handle silt and contaminants found in seawater.

If the pump is not supplied with the conversion kit, and it's belt driven, check with the engine or pump manufacturer to verify that the pulley ratio used spins the pump at the proper rpm for efficient water flow without overspeeding and damaging the pump at maximum engine rpm. Select a pump based on its "continuous" capacity rating and oversized enough to compensate for wear and subsequent lower performance with use. Extensive calculations can be done to determine the correct pump capacity, though the size required for most common engines can be obtained by asking the engine manufacturer or a heat exchanger supplier. When ordering the pump, order several spare impellers, cover gaskets and a rebuild kit.

Pump Drive and Mount

Seawater pumps are usually installed on a bracket driven by an adjustable belt and pulley run by the engine. Some are driven by electric motors, direct engine couplings, or incorporated in the lower unit of stern drive units. Some Volvo diesels (i.e. the MD11 2-cylinder) drive the seawater pump by means of a V-belt running in a groove on the outer edge of the flywheel. A new flywheel is not supplied, so the instructions specify

-Tip-

Dial to Recycle Oil

If you do your own engine oil changes, you should be recycling the used motor oil, rather than disposing it. If your area doesn't have an established oil collection program, you can search for a local or state recycling location on the American Petroleum Institute's (API) website at www.recycleoil.org/usedoil_collectioncenters.htm. Just select your state and click "search" to view a list of the nearest drop-off recycling centers. According to the API, just two gallons of used oil can generate enough electricity to run the average home for almost 24 hours.

—Jan Mundy

Figure 8

Heat exchanger with integral header tank-fill cap must be located to easily remove the cap for filling with a 50:50 antifreeze-water coolant mixture and to routinely check the level.

removing the flywheel, and having a groove machined in it for the belt. When installing an electric seawater pump, wire it to the ignition switch using tinned marine spec wire capable of handling the maximum pump amperage, and with a fuse or breaker incorporated just after the pump in the positive circuit to protect it against a jammed or short-circuited pump. [Ed: For complete wiring guidelines to ABYC standards refer to DIY 1998-#4 issue.]

Installation

Before attempting to install a freshwater cooling system on an old engine you should flush the engine (see "Removing Engine Scale" on page 20) to remove most of the dirt and scale before installing the new heat exchanger. Otherwise the dirt and scale in the engine could get into the new heat exchanger and cause engine overheating.

Installation involves installing the two main components, a heat exchanger unit and a second water pump, plus extra hoses, clamps, etc. to plumb them to the engine and seacock.

Typically, the seawater (raw-water side) is plumbed from the seawater intake seacock to the seawater strainer fitted with a removable debris basket to simplify cleaning, to the new seawater pump, to the raw-water inlet of the heat exchanger, and finally from the heat exchanger raw-water exit to the exhaust water-injection elbow.

The engine coolant system is plumbed from the engine coolant exit of the heat exchanger to the engine coolant pump intake (actually the old combined seawater-engine coolant pump), from the engine coolant pump exit to the engine water jackets and exhaust manifold, and then out the engine exhaust manifold to the engine coolant intake of the heat exchanger.

Most freshwater cooling configurations include both the engine block and the manifold(s) in the freshwater system. This is known as a "full system" and is found on most diesel engines (**Figure 7**) and earlier MerCruiser and Volvo Penta. Some designs are "half system" (i.e. some late model MerCruisers), and include the engine block in the freshwater system, leaving the manifolds in the raw-water system.

Hose clamps should be all-stainless gear clamps. [Ed: Refer to "Not All Clamps Are Equal," DIY 2000-#1 issue, for our review on hose clamps.] Be careful to not overtighten so they begin to cut the hose. Retighten after 8 hours of running.

The seawater side of the heat exchanger includes a threaded port for a sacrificial anode (zinc) to protect the metal parts of the system against corrosion (galvanic or stray-current) damage. This zinc must be replaced regularly, so order several when placing the heat exchanger order.

Determining Tank Positions

The freshwater side of the heat exchanger system includes a header (or expansion) tank (**Figure 8**) that holds the filler cap and provides storage for extra coolant required for coolant loss, coolant expansion and contraction and extra cooling capacity. The expansion tank is usually incorporated into an extra section of the heat exchanger assembly or the exhaust manifold water jacket. When space is restricted, it's sometimes mounted separately and connected by a hose. To prevent air locks, or the coolant draining out of the expansion tank neck when the cap is removed, always mount the cap so it's at the highest point of the system.

The expansion tank filler neck for the tank pressure cap (usually an automotive radiator cap) connects to an overflow hose leading to a separate small plastic tank called a catch, overflow or recovery tank. Mount this in a convenient spot that allows visual checks of the coolant level.

Thermostat Change

Many of the benefits of freshwater cooling come as a result of the increased engine operating temperature. Because raw water is not circulated through the engine, in order to get the increased temperature, it's necessary to purchase a new thermostat with a higher temperature rating, usually 82°C (180°F). Marine thermostats cost US$100 or more, so add this to the total job cost.

About the author: Robert Hess operates Atomic Four Engine Service in Vancouver, British Columbia, and specializes in the sales and rebuilding of Universal gas and diesel marine engines.

-Tip- SPARES

When purchasing the coolant conversion kit, order for the seawater pump several spare impellers, cover gaskets and a rebuild kit, and at least two spare zincs for the heat exchanger.

TUNE UP

PROBLEM:

How do you install deck hardware when a cabin headliner is in place?

SOLUTION:

Cut holes in the liner to access the underside of the deck, or fill the gap between the liner and deck, then hide the fasteners and holes or leave exposed.

Story and Illustrations by Nick Bailey

You've decided to improve your line tie-up points, or make short-handed cruising easier by adding some new or bigger and better cleats and other new hardware.

At the boat, you position the new hardware on deck. Since the fittings will be under considerable load, they require thru bolting with a nut and washer and a backing plate on the underside of the deck. When you go below for a pre-installation check, you see that the overhead in the main cabin appears to be smooth, seamless fiberglass. You rap on it with the butt end of a screwdriver. It sounds hollow and flimsy. What now?

Many production boats have a molded headliner beneath the underside of the deck molding. This contributes to an attractive interior, but complicates the installation of deck hardware. Any attempt to tighten nuts against a hollow liner instantly causes it to crush and crack. If you're lucky, the boatbuilder provided a removable panel in the right location for you to gain access to the underside of the deck, but if not, read on.

To save weight, fiberglass headliners are necessarily light and thin. Unlike the more massive structural grids and liners often installed in the hull, the headliner doesn't typically contribute to the boat's structure. During construction, the headliner is usually glued to the deck with polyester bonding putty applied at various strategic locations. This technique typically results in a variable gap between the liner and deck that can be almost nil, or more than 2.5cm (1") wide. In some areas this gap is empty and in others it's filled with bonding putty.

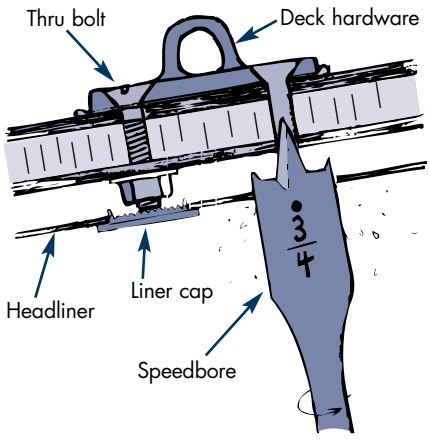
To securely thru-bolt hardware in the liner, there are basically two different approaches to the problem. Which one you choose will depend on the configuration of the liner, bonding putty and deck, and also your own aesthetic preferences. You can either cut holes in the liner to access the underside of the deck, and then hide the fasteners and holes under a cover plate or cap. Another approach is to ensure the gap between the liner and the deck is filled with a structural material that prevents crushing the liner as the fasteners are tightened. This latter method leaves the fasteners exposed.

Prep and Drilling

Once you've chosen the deck location of the new fitting, go below and tap the liner in the general area where the fasteners will mount. If it sounds consistently hollow, then the hidden fastener techniques will be the easiest (**Method 1**). If it sounds solid you can probably drill through and leave the fasteners exposed (**Method 2**). If you hear a transition from solid to hollow, you may be able to use one method for some fasteners and the other method for the rest. Cautiously approach this method as this "transition zone" is often an area where the gap is partly filled with bonding putty which may cause problems particularly if you want to cut an opening in the liner and install a backing plate (**Method 3**). If your deck layout is flexible, you may find it simpler to relocate the fitting in order to avoid a transition zone.

Once you are satisfied with the hardware placement, mark the fastener locations and drill a pilot hole from the deck. Double check the location from inside the cabin, then drill all holes for the correct size bolts. Dry fit the fitting and fasteners. Check the thickness of the deck and liner combination as well as the size of any gap that may exist. Once you know what liner gap you are dealing with, proceed with the most appropriate method outlined below.

Method A:1



Hardware installed in headliner with hidden thru-bolts.

Method A: Hollow Liner

1 Installing Hidden Fasteners

Purchase plastic or stainless-steel "pop in" plugs or caps. If these are not available at your local chandlery, check a fastener supplier or marine yard parts counter. For 6mm (1/4") bolts with 11mm (7/16") nuts, a cap sized to snap into a 22mm (7/8") hole is about right to provide clearance for the necessary socket wrench.

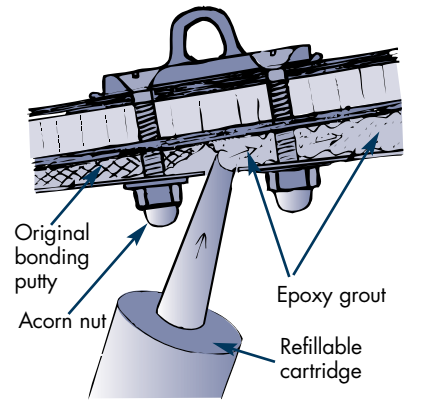
Drill bolt holes through the deck and liner, then go below, and using a speed bore or small holesaw, drill back up into the liner from underneath using the bolt hole as a guide. Stop drilling immediately after you feel the drill cut through the liner. Remove the cut out circle and continue with the normal hardware installation including potting (if desired), etc. Then pop in the plugs to neatly cover the holes (see "Protruding Bolts", on page 27). [Ed: Potting techniques to install hardware in cored hulls appears in "The Good, The Bad, The Ugly," DIY 2000-#3 issue.]

To installing hidden fasteners with a backing plate, use a router or Dremel style tool, and cut open a window in the liner large enough to insert the backing plate. Do not cut into the deck! Make up a small opaque acrylic or painted aluminum plate 3mm (1/8") or thinner and fasten with small screws to cover the hole once the hardware is fastened. Off-the-shelf plastic inspection ports or custom teak ones can also work well provided the liner curvature is minimal.

2 Exposed Fasteners

If the gap between the liner and deck is insufficient to hide the fasteners or backing plate, the best approach may be to fill the gap with a non-compressible grout made from thickened epoxy, or chopped fiber and polyester resin. If necessary, enlarge the pilot holes in the liner just enough to insert the nozzle of a caulking gun but no larger than the size of the washer so, for the sake of good cosmetics, it or a backing plate cover the holes. Obtain empty caulking cartridges (available from a West System retailer), mix up the epoxy or polyester grout, spoon it into the empty tube and quickly inject the grout into the liner gap in enough quantity to pack the gap full under the fitting. Tape the hole if needed so the grout doesn't drip. After it has cured, re-drill the fastener holes and proceed with the installation. If the gap is very small 1.5mm (1/16") the liner may compress without damage and filling with grout may not be necessary.

Method A:2



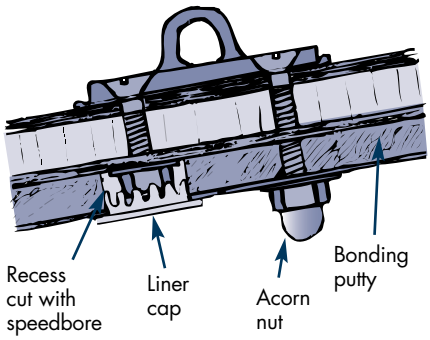
Partly filled gap between deck and liner.

Method B: Already Filled Liner

1 Hidden Fasteners or Backing Plate

If you can't stand the appearance of exposed fasteners and there is enough room between liner and deck, you can proceed as with Method A.1. Carefully use the speed bore to extricate the bonding filler to a depth sufficient to handle the fastener. Be very careful not to cut into the underside of the deck. Stop and check frequently for first contact with the glass fibers that will identify the deck. If you hit balsa or plywood core you've cut through the lower skin of the deck. This is difficult to repair in a satisfactory fashion and you should relocate the fitting.

Method B:1



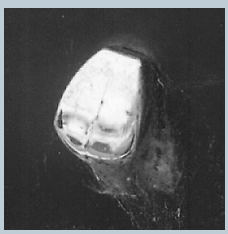
Fasteners with filled headliner showing hidden and exposed options.

If space allows, the same procedure holds for hiding a backing plate, but in this case you must router out the appropriate size opening without damaging the deck. This is really going about it the hard way. The cover plate required to cap the installation may not be any more elegant than the original backing plate.

-Tip-

Vent Snare

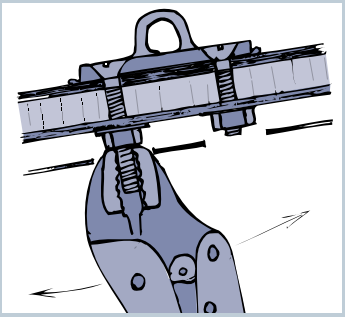
Check all tank vents to make sure they are not blocked by a spider web or other matter, including sewage that has been compacted into the vent line as a result of "stuffing" the holding tank. What goes in must inevitably come out, and the vent line is one of those escape routes. Vents equalize pressure in a tank, allow refilling and provide an escape for unwanted vapors.
— *Jan Mundy*



-Tip-

Protruding Bolts

If you can't find a bolt the right length to fit neatly (unfortunately, bolts are made in 1/4" length increments) you can cut the bolt to length and dress the burred thread with a die before using it or you can use the following shortcut to snap it off at the nut after the fitting is installed. For bolts 6mm (1/4") in diameter and smaller, this is easily done by locking Vise Grips on the protruding shank of the bolt right at the nut and flexing it back and forth, five or six times, until it fatigues and breaks off cleanly at the nut. This only works if enough of the bolt is exposed below the nut to make a decent sized lever, say 12mm (1/2") for a 6mm (1/4") bolt, or 8mm (5/16") for a #10 machine screw. Don't worry about the burred thread as presumably the fitting is on for good. The bolt can always be removed if needed but probably can't be re-used without being dressed. This also means that you can carry a more efficient inventory of fewer, longer bolts in your fastener box.



A quick way to trim small diameter bolts.

2 Exposed Fasteners

If you are happy with cosmetics of exposed fasteners and you are certain the liner is solidly filled, there are no special problems. Drill though, bed and bolt home. Use acorn (or cap) nuts for a finished appearance.

Method C: Liner in Transition from Hollow to Filled

You can choose to either grout the gap full (recommended if a backing plate is called for) as shown in Method A:2, or bore out the hole to hide the fasteners. The latter is recommended if nuts and washers are used and there is enough room to hide them.

About the author: Nick Bailey is service manager of Bristol Marine in Port Credit , Ontario, and a 25-year veteran of the boat repair business.

TUNE UP FITTING OUT CHECKLIST

A personalized guide to inspecting your boat's exterior, interior, onboard systems and gear.

By Susan Canfield

Routine preventive maintenance is key to both boating safety and an enjoyable boating experience. Timely preventive maintenance (and corrective maintenance when needed) also determines how well your boat retains its value.

Use this checklist as a guide and modify it for your needs. Delete inspection items that don't apply to your boat, or add any that do, but are not included. Review your owner's manuals for onboard equipment, and incorporate the manufacturer's maintenance recommendations in your personalized checklist. You can also download a copy of this checklist from DIY's website at www.diy-boat.com.

While this is a list of what you should inspect, it doesn't explain specifically what you should inspect for. Again, refer to your owner's manuals, back issues of DIY and other applicable marine publications for further guidance. An editorial index of DIY back issues from 1995 to 2000, with articles organized by category, is available online at www.diy-boat.com/Pages/Archives/ArchF.html or call 888-658-BOAT for your free copy.

Hull Exterior

✓Inspect the hull bottom for damage (abrasion, blisters, gouges); repair as needed.
✓Replace any bilge drain plugs if removed at lay-up.
✓Inspect the propeller, propeller shaft, strut, and cutlass bearing; service or replace as needed. Ensure that the propeller nuts are tight and the locking pin is secure.
✓Inspect the rudder and its fittings for damage and excessive play.
✓SAIL: Inspect the keel and centerboard for damage; repair as needed. Inspect centerboard pivot pin and pennant for wear; replace as needed.
✓SAIL: Remove any marine growth or debris from the centerboard slot, thru-hulls, external strainers, etc.
✓SAIL: If holes were drilled in the rudder molding to allow it to drain over the winter (to avoid freeze damage), plug them before relaunching.
✓Renew the bottom paint as needed; prepare the hull bottom per the paint manufacturer's recommendation prior to application.
✓Inspect all zinc anodes; replace if wasted.
✓Check swim platform and/or ladder.
✓Inspect the hull topsides for damage; clean, repair, compound, and wax as needed.

Deck

✓Check the deck for damage (gelcoat chips, cracks, delamination, etc.) Repair as needed. Lift and rebed deck hardware wherever water intrusion is suspected.
✓Inspect handrails, railings, stanchions and stanchion bases; ensure all are secure. Inspect lifelines and terminal fittings for deterioration, corrosion, cracks, etc.; service or replace as needed.
✓Check hull-deck joint.
✓Check rub rails and repair or replace as needed.
✓Disassemble, clean, and lubricate the anchor windlass and all winches.
✓Inspect all other deck hardware (blocks, cleats, davits, pad eyes, tracks, etc.) Clean and lubricate as needed.
✓Inspect all ground tackle. Ensure all anchor shackle pins are seized with stainless steel wire. Renew anchor rode markings as needed.
✓Check dinghy and life raft mountings.
✓Inspect all mooring lines, fenders, etc. Service or replace as needed.
✓Clean and inspect canvas (convertible top, bimini, cushions, dodger, etc.) for wear. Repair or replace as needed.
✓Clean the deck, scuppers and drains. Clean and inspect brightwork. Refinish as needed. Clean and polish deck hardware, stanchions, etc.

Steering System

✓Inspect the rudder stuffing box. Repack or service otherwise as needed. Lubricate the rudder bearings.
✓Inspect the steering cables and sheaves; service as needed.
✓Inspect the hydraulic steering system for leaks; replenish the oil reservoir as needed. Check the tiller arm assembly.
✓Service the autopilot system per manufacturer's recommendations.
✓Fit and test the emergency tiller.

Hull Interior

✓Check for evidence of water intrusion (water stained veneers, water stains on interior hull sides, standing water in the bilge, etc.). Track and eliminate any leaks.
✓Inspect all hatch gasket seals. Replace as needed.
✓Inspect the chainplates for corrosion. Replace and/or rebed as needed.
✓Inspect the keel bolts and other thru-hull fasteners.
✓Clean bilge areas. Ensure all limber holes are clear.

Machinery and Fuel System

✓Service engines and generators per manufacturer's recommendations.
✓Replace water pump impellers if removed at lay-up. Remove air intake and exhaust plugs if sealed at lay-up.
✓Inspect engine and generator hoses

for chafe and deterioration. Service or replace as needed.
✓Clean and inspect seawater intake strainers. Service as needed.
✓Clean and inspect the vented (anti-siphon valve) loop in the seawater cooling line.
✓Inspect the exhaust manifold, muffler (waterlift), and piping for leaks and deterioration. Service or replace as needed. Manifolds should be removed every few years and inspected for corrosion that restricts water flow. Renew deteriorated lagging, replace corroded hose clamps.
✓Inspect the engine mounts and shaft coupling.
✓Lubricate all moving parts.
✓Inspect and lubricate control cables (throttle and transmission). Replace as needed.
✓Check engine and generator alarms, gauges and indicator lights. Service as needed.
✓If hauled out, repack the propeller shaft stuffing box. If your boat wintered in the water and the stuffing box was tightened to eliminate drips, readjust it as needed.
✓Inspect all fuel tanks and lines (including fill and vent hoses) for leaks and deterioration; service or replace as needed.
✓Check fuel tank vent to make sure it's clear.
✓Check tension of all belts.
✓Clean fuel filters-water separators. Follow manufacturer's guidelines for replacement.
✓Ensure the bilge blower operates.
✓Check bilge for oil; clean if needed. Put an absorbent pad under engine and in bilge to soak up oils, etc.
✓Record maintenance in engine log, and include dates and engine hours of last service.

Electrical Systems

✓Reinstall the batteries if removed at lay-up. Fully charge all batteries, and equalize wet-type deep-cycle batteries. Top up electrolyte with distilled water. Clean and tighten battery terminals and both ends of all battery cables.
✓Check deck, interior and navigation lights. Replace any faulty bulbs.
✓Inspect wiring (including shorepower inlet and coaxial cable connectors) for loose connections, corrosion and chafe. Service or replace as needed. Clean and tighten grounding wire connections.
✓Exercise (turn on and off several times) all switches to clean any surface corrosion from the contacts.
✓Check bonding system.
✓POWER: Inspect and test trim tabs.
✓POWER: Check wiper blades. Replace as needed.

Electronics

✓Reinstall any electronic equipment, including antennas, removed at lay-up. Test for operation.

Pumps and Piping

✓Exercise (open and close several times) all seacocks. Service as needed. Close all seacocks before launching.
✓Inspect piping plumbed to seacocks for leaks and deterioration. Service or replace as needed. Replace corroded hose clamps.
✓Clean and inspect seawater intake strainers. Service as needed.
✓Clean and inspect vented loops (anti-siphon valves) installed in toilet and bilge pump discharge piping.
✓Service bilge, freshwater, macerator, sump, washdown etc., pumps (foot, manual and electric) per manufacturer's recommendations.
✓Flush freshwater tanks and piping. Fill the tanks, pressurize the system, and check for leaks.
✓Service all toilets per manufacturer's recommendations. Detach the toilet discharge hose and inspect for calcified deposits. Clean or replace as needed.
✓Check holding tank vent to make sure it's clear.
✓Check waste system piping and holding tanks for odor permeation. Replace as needed.
✓Service Type II MSD (i.e. LectraSan units) per owner's manual.
✓Clean shower sump. Check float switch operation.
✓Check bilge pump intake strainers for debris; clean as needed. Check bilge pump float switch (or hydrostatic control) operation.
✓Check hot water tank operating.

Domestic Systems

✓Inspect LPG/CNG cylinders. Service and refill as needed. Reconnect cylinders and test system for leaks. Check solenoid switch and stove operation. Check storage box vent to make sure it's clear.
✓Service refrigeration and air-conditioning equipment per manufacturer's recommendations.
✓Check refrigerator. Clean and freshen.

Safety and Compliance

✓Inspect Coast Guard mandated wearable and throwable PFDs, visual and sound signaling equipment, life rings and cushions, etc. Service or replace as needed.
✓Check distress signals and expiration date.
✓Inspect all fixed and portable fire extinguishers. Ensure seals are not broken/missing, that pressure gauges or indicators read in the operable range, and that there is no obvious physical damage.
✓Check and adjust compass.
✓Ensure Coast Guard mandated pollution placards are posted where readily seen (US only).
✓Check monitor or alarm (carbon monoxide, gas vapor, high bilge water, smoke, security, etc.) system operation per manufacturer's recommendations.
✓Ensure boat (and dinghy) registration or documentation certificate and marine radio license (for boats with SSB radios, satellite communications; all powerboats over 20m/65' in length) are current and onboard, and required numbers or decals are properly displayed.
✓Inventory navigational charts and publications. Augment or update as needed.
✓Inventory your boat's onboard spare parts and tools; replenish as needed.
✓Inventory the first aid kit and replenish.

-Tip- Drain Gauge

Put a quantity of water in the bilge and time how long it takes to pump out. Half fill the cockpit with water and time how long it takes to drain.

SAIL: Spars & Rigging

✓Clean and inspect the mast (including antennas, electrical connections, instruments, masthead fittings, masthead lights, sheaves, tang bolts, spreaders, etc.), booms, poles and bowsprit for damage. Repair as needed.
✓Clean and inspect the wire standing rigging for broken strands ("fish hooks").
✓Inspect all fittings (chainplates, clevis, cotter pins, terminal fittings, etc.) for wear and corrosion. Replace as needed.
✓Clean and lubricate all turnbuckles.
✓Renew the spreader boots and other chafing gear as needed.
✓Clean and inspect all roller furling gear. Check manual for servicing and lubrication.
✓Clean and inspect all blocks, running rigging, shackles, etc. Service or replace as needed.
✓Inspect halyards and swap end-for-end or replace if needed.
✓Check reefing gear.
✓Restep the mast if removed at layup. Clean and inspect all electrical connections at the bottom of mast and seal them against weather. Inspect the mast wedges and boot. Replace as needed.
✓Tune the rig. Tape all turnbuckles, cotter pins, spreaders, etc.
✓Inspect sails if not done at layup. Check reef points, battens and batten pockets, bolt rope, etc. Service or replace as needed.

Trailer

✓Check bunks, rollers and/or pads.
✓Inspect and lubricate wheel bearings.
✓Clean and lubricate winch and tongue jack.
✓Test lights and electrical connections.
✓Examine tires and check pressure.
✓Check brakes, if equipped.
✓Check current registration.
✓Check hitch, safety chains, tongue lock.

About the author: Susan Canfield is an accredited marine surveyor with Marine Associates, Inc. in Annapolis, Maryland. She is a member of the Society of Accredited Marine Surveyors and the American Boat and Yacht Council.

Not commonly seen on boat hulls, a fading paint job looks stunning and is easy to do, especially on lapstrake hulls — just count the laps, do the math and paint!

By Seward Owen

The lapstrake hull is common to many older wooden boats and is a natural candidate for a "faded" finish. Paint fading is much easier than it looks. About 15 years ago, during the original rebuild of our 8.5m (28') 1965 Owens cruiser, I took the topsides down to bare wood, and we (my wife has a fine hand at painting) painted the boat with primer and then a white topcoat. Later, we added blue accent lines. These looked nice, but something just always seemed to be missing. I recalled seeing a faded lapstrake hull many years ago on a boat of similar type in the Chicago, Illinois area. It always stuck in my mind as a neat paint job, and I vowed to have one like it someday.

A fading paint job goes on as easily as a one-color job. The ease with which it's done, and the ease of repair of the inevitable scratch, is remarkable. Don't be intimidated. Here's how I painted our cruiser white to blue. (You could use any colors.) The fading really creates a stunning hull.

The first step is the usual surface preparation. To repair any areas with cracks or chips, sand to the bare wood, apply filler, then prime. A light, touch-up sanding on the rest of the topsides with 120 grit sandpaper, by hand or with a palm sander, removes the gloss and preps the original paint finish. You will need equal quantities of two colors. Odd

"When the colors change subtley from plank to plank, it's very hard to tell that airbrushing was not used unless you are right up next to the boat."

numbers of lapstrakes work best but if you have an even number of laps you can fake it near the waterline without compromising the overall effect. Be prepared to buy a can or two more of paint for touch-up of scratches, etc.

Here's the math for determining the color scheme using blue. The top lap is plain white, the bottom lap dark blue, the middle lap half and half. On a seven-lap hull, for example, number the boards from the top down, starting with "1." Think of the seven boards as having six spaces. The color mix in quantities of 6ths are as follows: board 1 is white; board 2 is 1/6 blue, 5/6 white; board 3 is 1/3 blue, 2/3 white; board 4 is 1/2 blue, 1/2 white; board 5 is 2/3 blue, 1/3 white; board 6 is 5/6 blue, 1/6 white; and board 7 is dark blue.

If your boat has an even number of boards, say six, the bottom lap is the darkest. Use a dark bottom paint, and it will fade right into the bottom. I suggest the following color breakdown: board 1, white with just a hint of blue; board 2, 3/4 white, 1/4 blue; board 3, 1/2 blue, 1/2 white; board 4, 2/3 blue, 1/3 white; board 5, 5/6 blue, 1/6 white; and board 6, blue (consider lightening it up with a touch of white). To select your colors, mix very small quantities of a particular tint using plastic disposable teaspoons in small mixing cups before mixing up the large quantities. Then paint a small area on the boat laps to check out the colors. We used 2.2L (2 qt) blue and 2.2L (2 qt) white paint, applied by brush. I recommend painting the lap color to underneath the horizontal lap above as it makes a good edge. Be sure to write down your mixing ratios and label the cans 1, 2, 3, etc., for each lapstrake to facilitate touch up when needed.

It takes about three hours longer to paint different colors on my boat than it does all one color. The next time we paint the topsides, (they've been repainted twice), I would seriously consider adding just a hint of blue to the top lap as the all-white lap blends into the all-white deck. Likewise for the bottom lap, only adding a touch of white to separate it from the dark blue bottom paint. ⚓

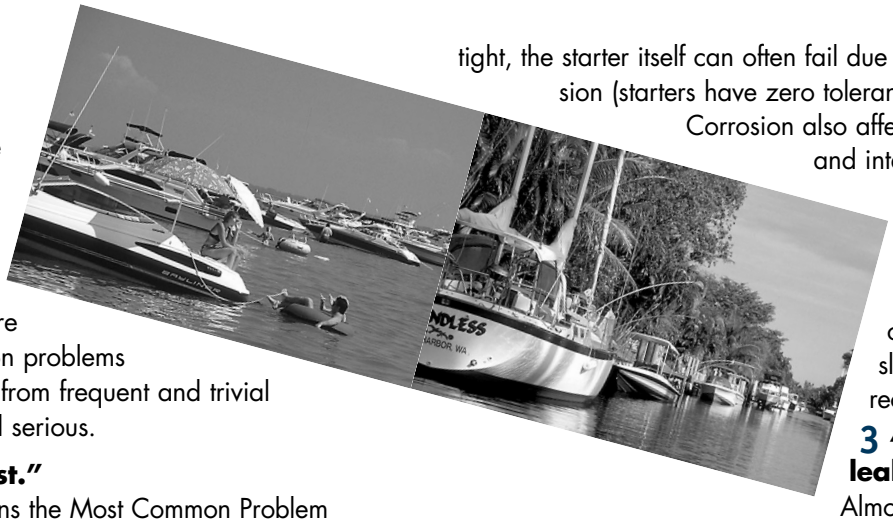
About the author: Seaward "Ben" Owen has spent more than 2,500 hours rebuilding a 1965 Owens Cruiser he purchased in 1985. The boat is berthed in Oshkosh, Wisconsin.

TUNE UP

PROBLEM SOLVING

Of all the maintenance problems boat owners face from time to time, these 9 seem to be the most common.

By Nick Bailey



After 25 years in the service side of the boat business, I've seen the same "complaints" over and over again. Here are the most common problems with boats, ranging from frequent and trivial to the inevitable and serious.

1 "I need a boost."

The dead battery wins the Most Common Problem Award. If you need a boost to get your engine started, the cranking (starting) battery has already been damaged. A "cranker" is built like a French pastry with lots of delicate layers of lead to maximize surface area and the available cranking amps. Any complete discharge kicks the hell out of this battery, whether it's a marine one or not. Somewhere between one and 10 full discharges, the lead plates will crumble. Volts may register high on the voltmeter, but it has no amp capacity left. If the cranker is more than two years old and shows any sign of trouble, replace it.

Deep-cycle batteries are very different than cranking ones. They cost double or more, and are built with heavy plates to survive many deep discharges. Rarely found on powerboats, these batteries deserve careful maintenance, but they typically suffer from insufficient charging. This allows the sulfide to harden, causing a lack of chemical reactivity, or an inability to charge properly, a process known as sulfation. If a troublesome deep-cycle battery is less than five years old, it's worthwhile to remove it and send it to a battery specialist shop for service.

Another common problem for any overworked battery is the "August drought." This typically occurs when a lead-acid battery must power a 12-volt fridge while being maintained by an automatic battery charger. The constant current flow breaks down the water in the battery into hydrogen and oxygen gas. By the time early August arrives, any battery that has not been periodically topped up with distilled water will be dry, and probably damaged.

2 "The engine won't start."

Assuming the cranking battery is good, engine failure to start is commonly caused by loose or corroded wiring from the battery to the starter. If the wiring is clean and tight, the starter itself can often fail due to internal corrosion (starters have zero tolerance for immersion). Corrosion also affects the key switch and intermediate solenoids. If the starter gets hot and draws too much power while cranking too slowly, remove it for reconditioning.

3 "My boat leaks."

Almost all boats do, but some leaks are more destructive than others.

Hulls: Planked wooden boats often leak steadily. If you are having trouble keeping afloat, recaulking, or possibly plank repairs, are required. Metal hulls should not leak. Haul out and hire a surveyor to check for perforations due to corrosion. Fiberglass shouldn't leak either. Haul out and check for cracks.

Hull fittings: Any leak below the waterline can sink your boat, and often does. Two leading culprits are excessively leaky stuffing boxes followed by outdrives with bad U-joint bellows that allow water to leak through the transom assembly. [Ed: Refer to DIY 1999-#2 for stuffing box repacking instructions.] Thru-hull fittings gradually corrode and suddenly fail. Rubber hoses age and crack. Keel bolts loosen and leak. Vigilance is required. Replace hoses and bellows when they show the first signs of cracking. Double hose clamps on all underwater fittings. Monitor thru-hulls for signs of corrosion, and be sure seacocks operate smoothly.

Deck fittings: Don't ignore deck leaks! Rebed leaking fasteners promptly and have your deck checked with a moisture meter whenever you suspect a problem. This is often the only way wet core problems manifest themselves before the core rots out and the deck delaminates. High load fittings, like chainplates, should be routinely rebedded as preventative maintenance. [Ed: Refer to DIY 2000-#3 for hardware installation methods.]

Hatches and windows: If you have tried to stop cabin windows from leaking and failed, you are not alone. Many original equipment window installations will suffer chronic leaking unless re-engineered. This involves changing the fastening technique, adding an external frame to properly capture sealant around the window, or purchasing new windows.

Hatches leak at three locations: under the hatch flange or through the fasteners where it's fastened to the deck (rebedding is necessary) at the bead between the lens and the hatch frame, which requires reseating the lens, and can be very difficult to do successfully; and through the hatch latches or dogs, which usually requires simple replacement of seals and O-rings.

4 "I'm taking on water."

This is high on the most frequent failures list, and usually tag teams with leaks to cause major grief. If you are relying on your pumps to stay afloat, good luck to you. If you are not aware that your pumps are keeping you afloat, I particularly wish you luck. The most common automatic pump failure results from a stuck or defective float switch, or from a pump clogged with bilge debris or sludge. Because bilges are usually a mess, pump failures are common. Another common cause of failure is corroded wiring or connections. Keep the bilge clean and any connections dry to ensure a reliable bilge pump. [Ed: Complete details on bilge pump installation and operation appears in 2000-#1.]

5 "The thing we all hate."

Head smells bad, won't pump, leaks — the list goes on and on. Most marine toilets (a.k.a. head) are very simple mechanisms and are amenable to do-it-yourself repair. Many repair shops won't even work on the common manual units. They take hours to tear down and service, and, at normal labor rates, why bother? It's cheaper, simpler and cleaner to just replace them. This may be an attractive option, but most problems occur on weekends when you are miles from home. Always carry a rebuild kit. Never flush anything you haven't eaten first, and make sure your landlubber guests understand this. Finally, if you are working on the thing, remember it's made of plastic and porcelain — be gentle! Don't try for another half turn

TUNE UP

when tightening fasteners. You will crack the housing. [Ed: Refer to DIY 1998-#2 for detailed information on head maintenance and rebuilding.]

6 "The ___ has stopped working."

Fill in the blank with anything electrical or electronic, water pumps, remote control search lights, trim tabs, outdrive tilt and trim units, navigation lights, horn, battery charger, inverter, autopilot, radar, knot log, air conditioner, gen-set, windlass, refrigeration. You name it. As consumers, we pay extra for this "marine" gear, so why does it fail so often? These failures drive marine repair yards crazy, too, because, most often, it's new equipment. The yard replaces it under warranty, and, as a rule, eats the cost of removal and reinstallation. Give a boat 10 years' exposure to salt, and it's a miracle that anything electrical works.

This is a big opportunity for hands-on boat owners. Develop the knowledge and skills to troubleshoot and replace DC electrical equipment to American Boat and Yacht Council (ABYC) standards. Most of the do-it-yourself electrical installations I see are pretty sad with messy wiring, bad connections etc. [Ed: Refer to the "DC Wiring Handbook" in DIY 1998-#4 issue for step-by-step wiring instructions.] I don't recommend a do-it-yourself approach to AC wiring unless you are a trained electrician.

7 "Do I really need antifouling?"

Antifouling's irrelevant for boats berthed on trailers or on a hydraulic lift beside the dock, but for larger boats requiring a mooring, it's a necessity. New powerboaters, in particular, are mislead by many boat dealers who, preferring the look of gleaming white gelcoat on their new showboats, assure the first-time buyer that it's not necessary. (Sorry, no one makes a high-gloss white antifouling.) Sailboaters are the opposite, and consider antifouling a Holy Rite of spring, arguing endlessly their favorite myths and misinformation over a brew at the local bar.

Regardless of the bewildering advertising copy, there are really only two types of antifouling paints — ablative copolymer and non-copolymer. Ablative copolymer paints have the paint binder and active ingredient (biocide) as one and the same chemical compound. These paints are semi-soft and are designed to ablate, or wear away, as the boat moves through the water. They are effective as antifouling as long as paint remains on the bottom. This can be several years if the original coating was thick enough.

All other non-copolymer paints have the paint binder acting as a vehicle for the biocide, nearly always copper or cuprous oxide as most other potent biocides have long

since been banned. The copper biocide compound leaches out and leaves the binder behind as a "dead" or inactive layer of paint, and with no antifouling characteristics. The binder can range from a soft and cheesy resin to an ultra-hard vinyl. It may go on thick and lumpy, or ultra slick and thin (i.e. V-17s Teflon binder), but all these paints eventually lose their biocide. What paint remains behind has no effectiveness as anti-fouling. This is not an issue if the binder is thin and durable, as with vinyl binders and Teflon, but most other conventional antifouling coatings build up to the point where they become aged and flaky, and eventually require removal.

Pondering which antifouling to use? To me the choice is obvious. Use a copolymer unless the slickest possible bottom is required for boat speed. In this case, use any hard antifouling that will burnish to a slick surface.

8 "The Hull Looks Chalky"

Sunlight, air pollution and acid rain take a heavy toll on gelcoat or painted finishes. Buffing and waxing is still the only method to restore dull and faded gelcoat, short of a polyurethane paint job. Buffing compounds come in many different grits and a careful choice is required. I recommend the 3M product line because they provide a helpful information guide and a wide range of compounds. A light compound that cleans, buffs and waxes in one easy step makes quick work of this task. Remember that, like sandpaper, all polishing compounds are abrasive, and you are removing gelcoat. The day may come when you abrade through to the laminate.

Due to moisture in wood, paint finishes on wooden boats tend to blister and peel long before the paint becomes badly weathered. Scrape the damaged area and repaint with a simple alkyd enamel that is easy to work on. The integrity of the finish is based on regular maintenance. Polyurethane painted fiberglass boats should not blister or peel, but they do suffer scratches, chafe, and become dulled by UV. Buffing with a light compound followed by one of the special polymer sealers (Awlgrip sells one) can do wonders.

9 "The Varnish Always Peels."

A good varnish job starts with "Bailey's Law." There is a direct relationship between the amount of preparatory labor and the number of coats of varnish to the longevity of the finish. Apply two or three coats over bare wood and the varnish begins to peel, sometimes in a few weeks. Twelve coats of varnish lasts a long time, and not need to be stripped and reapplied again, when properly looked after. Lesser finishes often require annual stripping to bare wood. After you build up to 12 coats, add one or two maintenance coats a year, with touch ups where needed.

About the author: Nick Bailey is a 25-year veteran of the boat repair business and currently service manager of Bristol Marine in Port Credit, Ontario.

CO -ODE TO CO-

What is carbon monoxide? How does this deadly gas get into your boat? How can you protect yourself and others? Read this article then follow our guidelines to minimize the chances of CO's intrusion into your boat.

Look, scratch and lick here to see, smell and taste carbon monoxide (CO).

Answer: *What you detect is paper and ink. CO is a totally colorless, odorless, tasteless and potentially deadly gas present in many boats.*

By John Ford

If you own, or are responsible for the safe operation of a boat, you must accept that carbon monoxide (CO) is a potential problem. The potential for significant problems is greatest in certain types of boats, especially those powered by gasoline engines. The possibility of a problem exists in any boat powered by an internal combustion engine, either yours or your neighbor's. Cooking appliances, heating systems, refrigerators and water heaters that burn alcohol, LPG or CNG, or any carbon-based fuel, even a charcoal fired barbecue, all produce CO.

The records of accidents involving carbon monoxide, which include fatalities, indicate that some of these tragedies might have been avoided had the victims been better informed and more acutely aware of the potential dangers of carbon monoxide, and had taken proper preventative measures.

Carbon monoxide (CO) is a colorless, odorless and tasteless gas containing one molecule of carbon and one molecule of oxygen. It's only slightly less dense than air and therefore mixes readily with it. Carbon dioxide (C02) is also a colorless and odorless gas. It contains one molecule of carbon and two molecules of oxygen. It's considerably denser than air and therefore will stratify and remain in the lower levels of a closed space with poor circulation. The third element is carboxyhemoglobin (COHb). A compound formed from the reaction of carbon monoxide and blood hemoglobin. Normally, hemoglobin transports oxygen through the body, but in a CO-rich atmosphere, the CO displaces the oxygen.

Most fuels used in internal combustion engines are a form of hydrocarbon. If you have sufficient oxygen when you burn a hydrocarbon, such as oil, fossil or wood-based fuels, the products of the combustion process are water vapor (H2O) and carbon dioxide. With perfect combustion, the chemical equation would be $4HC + 5O_2 = 2H_2O + 4CO_2$, where 4 molecules of gasoline burn with 5 molecules of oxygen, resulting in a safe, breathable gas.

A mere 20% reduction in oxygen results in the production of C0. Consider this equation: $4HC + 4O_2 = 2H_2O + 2CO_2 + 2CO$. Just one less oxygen molecule and combustion produces water vapor and carbon dioxide plus CO. This equation represents what exits the exhaust of a typical combustion engine (plus the stuff that you smell like metals, sulfur and other oxides). Besides limiting oxygen, carbon monoxide is also produced by a less-than-perfect combustion process, such as an engine that is poorly tuned, improperly trimmed, operating with damaged props or propped incorrectly, or an overloaded boat or fouled bottom. Any of these can combine to cause the engine to run rich and create more CO.

Common Sources of CO

There is always some degree of danger from the possible generation of CO from engine exhaust, though gasoline engines pose more of a risk than diesels (see "Symptoms" on facing page). Carbon monoxide also originates from any open flame device. For example, if you operate

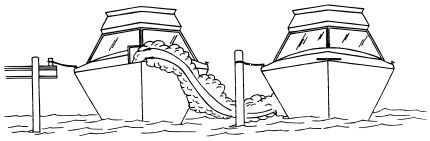
Figure 1

Station Wagon Effect: Operating a boat at slow speed with a following wind or a too-high bow angle can cause CO mixed with exhaust gases to roll back into the cockpit, cabin or flybridge.

Figure 2

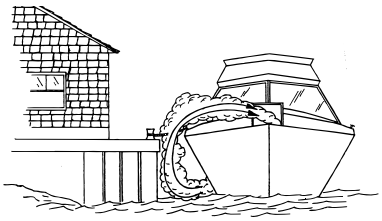
Backdrafting: Canvas tops, side and back curtains can draw exhaust gases into the cockpit.

Figure 3



Exhaust From Another Boat: Docking or anchoring where neighboring boats are running engines or gen-sets puts other boats at risk.

Figure 4



Exhaust Blockage: Running an engine or gen-set at the dock can create a trough for trapped exhaust to migrate into open hatches or ports.

Figure 5

ABYC

Fresh Air Flow: Opening hatches and removing aft canvas circulates fresh air and reduces CO levels. Use the streamer test to check air flow on your boat (see "Tip" on page 38).

a LPG stove in a sealed cabin (no ventilation source), initially the stove will burn with good combustion. But as oxygen is consumed in the cabin, and the hydrocarbon-oxygen ratio changes, the net result is production of CO. When cooking or heating with an open flame, always provide for ventilation by leaving a hatch or port light open.

CO settles in accommodation areas with absolutely no indication that it's there. You can't smell it or see it. Outboards generate CO, too, and concentrations are usually not a concern, except boats with cuddy cabins. The station-wagon or venturi effect (**Figure 1**) causes CO to roll back into the cockpit when idling at the dock or at anchor, or when operating at trolling speed, especially when running downwind when a gust pushes engine exhaust back over the transom. Adding a canvas top changes the airflow and acts as a scoop to trap CO, and, if the companionway hatch is open, can significantly increase CO levels in the cabin. Backdrafting is accentuated on fully canvassed aft-deck cruisers where low-pressure pulls exhaust gases into the cockpit **(Figure 2**). (Open a fore hatch or install a grill on the cabin door to create positive pressure and reverse the air-flow.)

A blower is mandatory (federal law) on all stern drive and inboard-powered gasoline boats (and recommended with diesel engines), but not to be completely relied on. In a station wagon effect condition, running engine blowers brings in fresh air but may also pull in CO. Again, canvas tops and enclosures aggravate the station-wagon effect and give CO an opportunity to accumulate. Other sources include a leaky exhaust system, engine exhaust backpressure, or an exhaust thru-hull located close to an opening to the interior that draws exhaust back into the engine room or cabin.

CO easily flows through open crevices or holes for cables, hoses or wires passing through bulkheads or the deck between accommodation areas and the engine. Be sure the engine compartment is well sealed so that vapors cannot migrate into accommodation spaces, seal all leaks and purchase a marine grade CO detector (see "Marine Alarms" on page 40).

Opening ports in aft cabins leading to the cockpit are a sure source for CO. Best to leave these closed during engine operation.

For many years, boatbuilders put the evaporator unit for the air conditioner in the engine room, and connected the return air grill back through a sealed hole in the cabin area. In time, this seal wears and sucks air from the engine room.

CO can also enter cabin areas through sink and shower drains if not equipped with a double-loop in the drain line or a P-trap, just like one used in household plumbing drains. If you are moored next to a boat with the gen-set exhaust blowing toward an above the waterline drain (cockpit, deck scupper or other), it's conceivable that CO will find a way into the cabin (**Figure 3**).

At the dock, factors such as wind direction, seawall height and placement of fenders need to be considered. Placement of fenders near exhaust outlets (gen-set or engine) can create a trough for trapped exhaust vapors to migrate into open hatches or ports (**Figure 4**). An operating air conditioner does an effective job of quickly spreading CO around the cabin.

Symptoms of CO Poisoning

When inhaled, CO reacts with blood hemoglobin (Hb) to form carboxyhemoglobin (see definition on page 36). It displaces the oxygen in the blood that in turn leads to oxygen deprivation and suffocation. The level of COHb in the blood is a function of both time and concentra-

tion. The body can safely dilute small quantities of CO for a long period of time, but large dosages quickly saturate the blood.

Early symptoms of elevated COHb levels include a flush appearance, and perhaps watering and itching eyes. Continued exposure will cause victims to feel throbbing in temples, headache, inattentiveness or inability to think coherently, ringing in the ears and chest tightness. Sustained levels of COHb eventually cause drowsiness, incoherence, nausea, dizziness, vomiting and collapse, followed by convulsions and death. Not a pretty picture. Early symptoms are similar to those of the flu or seasickness, and are therefore often attributed to less serious causes. Such assumptions can be fatal.

-Tip- CO Locators

A simple way to check air flow onboard your boat while at dock or anchor is to hang short lengths of flexible tape over every deck or bulkhead opening, over the transom, in the flybridge, under the bimini. If these "streamers" blow away from the opening or blow into the boat or canvas, air is coming in and there's a chance of CO entering as well.

Use a flashlight to check smaller cutouts for openings for cables, wires, hoses, ducts, etc. Wait until nightfall and have a friend hold the flashlight on one side of the bulkhead or opening and turn out the lights. If you see light coming through the bulkhead, you need to seal the opening.

A good method to check the engine is to smoke bomb the compartment. You may be amazed at all the places the smoke passes *through.*
— Jan Mundy

CO absorption rates are often aggravated by other factors. A smoker typically has a head start of 5% carboxyhemoglobin already in their blood. Lung disorders and heart problems can reduce oxygen-carrying capability, while alcohol tends to dilute the blood.

A typical gas engine or gen-set generates 5,000ppm (parts of CO per million). A well-tuned, turbocharged diesel engine generates on average 500ppm of CO. On average, a concentration of 50ppm for 70 minutes, and remember symptoms are based on concentration and duration, generates about 5% COHb in the blood and has little effect. Should CO levels jump to 180ppm and time decrease to one hour, blood concentration raises to 15% COHb, enough to produce a slight headache. Raise the concentration to 400ppm, and it only takes about 27 minutes before a headache takes hold. This means that at higher concentrations, headaches occur earlier. Continue breathing an atmosphere where the CO concentration is 400ppm and, in two hours, the COHb level in your blood reaches 50%, causing permanent brain damage or, ultimately, death.

Testing and Inspection

It's a good idea to determine if the inherent carbon monoxide levels on your boat, under normal operating conditions, are within safe limits. This can be done by conducting a CO concentration level analysis on your boat under certain conditions, such as operating in varying wind direction, opening and closing doors and windows, varying boat speeds, various loads, with canvas up and down. There are qualified people with the appropriate equipment who can perform this service. Repeat the CO test after doing a major canvas retrofit, deck modification or installing a gen-set.

Another suggestion would be to check with the builder of your boat and ask if they have received any reports of CO problems on any of their boats, especially models the same or similar to yours. Ask these questions with a complete absence of any hint of a confrontational or threatening attitude. You are much more likely to get honest and helpful answers with this kind of approach. The U.S. Coast Guard maintains a database that may contain information about CO problems with boats, and BOAT/U.S. is also a source of this kind of information through its consumer affairs department.

As a preventative action, you should establish a periodic schedule for inspecting and testing all the exhaust systems on your boat. The

WARNING HOUSEBOAT OWNERS

In late February, the US Coast Guard issued mandatory recall notices to houseboat builders advising them of a design flaw that can produce excessive levels of carbon monoxide (CO). This recall relates to boats equipped with swim platforms and an auxiliary generator that exhausts through the transom into a stern cavity. Such design has been linked to a number of CO poisonings. Running the generator at dockside or while anchored allows lethal concentrations of CO to accumulate beneath the swim platform or above the stern. Those affected were swimming near the platform or sitting on the stern deck.

If your houseboat has this design and the manufacturer has not contacted you, contact your dealer or builder immediately. Venting the generator exhaust through the side is an approved solution. It's also recommended not to run the generator while stationary, and keep swimmers away where exhaust is discharged.
— Jan Mundy

schedule might be once or twice each boating season. More importantly, stick to the schedule, and make these inspections a very high priority. The inspection should include a thorough examination of all joints of the system for evidence of carbon or salt deposits. Check all clamps for tightness and any rubber hoses or other connectors for oxidation (rust) or hardening. Have a qualified mechanic pressure test the exhaust system following the steps in "Exhaust Check" below. Record any and all signs of deterioration or change and compare the condition to that recorded on the previous inspection. If you observe changes or deterioration, make repairs immediately.

EXHAUST CHECK

Pressure testing of all exhaust systems to detect any leakage is important. The following simple method is suggested.

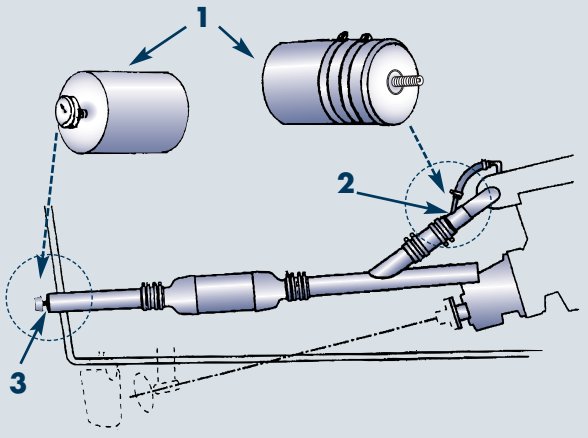
1 Make two cylindrically shaped plugs (aluminum is a good material) with the OD to fit into the ID of the exhaust hose in the system. Fit a pressure gauge (0 to 10 psi) in one of the plugs. Fit a valve stem in the other plug, or the same plug as the pressure gauge if space permits.

2 Disconnect the hose in the system at or near the water injection ring. Fit one of the plugs in the open hose and double clamp securely.

3 Fit the other plug in the hose as near to, or on the end of the thru-hull fitting.

4 Pressurize the plugged system with compressed air to 7 ± 1 psi.

5 Wait at least 30 minutes and inspect for pressure decay. Zero decay means you have a tight, secure system. Decay of the pressure by 50% means you have a potentially dangerous leak. Thoroughly inspect the system to locate and repair the leak prior to further engine operation. Be sure to record the pressure after the 30-minute period for comparison at the next test.



CO Prevention

There are several things that you should do to protect yourself, those onboard, and occupants on other boats. To minimize the flow of gas or vapor, be sure all deck and bulkhead openings for cables or wires, hoses or ducts into accommodation areas are well sealed. After sealing check for any leaks (see "Tip" on opposite page). Canvas enclosures must be installed to provide sufficient amounts of fresh air to keep CO to acceptable levels in the cabin. If necessary, add fans to circulate fresh air. If you or your mooring or dock neighbor must run your gen-set, make sure you provide for ventilation of your boat's interior spaces by opening a hatch, port-light, companionway, etc.

Examine your deck hatch configuration. If a station-wagon effect is suspect, or when running downwind, keep the salon door and forward hatches open to improve air flow, or change direction. Install a grill on the cabin door for ventilation when the door is closed. Foredeck hatch opening directional orientation is important. Underway, a hatch hinged on the aft edge scoops

fresh air into the cabin. If hinged on the forward edge, air goes around the hatch, and can create a venturi effect that reduces pressure in the cabin, sucking air and possibly CO into the interior (**Figure 5**).

Air intake and exhausts, including air conditioning ducts located in accommodation spaces, should not connect to the engine room.

For added insurance, the American Boat & Yacht Council (ABYC) recommends that all boats with enclosed accommodation compartments (any area where one can sit or lie down), and with a gasoline gen-set or a gasoline engine, which also includes outboard motors, stern drives and saildrives, install a CO monitor (see "Marine Alarms" below). Keep your engine tuned and clean running. Since less oxygen creates more CO, if your engine is preset to run at sea level and you live at higher altitudes, have a dealer reset the engine for the operating atmospheric condition.

Crewmembers who get sleepy and want to go below and lie down may be suffering from CO exposure. Keep them on deck, in the fresh air, and be alert to the CO hazard. They might be seasick or otherwise ill, but it's best to exercise extreme caution. If you suspect CO poisoning, stop the boat, change the direction, ventilate the interior. Do anything and everything you can to identify the hazard and eliminate it. Get help immediately. If your crew is suffering from a CO condition, time is of the essence.

Exposure to CO is dangerous business. This article is not intended to scare you, but to bring your consciousness of the potential for CO problems to an appropriate level. Some suggestions for appropriate actions have been offered. Consider what you need to do. ⚓

About the author: John Ford is a technical and engineering consultant to select marine companies. He was formerly president and general manager of Vernay Products, a manufacturer of marine exhaust components, where he worked for 22 years prior to the firm's sale to Centek Industries.

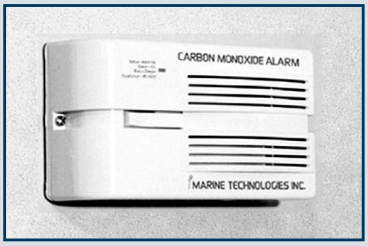
References

ABYC A-24 Carbon Monoxide Detection Systems
ABYC TH-22 Educational Information About Carbon Monoxide
ABYC TH-23 Design, Construction And Testing Of Boats In Consideration Of Carbon Monoxide.

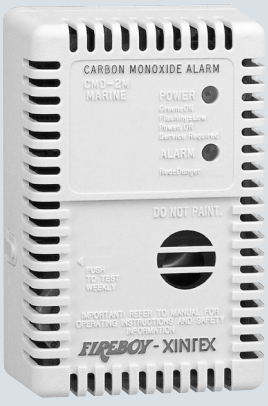
Underwriter's Laboratories also has standards for engine exhaust system components and CO detectors (UL 1129, UL 2034 and UL 1524).

MARINE ALARMS

Even with the best boat designs, and careful attention to ventilation of the boat's interior, there are times when accumulation of CO in accommodation spaces is unavoidable. That's why you need a marine grade CO detector. ABYC recommends CO alarms be installed in all gas engine powered boats with enclosed heads, galleys and sleeping compartments. A detector should be installed in each of the defined compartments. This means that aft-cabin cruisers require three detectors.



Older detector models often sounded alarms at every engine start or during fueling. Great improvements have been designed into these devices in recent years. Newer detection units designed strictly for marine use use sophisticated microprocessor technology to "monitor" CO levels while factoring in humidity, temperature and time, thereby increasing accuracy and reducing false alarms. Underwriter's Laboratories (UL), the folks who conduct third-party testing and certification of electronic components, has changed the standards for COHb levels registered by marine CO detectors. Effective December 30, 2000, standards are reduced from 20% to 10% COHb (same as for homes). There is some concern that this level may be too sensitive for boat use, especially during short-term exposure when operating conditions can't get below 10%. It will likely take a year before these units are available in the market place.



Fireboy/Xintex (fireboy-xintex.com) and Marine Technologies (www.mtiindustries.com) are currently the only brands intended for marine use. These units are designed to operate within the safe CO levels often present temporarily while boating without sounding nuisance alarms, are built to withstand moisture and corrosion. Unlike units designed for homes, the marine detectors don't require batteries, instead, they are wired and fused to the boat's DC power source. Prices range from US$55 to US$115.

— *Jan Mundy*

Rigging Sailboat

STEERING TUNE-UP

Steering is one of the critical systems onboard that must be routinely inspected and maintained to ensure reliable and safe operation. Here's how to troubleshoot, maintain and service cable wheel steering systems. Details on hydraulic systems appear in the next issue (2001-#2).

By Nick Bailey

In most cases, wheel steering system failures could be prevented by a little ongoing maintenance. Steering systems are not complex, but access usually demands contortionist work in a claustrophobic locker.

Any wheel steering system is required to translate the motion of the steering wheel to movement of the rudder. This is usually accomplished in sailboats with wire rope cables or a direct mechanical linkage.

The most direct systems are the geared steering units that attach directly to the rudderstock or a transom-hung rudder. This type of system employs a rack and pinion, or worm gear drive, connected by a short shaft to the wheel, usually located so that the helmsman sits behind the wheel in the after end of the cockpit. Modern rack-and-pinion-geared steerers, such as those available from Whitlock and Edson, are now also common in the familiar steering pedestal configuration. These also connect to the rudder with a solid linkage. The geared systems are precise, elegant and very low maintenance, and for that reason I will not address them in this article.

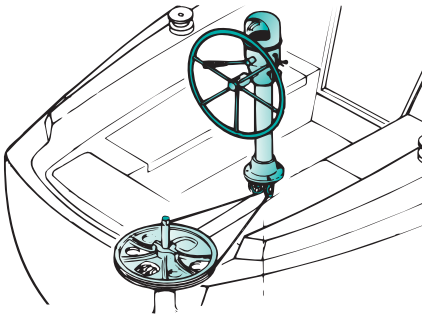
Hydraulic steering is very much the norm in powerboats. It is sometimes used as an alternative to the mechanical wheel steering on sailboats, especially for center-cockpit sailboats or motor sailors where the helm may be a few cabins away from the rudder head. A motor sailor where both pilothouse and cockpit helm stations are desired is also a good candidate for hydraulics. In these installations, hydraulics are much simpler to install as multiple helm stations, or an extended separation of the wheel and rudder assemblies, make for complicated linkage arrangements. [Ed: We'll discuss the troubleshooting and servicing of hydraulic steering systems in the next issue (2001-#2).]

Cable Systems

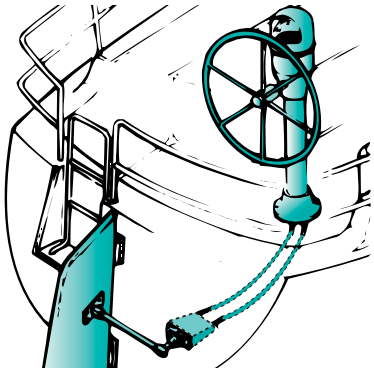
The most popular sailboat steering systems use cables. There are two types: open cable or enclosed cable with either a pull-pull cable or push-pull cable.

Open cable The first wheel steering design, which is still the most popular, usually has the wheel mounted on a steering pedestal in the cockpit. The steering wheel shaft is fitted with a sprocket that drives a bicycle-style chain that connects to two stainless-steel wire rope cables. Cables are routed back to the rudder shaft through one or more idler sheaves to connect on opposing sides to a rudder head quadrant that is firmly fixed to the rudder shaft or stock. The circular or fractionally curved quadrant allows the wire rope to load and unload smoothly at a constant radius and angle regardless of the rudder position. When the chain, which is moved by the sprocket on a wheel shaft, pulls one cable or the other the rudder moves. The unloaded, or slack cable, follows along for the ride. For this reason, all open cable systems are referred to as "pull-pull" systems. One cable pulls in one direction and the other cable pulls in the other direction. As everyone knows, you can't push a rope, except when it is enclosed. Read on.

Enclosed cable systems These use plastic sheathed cables where the outer sheath is firmly fixed at both ends and forms a close fitting, but low friction, conduit for the inner metal cable. The advantage here is



Easy to install and maintain, cables lead directly to the drive wheel in a radial drive system.



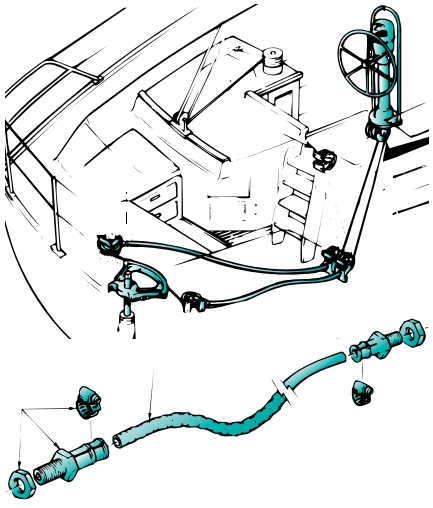
EDSON INTERNATIONAL

Edson's RLA push-pull system for small boats.

Rigging

that the sheathed cables can be led through curved circuitous routes that would be impractical for open cables, which need straight runs between idler sheaves. The disadvantage of enclosed cables is a bit higher friction and some loss of feel. This disadvantage increases for each bend in the cable, especially if the bends occur in a tight radius. Enclosed cable systems are either pull-pull type, where two cables act on a quadrant from opposite sides just like the open cable system described above, or they are push-pull type.

Push-pull systems such as Edson's RLA (Remote Linear Actuator) are only used on small sailboats where the rudder loads are modest. They are inexpensive and relatively easy to install. A single sheathed cable acts like a solid actuating arm or "drag link." Both rudder and wheel ends of the cable use solid metal rod similar to an oversized shift or throttle cable. The end at the wheel is attached to one side of the chain drive in the pedestal while the cable sheath is fixed near the pedestal base. As the wheel turns back and forth, the cable's solid rod end that is attached to the chain goes up or down, and pushes or pulls the rest of the cable connected to a lever arm at the (usually outboard) rudder.

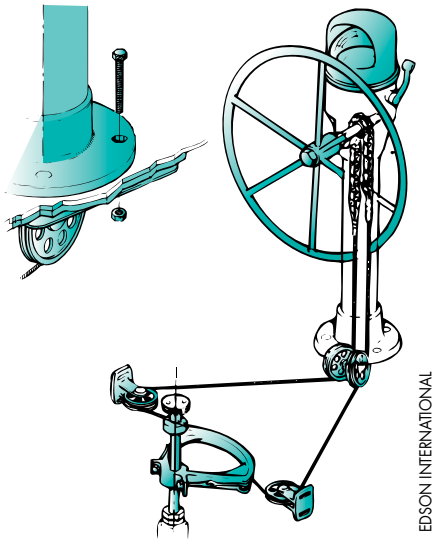


Center cockpit steering installation has wire leading from pedestal and pull-pull conduit routed to quadrant. (bottom) Replacement conduit and end fittings are available in pre-assembled lengths.

Troubleshooting

The most common failure in an open cable system is a jumped or broken cable caused by inadequate cable tension. When the wheel is jammed or very stiff to move, check for a cable that has jumped the sheave and jammed in the idler. If the steering is jammed, yet everything looks okay below, release the steering cables from the quadrant and try moving the quadrant by hand. If it won't budge or is very stiff, you have a rudder bearing problem or a bent rudder shaft. If the rudder is free, check that all the idler sheaves turn freely before reconnecting the cables.

If your boat won't steer, but the wheel moves freely, check cables under the cockpit floor at the pedestal base. If they don't move with the wheel, the drive chain or cable has broken in the pedestal, or the drive sprocket is loose on the steering wheel shaft. Also make sure the wheel itself hasn't somehow dropped its key and is spinning on the wheel shaft. You are more likely to find that all is well on the pedestal, and that a cable has broken between the pedestal and quadrant. When cables and chain all look okay, make sure the quadrant isn't loose on the rudder shaft. The quadrant clamps to the shaft. On a solid shaft, it's usually secured with a key and grub screw combination, and on a hollow shaft with a through bolt acting as a pin. If the quadrant is securely fixed to the shaft, and the shaft turns with it, you have probably broken your rudder. Time to jury rig a rudder (use a floorboard or hatch lid) and carefully balance the sails. If the rudder is still there, and you can't immediately fix the problem, it's time for the emergency tiller. It's a great idea to practice fitting the emergency tiller so that, if you have to do it in response to an emergency, you will not discover that it doesn't fit.



(right) Quadrant system routes cables through one or more sheaves. (left) If service access to the idler sheaves at the pedestal base is restricted, you may need to unbolt and remove the pedestal.

Closed cable systems require the same general troubleshooting steps. Sometimes cables bind and seize if neglected. Release them from the quadrant and move the wheel. Replace if they are stiff since typically, they are not serviceable. Don't try to force a resistant cable. A replacement is cheap insurance for the peace of mind of reliable steering control.

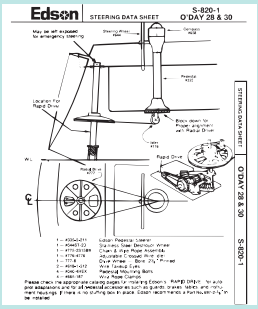
Maintenance and Service

The most important maintenance factors of an open cable system are frequent lubrication of cables and all moving parts, and proper tension of the cables. Idlers should be oiled monthly with SAE 30 or any light oil. Cables should be visually inspected and lubricated annually by soaking a pad of paper towel or tissue with SAE 30 oil and carefully rubbing oil into the wire strands. Any broken strands (be careful not to cut yourself) will snag the towel leaving an obvi-

STEERING PLANS

Edson offers data sheets for steering systems on virtually all production boats. Sheets include a schematic of the steering system mounted on the specific boat and a list of parts and hardware. To obtain data sheets for your boat, call Edson Customer Service at 508/995-9711 or send an email to info@edsonintl.com, and give the name of boatbuilder, model, length and year built. Edson will mail or fax you the appropriate data sheet.

— Jan Mundy

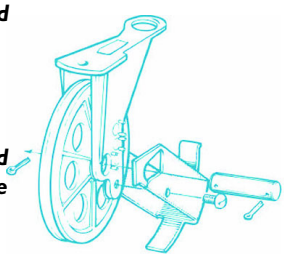


ous paper scrap stuck to the wire. A broken strand means the cable is weakened and must be replaced.

Cable replacement requires backing off the lock nut and securing nut on the cable take-up eye where it fits into the quadrant. Once the cable is slack remove the cable clamps or, if swaged in place, cut the cable end loop to free it from the take-up eye. Go back on deck and prepare to pull the cable and chain out of the top of the pedestal. If you have a pedestal-mounted compass carefully mark the binnacle position on the pedestal. (Tip: Overlap tape across the pedestal to binnacle join, and cut the tape when you remove the compass.) This preserves the exact position for reinstallation when you'll need to reswing the compass. Remove the compass to expose the chain and drive sprocket. While you are at it (assuming this is an Edson pedestal) do the annual lubrication of the wheel shaft needle bearings by squeezing Teflon (Edson part #827) grease into the holes located on top of the bearing housings inside the pedestal. Spin the wheel to work the grease in but don't over lubricate. The bearings need the grease, not the wheel itself.

As well, the roller chain needs annual oiling with SAE 30. Lift the chain off the sprocket to remove the clevis and shackle holding the cable. Notice that the end of the chain attached to the loose cable seems to be opposite to what you expected. That is because many installations require the cables to cross sides inside the pedestal. If you reinstall them straight you will end up going to port when you steer to starboard. Regardless of evidence of service wear, the cables are recommended for replacement every five years. Replacement chain and wire kits are readily available from your local dealer or direct from the manufacturer. (Prices of Edson kits range from US$164 to US$427.)

To adjust cable tension, Edson recommends tightening

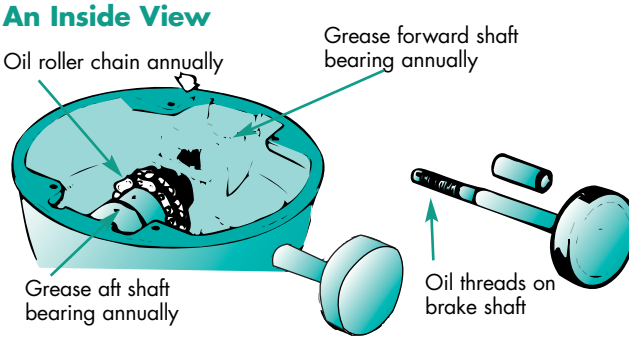


Retrofit sheave guard kits, available from Edson, help prevent derailing and jamming due to slack cables.

just enough to prevent the quadrant and rudder moving independently of the wheel. To check this, lock or tie the wheel and try to move the quadrant and rudderstock. If any movement is noted, the cables need to be tighter. Don't over tighten. This increases friction and deadens feel at the helm as well as accelerating wear at all bearing points. Others suggest a maximum cable deflection under moderate pressure of 2.5cm per 30cm (1" per foot) of cable run.

Monthly lubrication with SAE 30 is recommended for idler sheave bearings. In some cases, if the bearing seizes, the entire axle pin may turn in the housing. This damages the housing and leads to a nasty failure. It's good practice to dismantle the idlers to check pins and bearings for unusual wear any time you have the cables out for replacement. During an extended cruise the system should be inspected daily and lubricated weekly. In a tropical environment or charter service, the maintenance schedule should be accelerated.

An Inside View



Sheathed cables (pull-pull and push-pull) require lubricating wheel bearings and chain as outlined on page 43. Some sheathed cables are fitted with an in-line grease cup. This should be given a turn or two monthly and re-filled when necessary. If the inner cables can be removed, lubricated and refitted, perform this task every five years, or more frequently in a corrosive saltwater environment. The worst wear on sheathed cable systems occurs where the cable enters or exits the sheath. Even minor misalignment of the sheath mount and the inner cable axis will result in premature wear. Tight radius bends are also to be avoided. Anything less than a 15cm (6") radius is unacceptable.

On all systems, periodically check the tightness of quadrant cap screws and rudder stock grub screws, pin, etc. plus all clevis pins and idler mount fasteners.

Edson's handbook also recommends putting the whole system through its paces once a season, and before any extended cruise. While motoring at full speed, well away from any other boats, have an assistant take the helm. Squeeze yourself into a cockpit locker to a position where you can observe the steering gear in action. Then have the helm put full over. Watch for any movement and listen for any creaks or groans in the system that might indicate loose, worn or poorly installed hardware. When the boat is moored, always lock or tie off the wheel to prevent wave action from beating the steering system to death.

About the author: Nick Bailey is service manager of Bristol Marine in Port Credit, Ontario. He is a 25-year veteran of the boat repair business. In his spare time, he is a fanatical racer (and equally fanatical maintenance chief) of the antique wooden T-Bird "Looney Tunes."

Electronics

PLUGGED IN

Electronics range from basic systems for small boats to sophisticated, multi-interfaced operations centers for large cruisers. Here's the latest in power and sailboat electronics for staying in touch, navigating, handling emergencies and onboard entertainment.

By Charles Husick

Advances in technology have made marine electronic equipment less costly, more capable, easier to use and more reliable. Yesterday's problem of finding a few pieces of equipment has become the problem of selecting from the bewildering array of products found in chandleries or marine mail-order catalogs. As a prudent boat owner you will want to select the devices that will best assure communications safety, navigation safety, convenience and enjoyment, preferably in that order.

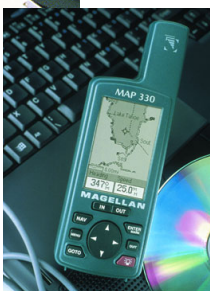
In boating, safety must always be number one. You need not be in an ocean, miles from shore to be very much alone and out of touch with any possible source of assistance should something go awry. A large pond or lake provides all the isolation needed to create a potentially dangerous situation.

Regardless of the size of your boat, from a canoe to a motor yacht, you should carry at least one marine VHF radio and preferably two, one of which is a waterproof hand-held, battery-powered unit. Cellular phones are valuable in areas where the user is in range of a cell site but should not be considered a substitution for a VHF radio. Unlike cell phones, which communicate only with the called party, any boat or shore station with an operating VHF radio in reception range can receive transmissions.

The following equipment suggestions are intended to spark your thinking about your boat, how and where you use it, and the way in which marine electronic equipment may be able to ensure your safety afloat and your boating enjoyment.

Runabout

The basic equipment list for a typical 5.4m (18') runabout used on protected waters such as a lake, bay or near-shore ocean coastal should include a fixed mount VHF set powered by the boat's battery. With a fixed antenna, this radio has longer range than a hand-held unit.



(right) Use the street maps in the Magellan 333M GPS to find the launch ramp, then locate your favorite fishing hole on the water.

Next on the list is a depth sounder or fish finder. Knowing the depth of the water under your boat reduces the chance of running aground and doubles as a valuable navigation tool. If caught in suddenly reduced visibility, drive in a direction that will bring your boat to a water depth shown on the chart. By following a given depth contour and comparing the steered compass course with the chart, you can locate your position and plot a safe course.

Many boat owners, regardless of boat size, carry a GPS. Cost for a basic hand-held unit is as affordable as US$100, while units with minimal chart-plotting capability in the US$200 range. A chart-capable GPS still requires having the proper marine chart for your boating area. A great deal of vital information contained on the paper chart does not appear on the GPS plotter.

Almost every boat has an entertainment system and runabouts are usually equipped with an automobile radio, often with AM-FM, tape and CD capability. A word of caution regarding the system's installation. Be sure the boat's compass is not adversely affected by the magnetic field of either the radio or speakers. It's common practice to use speakers that have no magnetic shielding. Such speakers can influence a compass more than .9m (3') distant from the speakers. You can effectively reduce the stray magnetic

Electronics

field of speakers by using a simple disk magnet (see "Reducing Stray Magnetic Field" on page 48).

Onboard electronics are powered from the boat's engine starting battery. With small horsepower engines, replace the conventional starting battery with a marine deep-cycle battery. It delivers the modest current demand of the engine's starter motor and better withstands occasional discharging while operating electronic devices when the engine is not running.

Equipment Summary: Stereo, fixed or hand-held VHF radio, GPS, depth sounder.

Daysailer

The electronic equipment compliment for a 7.3m (24') daysailer resembles that suggested for a runabout. Boats sailed in open waters should also carry a 406 EPIRB. The fixed mount VHF radio connects to a masthead mount 3db antenna, not a 6db that can cause communication problems. With a mast height of 9.1m (30'), the radio horizon will be approximately 7 nautical miles distant and communication with shore stations as much as 56km (35 miles) distant. Although the length of coaxial antenna cable between the radio and the antenna may be only 15m (50'), it's important to use low-loss antenna cable, either RG-8X or even better, RX-213 coax. The small diameter coax supplied with many VHF antennas is not suitable for use in a sailboat antenna installation.

The pocket-sized, battery-operated Davis Turbo Meter (US$165) gives accurate wind speed readouts and makes a good substitute for a hard-wired unit installed at the masthead.

Remaining gear includes a GPS, depth sounder and if desired, a hull-speed readout, and wind direction and wind speed instruments. A compact, battery-powered, hand-held wind speed measuring device, such as the Davis Turbo Meter, is a good alternative for small boats to installing a fixed unit with masthead- or backstay-mounted sensors. A hand-held VHF set is a desirable back up for the fixed mount radio.

An autopilot may seem a bit out of place on a small sailboat. An inexpensive electric (or manual) tiller pilot, capable of holding the boat on a constant magnetic heading can be really welcome crewmember. Power consumption is low and easily within the capability of the boat's battery.

Although a GPS reads speed over the ground, a hull speed display is valuable in developing optimum sail trim. Unless the boat is dry sailed, install the thru-hull sensor so it's easily removed when not in use. The small paddle wheel-type sensor rapidly fouls in most waters.

It's likely that a car radio will be onboard. Consider the cautions regarding the magnetic field from the speakers as noted in "Reducing Stray Magnetic Field" on page 48.

The electrical system on a daysailer need not be complex but it should be carefully designed and properly installed. A single, 12-volt marine deep-cycle battery will usually suffice. A group size 27 battery is a better choice than the slightly smaller and lighter group size 24. All positive wires should be fused or equipped with a circuit breaker with a current rating determined by the current-carrying capacity of the wire. Battery charging can be done from the boat's engine (inboard or outboard) or from a battery charger powered from shorepower when dockside. A small deck-mounted solar panel (see "Solar Solutions" on page 12) is a great addition, especially for boats kept on a mooring. It provides sufficient energy to run a small bilge pump and maintains the battery at full charge.

Equipment Summary: Stereo, fixed VHF radio, hand-held VHF radio, GPS, depth sounder, hull speedo, apparent wind direction and wind speed, tiller pilot, 406 EPIRB.

Mini Cruiser

Electronic equipment for a 7.3m (24') mini cabin cruiser very likely includes all the electronics suggested for the daysailer, with the possible addition of a chart plotter and elimination of the wind speed and direction system. An autopilot specially designed to drive the boat's wheel steering system would replace the tiller pilot referenced above. Some models interface with a GPS, allowing the pilot to automatically follow a course to a waypoint. If this option is used, remember to keep a good lookout. Given the repeatability of

(left) Compact and waterproof, the Furuno 1712 LCD radar is perfect for smaller boats. (right) ACR's Satellite 406 Category I EPIRB automatically activates at a depth of 4m (13'), operating for more than 48 hours. Regulations require battery replacement every 5 years.

GPS and the capability of autopilots, there is a good chance that an unattended boat will run into the daymark used as a waypoint.

A chart plotter need not be a large or complex device and can be packaged with the GPS. Boats run at night or in areas where fog or heavy rain is likely, should install radar. [Ed: Refer to DIY 2000-#3 issue for radar selection and step-by-step installation.] Once you navigate in difficult visibility with radar onboard, you won't want to travel without it.

Equipment Summary: Stereo, fixed VHF radio, hand-held VHF radio, GPS, 406 EPIRB, depth sounder, autopilot, chart plotter, radar.

Sailing Yacht

Electronics systems on these boats vary substantially, depending on the intended use of the boat. Electronics may include fixed and hand-held VHF radios, GPS, 406 EPIRB, sailing instruments, depth sounder, radar, autopilot, single sideband radio (SSB), or perhaps an Inmarsat C satellite communications system. Some owners may also include some type of satellite communications system or satellite telephone.

With the proper modem, digital communication is possible with commercial shore stations or via ham radio. With a laptop computer and appropriate software, an SSB radio can receive weather faxes. If desired the computer can also serve as a chart plotter, using a variety of soft-

(above) Yeoman's "operations" board integrates GPS data with electronic plotting. (below) Command center onboard the Catana 472 multihull.

TWO-WAY MESSAGING

Family radio service (FRS) portable radios operating in the 400 MHz band are very useful on a boat for boat-to-shore and onshore communications. Prices start as low as US$50 a pair for a very basic radio, with units with all the bells and whistles selling for about US$120.

Communication signals are good for up to about 1.5 miles, although longer ranges are claimed. These radios do not require a license to operate, unlike VHF radios, however, they are not a substitutes for a marine VHF radio. With headsets and microphones, some larger boats use them for communication between the helm and the anchor crew on the bow. They are also very useful to communicate with someone up the mast.

— Chuck Husick

REDUCING STRAY MAGNETIC FIELD

Some speakers designed for marine use are built to greatly reduce the magnitude of their stray magnetic field, thus reducing the interference with compasses and the magnetic heading sensors used with autopilots.

It's possible to reduce the stray field from standard speakers with a simple disk magnet. Glue a disk magnet (about US$3 from Edmund Scientific in New Jersey) of approximately the same diameter as the back of the speaker magnet to the rear of the speaker magnet. When the disk magnet is securely glued to the speaker magnet, the magnetic repulsion force decreases to a low level, canceling much of the speaker magnet's stray field. The added magnet need not precisely match the size of the speaker, but must be placed so it's repelled by the magnetic field of the speaker. When modified in this manner, the speaker's magnetic field may be low enough to permit mounting the speaker as close as 30.4cm to 45.7cm (12" to 18") from the compass or autopilot sensor without creating problems.

— *Chuck Husick*

ware programs and chart databases. Alternatively, the Yeoman chart system may be more attractive than a computer-based approach since it uses conventional paper charts, including special purpose charts drawn by the navigator. [Ed: See DIY product review of the Yeoman Sport XL in "Dockside," 1998-#4 issue.] A paperless Navtex receiver, such as the Furuno NX300, is a fine addition when operating in areas where up-to-the-minute knowledge of buoyage is critical to safety. This compact receiver functions in a continuous unattended mode, displaying navigation, safety and weather notices to mariners. Many laptop computers can also be used to show movies, perhaps not in the old salt tradition, but fun nonetheless.

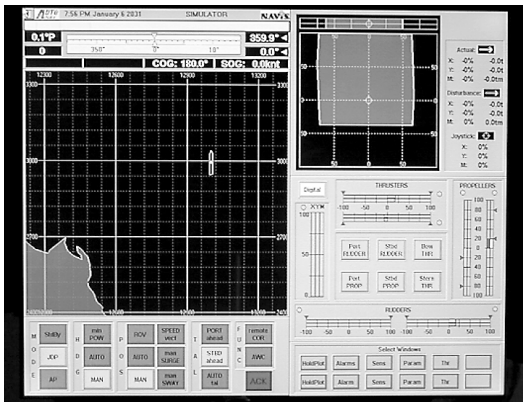
Equipment Summary; Stereo, TV, fixed VHF radio, hand-held VHF radio, GPS, 406 EPIRB, depth sounder, sailing instruments, autopilot, radar, SSB radio, laptop computer with modem, chart plotter or plotter software for the computer, Yeoman, Navtex receiver.

Motor Yacht

There is likely room at the helm station(s) on a 12m (40') motor yacht for all the equipment the owner believes necessary for safe and enjoyable cruising.

The equipment compliment can include fixed and hand-held VHF radios, apparent wind direction, wind speed and hull speed displays, depth sounder and/or fish finder, forward-looking sonar, radar with optional built-in ARPA (automatic radar plotting aid), DGPS and associated chart plotter with radar interface, remote heading sensor system (necessary for operation of radar display options and for overlay of radar data on chart plotter), autopilot with interface to chart plotter, satellite television and, depending on the cruising area, satellite telephone, Navtex receiver, 406 EPIRB and an extensive entertainment and stereo system. [Ed: With maximum baud rates of only 9,600, Internet and email access via satellite is too slow to be practical.]

Major navigation elements will be extensively interfaced. The remote heading sensor (i.e. Co-Pilot electronic compass, US$120; KVH Azimuth 1000 fluxgate compass, US$270) will provide information to the radar, chart plotter, autopilot and to the helmsman's compass display. The radar, DGPS, chart plotter and fish finder will interconnect, allowing exchange of data between all of these devices. The heading sensor will also provide the heading, roll, pitch and yaw data necessary to aim and stabilize the satellite TV and satellite telephone system antennas. In the most capable installations, a general-purpose computer will replace the dedicated chart plotter. This computer runs the chart plotter software and, in addition, provides



Beier IVCS 2000 from AutoNav Marine Systems offers touch screen control of onboard systems and monitoring of all vessel movements.

flexibility in the use of the main display panels. Possibly included is vessel management software (Autonav and RGM) to monitor propulsion and energy systems, including archival storage of monitored parameters. Given enough money, this type of boat can be equipped as extensively as any cruise liner.

Equipment Summary: Entertainment system with stereo, TV, VCR, DVD and satellite dish; fixed VHF radios, hand-held VHF radios, GPS, 406 EPIRB, depth sounder, wind instruments, speedo, autopilot, radar, laptop computer with modem, chart plotter or plotter software for the computer, Navtex receiver, satellite telephone system.

About the author: Charles Husick is an electronics engineer and the former president of Chris-Craft Boat Company. He currently operates an aviation and marine consulting company based in Tierra Verde, Florida.

IT'S IN THE NITS

Monitor readability on laptop computers has certainly improved in the last decade. You can now view these LCD monitors from different angles in most controlled lighting conditions. They work great below decks where there is a controlled light environment, but on deck, are totally unreadable, unless you engineer a shield to mask the light, and even then, visibility is marginal.

Just launched by VEI Computer Displays (954/764-1640, www.vei-systems.com) and other electronics suppliers are daylight and sunlight readable screens. Waterproof, these monitors are perfect for e-charting in the cockpit. So, what's the difference? A conventional laptop has a 150 nits monitor, a nit being a measurement of brightness. To operate in sunlight, a monitor must have 1,000 nits or higher. In terms of visibility, it's like placing a 100-watt bulb in the back of the screen.

— Jan Mundy

INFLATABLE Maintenance

ALL ABOUT INFLATABLES

There is more to caring for your inflatable boat than an occasional cleaning. A professional tells you how to maintain your boat to ensure longevity, improve it and effect repairs when necessary.

Story and Photos by Jan Mundy

SHERYL SHARD

The tender-of-choice for most cruisers surely is the inflatable boat — you rarely see hard-shell boats tied up at dinghy docks anymore. And rightly so, since inflatables are near-recklessly stable, a blast to drive and seemingly low maintenance. No longer a low-priced, blow-up toy, a well made inflatable is expensive, but will last many years when cared for properly.

Before doing any work on your boat, you need to identify its construction. There are basically two categories of hull fabrics and each has distinct requirements. The most common fabrics are PVC and its derivatives, and Hypalon and it's relatives. Inflatables from Quicksilver, West Marine and Zodiac, for example, are made of a PVC-type, thermoplastic that's welded together. The more traditional rubber, Hypalon-based inflatables, such as AB, Achilles, APEX, Avon,

INFLATABLE Maintenance

Novurania, Seaworthy and older West Marine models, are entirely hand glued.

Care: Dos and Don'ts

Do you know what causes inflatable wear and tear? What cleaners to use? What damages are unrepairable? How do you properly prepare your boat for long-term storage? For answers to these and other questions, DIY interviewed Howard Shure, president of The Air Works, Annapolis, Maryland (410/269-0552; airworks@annap.infi.net). Air Works is a busy shop that specializes in sales and service of inflatable boats and liferafts on the East Coast. The company is also an authorized warranty and repair station for inflatable boat manufacturers. The shop repairs 1,600 boats and liferafts annually, including Coast Guard, Marine Corps, Army Special Forces, Navy Seal and rescue boats.

The single-biggest source of damage is running your boat underinflated. "When properly inflated, the boat's a rigid structure," explains Shure, "but when underinflated, it's a bag of air that constantly flexes. Floorboards chafe the tubes, the weight of the engine strains the transom-tube joint and the boat slowly tears itself apart."

Maintaining the wood transom finish is a lot cheaper than buying either a replacement transom from the manufacturer or a custom-made one.

SHERYL SHARD

Bottom cleaning is a dirty job. It's better to stow the dinghy in davits or on deck. To prevent damaging Hypalon or PVC fabrics when removing algae, barnacles, etc., Howard Shure of The Air Works recommends Mary Kate On/Off.

Inflatables must be inflated drum-hard, typically 3.5 psi (check owner's manual for specs), according to Shure. "Pump up the boat as hard as you can using a foot pump. You'll never overinflate, unless there is a 50° range in day-night temperatures."

Cover it up — protect your boat from UV damage, the ultimate terminator of Hypalon and PVC inflatables.

Shure recommends checking inflation pressure before every use and offers this tip. Sit on the tube. If there is a noticeable depression, the boat's not fully inflated. A pressure gauge gives a more accurate measurement. It's a nice tool to have for small dinghies with low-horsepower engines, and it's mandatory equipment, according to Shure, for all sportboats powered by 10 hp or larger.

If you plan to leave your boat in the water, don't! There are inflatable bottom paints, MDR sells one, but if you have a foldable boat, when you roll it up, the paint may crack and flake. Instead, Shure recommends storing an inflatable on deck or in davits and when necessary, use MaryKate On/Off, a highly toxic, acid-based cleaner (apply this product only on land in a secure runoff discharge area), to remove algae, barnacles and other bottom growth. (Refer to DIY 1997-#2 for test results of this and other bottom cleaners.)

To reduce wear, keep your inflatable clean. Dirt, grit and sand tracked into the boat accumulate under the floorboards, abrading the tubes and keel, and rubbing the finish off floorboards. After each use, slightly deflate the boat, remove the floorboards (or inflatable floor), reinflate the boat and rinse thoroughly with soapy water. Don't let water collect under the floorboards. It rots the boards (see page 53) and nurtures mildew stains that are impossible to remove.

Valves typically have an O-ring in the cap and a diaphragm as part of the valve assembly. It's a smart preventive practice to replace all rings and valves before tubes go soft. To eliminate air leaks, replace O-rings annually, or sooner if the rubber dries out, and replace valves every three years or sooner, depending on use. Valve replacement on newer, high-end models is a simple task that requires exchanging valve inserts; on older boats you will have to install entire new valve assemblies. Clean valves frequently to remove dirt and salt buildup. Since valves are self-lubricating, never

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Maintenance

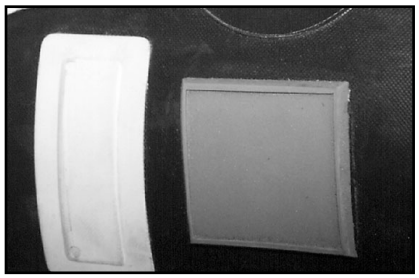
DRESS UP

Customizing is easy with the inflatable accessories available: covers, electric pumps, extra grab handholds, light mounts, pressure gauges, rod holders, seats, steering consoles, D-rings or towing rings and more. Here are some of our favorites. When adding D-rings and other critical components, we suggest you purchase only manufacturer-brand parts to ensure longevity.

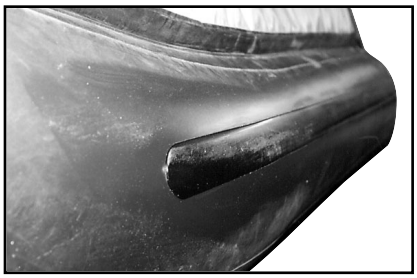
Mount battery-operated navigation lights for after-dark runs. (top) Best: Bow nav light patch of matched fabric with mounting bracket. (middle) Poor: Pad mount doesn't always stick well as it's incompatible with most fabrics and has a small surface area. (bottom) Engine-mounted stern light.

Comfort is found in a fold-down, padded, swiveling seat.

Removable canvas storage bag holds lifejackets, binos or whatever, and unzips from seat for carrying onboard or ashore.

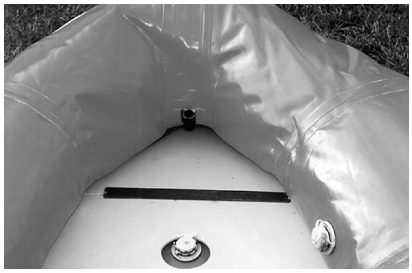


(right) Permanent registration sticker frame holder; (left) Sleeve patch securely anchors a plastic number board when boat is inflated and when deflated, board pulls out easily.



"Caribbean kit" consists of glued-on, heavy-duty strakes to protect tubes when landing or dragging boat on beaches.

Seat patches for added Zodiac-style seat.



Plywood floorboards should be sanded bare, all surfaces coated with epoxy resin, then overcoated with urethane or epoxy paint, preferably in safety yellow or orange. (top) For a secure foothold, apply a sprayable non-skid or a peel-and-stick non-slip matting.

grease them, which only attracts dirt.

Frequent doses of a protectant shields fabrics against UV damage. Never use Armor All or other silicone-based products that can make it difficult to repair or add accessories. According to Shure, the only UV protectant recommended by inflatable manufacturers is non-silicone-based 303 Protectant. "Although using a protectant makes the boat very slippery, I recommend applying it several times a season or as recommended by the manufacturer, or when the fabric looses it's slick feel." You'll also prolong the life of your inflatable by covering it. Inexpensive, off-the-shelf covers start at US$100.

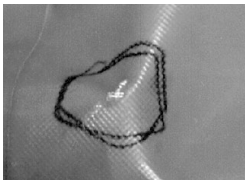
To reduce production costs, inflatable manufacturers continue to produce boats with plywood transoms, and those made of fiberglass are wood cored. The factory finish may last only a few seasons. Once it's deteriorated, the transom begins to rot, especially where brackets or patches that attach it to the tubes are bonded to bare wood. If water migrates through the plywood, the end-grain swells up like a sponge, and the wood plies begin to separate. Similar damage also occurs on boats stored uncovered in davits or in chocks on deck, where rainwater rots wooden floorboards. Replacement transoms and floorboards are available from the manufacturer, but repairs are expensive, about US$400 for a transom replacement.

To preserve floorboards and transom, don't revarnish. Instead, Shure recommends sanding with 120-grit paper then overcoating with a neutral color, long lasting paint, such as Epifanes Polyurethane, Interlux Brightside, Pettit Easypoxy or Sikkens Yacht Paint. I would add an extra step prior to painting. Remove the original finish, and seal the plywood and all edges with three coats of unthickened epoxy resin. Be sure to coat edges well to prevent water wicking through the end grain.

Storage

To prepare your boat for long-term storage, wash and dry it thoroughly, deflate, fold the tubes toward the center and roll it up loosely. Don't jam-pack it into a carrying bag. Store the boat in a dry, low humidity area away from hungry rodents.

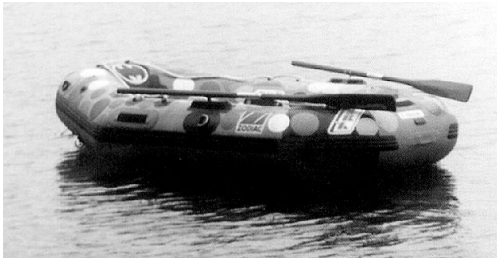
For boats used seasonally, Shure recommends a thorough inspection and pressure testing before stowing for the winter. To pressure test your boat, inflate it to the manufacturer's recommended operating pressure, wait 24 hours, then note any pressure loss. Depending on the age of your boat, you can expect some air loss, providing it's within the manufacturer's allowable tolerances. You can also take your boat to an inflatable service shop, such as The Air Works, where it will be inspected and pressure tested for a minimum charge. Some shops will store your boat as well.



Mice like the taste of the glue that holds Hypalon boats together.

INFLATABLE
Maintenance

PATCH WORKS



Whether it's a small tear, rotted transom or a replacement tube on a RIB, most inflatable boats are repairable, except those bathed in a silicone cleaner. "We see some repairs that won't stick no matter how much we terrorize the fabric," remarks Shure.

Inflatable boat repair is similar to gelcoat or fiberglass repairs. It requires carefully prepping the repair area, applying glue, then the patch. You'll need mixing containers, either plastic or paper, but not foam which the glues dissolve instantly; neoprene gloves; natural bristle brushes; safety glasses; emery cloth (for PVC only), or for Hypalon boats, a hand-held rotary tool, such as a Dremel, to abrade the repair area; a boning tool (shown in center of photo below); grease pencil; glue, patches and solvent as specified for your fabric.

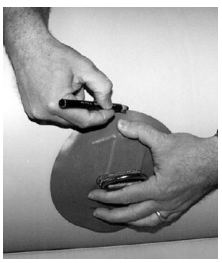
Since patches mechanically bond to Hypalon and chemically bond to PVC, before doing any repairs, you need to know your boat's fabric composition. Because of fabric and glue compatibility requirements, Shure advises using only PVC glue, solvents and patches on PVC boats. Ditto for Hypalon-based inflatables.

Professional repair shops use a two-part glue applied in a humidity-controlled environment. A field repair kit (about US$20), available from many chandleries, consists of Hypalon or PVC single-part glue, a compatible solvent, emery cloth and assorted, pre-abraded fabric patches. Bond strength is not as good as a professional repair, but the glue has the advantage of a long shelf life (until opened), tolerates high humidity and holds most times with the proper surface preparation.

Howard Shure of The Air Works demonstrates the steps to follow when adding an accessory patch (or repair patch) to a Hypalon (glued) or PVC (welded) boat using a field kit.

Step 1

Inflate boat. Cut a patch to cover the hole, a minimum size of 10cm (4") in diameter and round all corners (square edges lift easily). Place the patch in position and outline edges with a grease pencil. Don't use a ballpoint pen as it leaves a permanent mark. Lap the seams when the repair is near a glued seam. To do this, lift the seam (use a heat gun to melt the glue), complete the repair, and then reglue the seam. Repairs along rub rails, or anywhere near a welded seam are more complicated. You must grind the fabric edge to form a gradual, smooth transition. Simply gluing a patch over the entire area guarantees air seepage.



Step 2

On glued boats, thoroughly abrade the surface using a grinding stone in a rotary tool run at slow speed. Welded boats require a light sanding with emery cloth. Also grind (or sand) the patch if not pre-abraded.

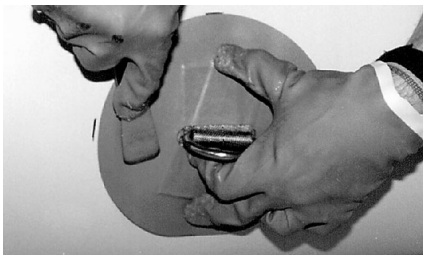
Step 3

Wipe both surfaces (boat and patch) with acetone (glued boats) or MEK (welded boats) and a paper towel to remove grinding dust, and prep surfaces before gluing. Repeat the solvent wash three times using clean rags. Wear gloves and apply in a well-ventilated area.

Step 4

Redraw alignment marks, if necessary. Use a natural bristle brush to apply three very thin coats of glue to the patch and repair area, five minutes apart (or according to directions).

Step 5

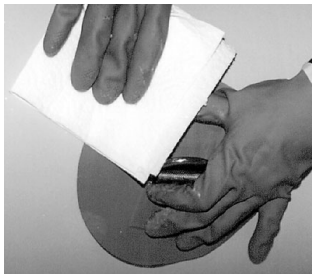


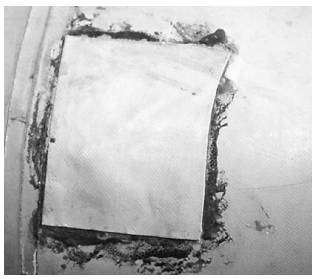
Apply patch and smooth with boning tool, firmly pressing down, especially along the edges and ridges of the various layers to ensure a solid bond.

Step 6

Remove excess glue before it cures as UV turns the glue an ugly brown color. Let cure for 24 hours before loading.

Difference between a good job and a bad job? (left) Round edges, no glue line; (right) square edges, unsightly cured glue.





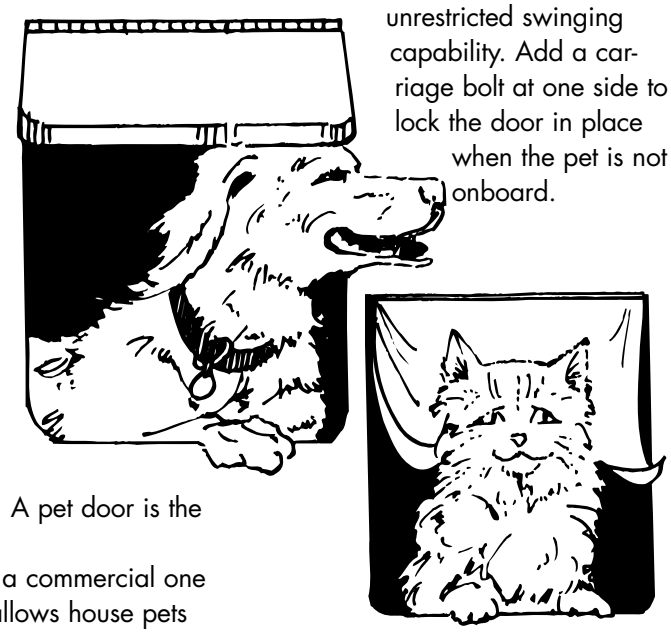
Good Boatkeeping

Story and illustrations by David and Zora Aiken

CUSTOM PET DOORS

Pets bring a lot of fun onboard, but they bring a few problems, too. It's hard to keep them from getting underfoot, especially at feeding time.

Dogs and cats both need a place for their dishes, and cats also need space for their "necessary" box. In some boats, the head may have room for these items, but it's neither practical nor Bristol to leave the head door open all the time. A pet door is the obvious solution.



You can buy a commercial one — the kind that allows house pets the freedom of indoor-outdoor living — but it's easy to make a suitable substitute.

The simplest door is made of fabric. Acrylic canvas is good because it's easy to clean and looks nautical. Use a jigsaw to cut a hole in the head door near the bottom. Hole opening for a cat is about 15cm x 17.8cm (6" x 7") high. The size of doggy doors will, of course, vary greatly. Hem the sides of the fabric so it fits just inside the opening. Wrap the top edge around a narrow, flat batten, and then screw the batten to the cut edge in the top of the opening so the fabric hangs in place. Dry-fit the cover, then hem the bottom edge. Gently push the cat (or dog) back and forth through the door a few times. You may have to offer a reward on each side until the animal catches on.

Another style of pet door is a solid panel, hinged at the top to swing both ways. Use a piece of lightweight plywood or Plexiglas for the door. Cut the door slightly smaller than the opening to ensure unrestricted swinging capability. Add a carriage bolt at one side to lock the door in place when the pet is not onboard.

EASY-TO-MAKE PEDESTAL GUARD

You can easily put together a pedestal guard made of stainless-steel tubing and fittings, the 19mm or 25mm (7/8" or 1") tubing typically used for pulpits and stanchions. Materials are readily available from a metal supplier or custom fabricator of marine tops, rails, ladders, etc.

For the base, take two stanchion bases, either round or rectangular bottom, and thru-bolt them to the cockpit sole on either side of the pedestal. To prep the sole for mounting, degrease the mating surfaces and scuff lightly with sand paper. Be sure the bases are well sealed with polysulfide or polyurethane caulking. Attach two lengths of tubing to the bases and extend them up to an appropriate height above the pedestal. Cut a piece of teak or a composite, like King StarBoard, to make a collar to fit around the top of the compass. The upright tubes fit through holes cut in the sides of this collar. Now cap the tops of the tubes with 90° stainless elbows that also create end fittings for a cross bar. These can either be thru-bolted or drilled and taped for Allen screws. Finish the crosspiece (the stainless "grabrail" portion) with some French braid or other decorative knotwork.

About the authors: David and Zora Aiken are the authors and illustrators of numerous boating, camping and children's books, including "Good Boatkeeping" and "Good Cruising" published by International Marine. They live aboard "Atelier," in Grasonville, Maryland.