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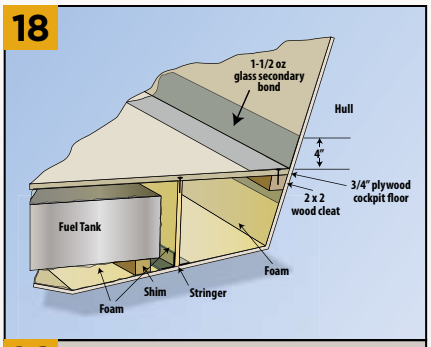

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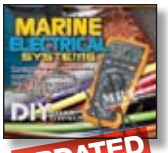

UPDATED

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

Painting & Refinishing

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

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Currents

Edited by Jan Mundy

I just read your interesting article in "Scuttlebutt", DIY 2005-#2 issue, about the HIN requirements. Immediately, I had an idea for my problem in locating a very rare sailboat, the YY-26, built 32 years ago that I absolutely must have. From your article it appears to me it should be possible to locate all the boats of that make and model in the state of California. Not only that, but also where they are presently located (so one can look at them) and also their most recent registered owner.
A. Burgelis via email

Pat Kearns replies: *You have taken the HIN concept to the logical conclusion for its potential application but that potential is not the reality. Let's look at the analogy of the VIN (vehicle identification number) for motor vehicles. That number contains a similar, even more extensive, base of data than the HIN for recreational boats. However, neither number provides for locating a boat or car. Both numbers were envisioned as identification numbers (the "I" between the "H" or the "V" and "N"), not a method of locating the property. Each number can be matched to a documentation or state (or province) registration database and that database contains the name and address of the property owner but it does not affirm exactly where the property is at any given time. While the HIN matched to documentation or registration paperwork can tell us the boat owner's address, it cannot and does not tell us where the boat is at any given time and the address given for the owner may not be where the owner lives. The HIN's purpose is to identify the boat, who built it and when and its model year, period. In the case of a boat that is suspect of being stolen, has been found adrift after a storm or is, for some reason, in need of being identified, the HIN is often capable of being matched to the owner via the boat's registry information. Even that is not easy because individual states often are not consistent in their registration formats, making finding the owner of a state registered boat not so easy if the only basis for identifying the boat is the HIN and the registration markings (numbers, validation stickers) have been removed. Could a HIN be the way to find a boat? Possibly, but that would require a totally revised mission for the purpose of the HIN. Law enforcement agencies have long desired a similar application for the HIN and VIN and issue is raised often when these people gather to discuss improving their ability to deal with vessel and motor vehicle theft. Using the HIN as the identifier for locating a boat would require a completely different intent and technology. Theoretically, you could probe a state or national database for HIN data of each boat you seek to find which registration records contain boats bearing the HIN prefix that identifies the boat's manufacturer. You still might not be able to physically locate the boat based on that information. It's a huge task and now national and state agencies that maintain databases of this type are coming under tremendous pressure to protect that data as confidential under the rights of individual privacy. A year ago, I could search the USCG database for a documented boat using a single or combination of known identifiers, including the HIN. I can't do that anymore as those records are no longer open to the public.*

Added Anode Anomalies

On page 5 in DIY 2005-#2 issue, "What's Accurate with Anodes," Martin Wigg of Performance Metals raised a question about anode chemical reaction. Is it electron flow, as per Steve Auger in the article titled, "Corrosion Protection" in DIY 2005-#1 issue, or is it ion flow as suggested by Wigg? In fact, both happen and one cannot happen without the other. The anode works because the metal atom (solid metal) gives up one or more electrons, depending upon which metal it is, and becomes an ion. The anodic reaction for zinc looks like this: $Zn \rightarrow Zn^{+2} + 2e^{-}$. The zinc atom (Zn) becomes an ion (Zn^{+2}) and it gives up two electrons ($2e^{-}$). The ion (Zn^{+2})normally dissolves instantly into the water resulting in a loss of material. The electrons produced ($2e^{-}$) flow off through the metal parts creating voltage and current, protecting various other metal parts on the boat (e.g., motor, sterndrive, prop) preventing them from corroding. It all depends upon which side of the fence one sits as to what is important. Auger is interested in stopping corrosion; that work is done by the electron flow. Wigg sees ions flowing around and wants to know how much metal is lost.
Wes Herdman, "pNeuma J," Ladysmith, British Columbia

Show and Tell

Readers' Boats

We've launched a new column in this issue: Readers' Boats. Now you can showcase your boat to DIY's international audience. You don't have to be a writer to have everyone see and read about your boat. Just send us a complete description of your boat (point form is okay) along with photos. Include details of any repairs or upgrades and, if available, provide a breakdown of materials, costs and labor. If published, you'll receive a DIY MRT SERIES CD-ROM of your choice (value US$19.95/ CDN$24.95). Choose from 13 topics (see page 2 for CD titles). Go to page 43 for complete details.

Return from the Past

I was amazed to see my old boat, a Cape Dory 26, hull 8, on DIY 2005-#2 cover. I'm the original owner and after 15 years sold it to the current owner. I most certainly will renew my subscription.
Larry Scott, Ankeny, Iowa

Torque for Thread Lockers

Most people don't realize that applying Loctite to a threaded fastener has an impact on the proper installation torque to be utilized. Loctite blue medium strength or equivalent reduces clean and dry torque by 26%, functioning as a lubricant while in the liquid state.
Doug Cohen, "DreamKetcher," Rotterdam, New York

Steve Auger replies: *When instructed by manufacturers' service publications to apply a specific thread locker, such as a Loctite 271 as stated in the Mercury Marine service manual, the published torque spec has been determined based on the fact that Loctite is a liquid until it sets. Therefore, the torque value is not for a "dry" fastener, as the value would be too low.*

Two Holes in One

Every fall we shrinkwrap the DIY project boat and, last year, we picked a cool and snowy day for this job. Halfway through winter, two of the plastic caps a top vertical support posts punctured the film on top of the cover. According to Mike Stenberg of Dr. Shrink, this was a case of too much height and loose strapping. We needed to lower the support structure so that more weight rests on the strapping running both fore and aft and side-to-side and super tighten the strapping. Mike kindly didn't mention the wrinkles in the film. (Actually, it was much to cold to "chase" the wrinkles.) When shrinkwrapping, ideally, you want to achieve a wrinkle-free cover. Wrinkles allow a cover to trap snow, which can weigh the shrinkwrap down enough to put pressure on the top posts.

Don't be Fooled by Imitations

According to a news release received from Lewmar, there are a number of patented Lewmar Delta anchor look-alikes now available. The original Delta can be recognized by its Lewmar branding, which comes with a lifetime guarantee and Lloyds Register type approval.

DIY boat owner the MARINE MAINTENANCE MAGAZINE

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DANGER, DO NOT SWIM IN MARINAS

Patricia Kearns

Swimming in marinas with shorepower can be lethal. Read this story of 9-year-old Lucas Ritz, written by his father Kevin, and spread the word.

Following is a summary of the facts surrounding my son's electrocution and my findings from the subsequent research that brings us to where we are today. First, you should know that this type of accident has happened before and will happen again unless something is done to stop an activity that is almost irresistible to young and not so young "kids."

On August 1st, 1999, my eight-year-old son Lucas N. Ritz was killed while swimming in the marina where we lived. It was a hot summer day and the children had worked and played hard. Other children were already swimming, so Ian, our other son, and Lucas asked to swim with their friends. All of the children were under close adult supervision and Lucas was wearing a Type II PFD life jacket. Swimming in the cove was a common practice for adults as well as children.

As the children were floating on an inner tub down on the inside of the dock, Lucas moved away from the others and towards his mother, Sheryl, who was walking along the dock, moving in time with the swimmers. As he approached the dock to get out of the water, a witness said that he let out a loud gasp and immediately rolled onto his back, apparently unconscious. His life jacket functioned perfectly and his face never was in the water. Sheryl yelled to the other children to help him and jumped in herself. As the children approached Lucas, they felt a slight tingle and immediately backed off. Sheryl's extremities went numb upon hitting the water and she had difficulty even moving. She felt at the time that it must be from fear and had no clue as to the real culprit. Sheryl was able to pull our son to the dockside where others assisted in getting him out of the water and onto the dock. I arrived moments later after hearing some commotion and, along with another onlooker, started CPR until the paramedics took over approximately 15 to 20 minutes later. Lucas was pronounced dead at 6:30 pm at Emanuel Hospital.

The first assumption by many was that he had drowned but we could not understand how, as his face never was in the water. He had the best life jacket money could buy; the type that keeps your face out of the water even if you are unconscious. He was pulled out of the water only moments after rolling unto his back and CPR was started immediately. At no time during CPR could we detect a heartbeat but his color was good. Neither of these observations would indicate drowning. It was not until the next morning that I was really able to start asking questions of Sheryl and Ian, our other son. As Sheryl was telling me what had happened, she said to me that she had never been so fearful in her life as to have her extremities tingle and go numb to the point that she could hardly move.

As she said this, Ian related to me for the first time that he also felt a tingling. Upon hearing this, it was clear to me that somehow, some way, AC electricity was in the water. I first called the County coroner's office and told them that if they were not already going to do an autopsy, I was requesting that one be done because I was very suspicious that Lucas had been electrocuted and he had not drowned. They argued with me that there were no burns on his body and, therefore, my theory could not be correct. I argued back that Lucas was completely submerged in an electrolytic solution, which eliminated the resistance of the skin. Burns are caused by the resistance of some kind and, because of his almost total emersion, the resistance would not be there. The office reported that they would not even know how to test for something like that. I told them that I did and that I was going to test the water in the area. I then called the local Sheriff's Department and left a message telling them of my suspicion. I went to the area with my digital voltmeter and put the negative lead to a good ground and dropped the positive lead into the water. I immediately got AC voltage confirming my suspicion. I called the Sheriff's Department again and reported what I had found and that I wanted to get an electrician out to test this. The Sheriff's Department agreed to send out some deputies. I called in a professional electrician. He arrived later that morning with equipment and started testing. The electricity source was traced to a powerboat.

More investigations and investigators followed: more deputies were called; the local utility company sent a team; the owner and manager of the marina; and all became involved in determining the source of the current. After further investigation it was found that a 12V wire was lying on top of an AC wire and had gotten hot to the point of melting its own insulation and that of the hot (black) AC wire.

This put 120V AC into the entire ground system of the boat. Every conductive part in the boat connected to the ground was energized with 120V AC. This included the engines and sterndrives. The sterndrives and propellers were emitting the bulk of the AC into the surrounding water. Freshwater is not a good conductor, therefore the AC was unable to reach ground and potentially short and trip the breaker. As Lucas approached the finger of the dock to get out of the water, he passed into the field of AC and for a brief moment completed the circuit to ground, causing his death by electrocution. The human body is a much better conductor than freshwater because of its high salinity. At first, we thought that this was just a freak accident that had not happened before and probably would not happen again. During further discussion with the electrician, he noted that had the 120-volt AC ground wire been bonded to the metal components on the boat (i.e., the negative side of the battery), the energizing of the 12-volt DC system with the 120-volt AC would have tripped off the shorepower breaker.

– Kevin Ritz is now a ABYC certified marine electrical technician, based in Scappose, Oregon, offering marine electrical services and surveys for recreational, commercial and government agency boats. The article was reprinted with permission from the Summer 2005 issue of "ABYC News."

Gasket Substitute

I need to replace the worn cork gasket on the lid of the water strainer for the Yanmar 2GM diesel engine on my 1983 Hunter 31. The water strainer comes off occasionally for cleaning and is made of clear plastic with a stainless-steel strainer basket inside and a bronze cap. This cap, which is held on by two wing nuts, has a cork gasket fitted in a circular groove. Where do I find replacement gasket material?
William Vollmer, Elmhurst, Ilinois

DIY replies: *We recommend sourcing bulk cork or rubber gasket material only when the correct manufacturer's gasket is not available. (This presumes it's still in business.) You should replace the gasket with the same material. Contact an automotive supplier, such as NAPA, for replacement gaskets. You'll need to provide the diameter and thickness.*

NEAT BOATING STUFF

VinylLIFE, a new addition to the BoatLIFE (800/382-9706; www.boatlife.com) boat maintenance product line, is a one-step vinyl cleaner and protectant. It cleans vinyl seats, boat tops, upholstery, fenders and other rubber products and protects materials from UV degradation.

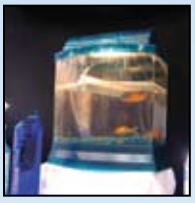
One-step vinyl cleaner.

Racor RFF.

Use a **Racor Filter Funnel** and you'll be pumping cleaner diesel into your tanks. A non-clogging sump in the filter bottom traps water, debris and solids down to 5/1,000" in size. Self-cleaning and non-corrosive, filters are available in several sizes and various flow rates.


St. Croix TipUp davit.

Three different models of St Croix's (952/858-8393; www.davit.com) **TipUp Davits** (US$600) fit swim platforms up to 24" (61cm) off the water. Made of 304 and 316 stainless steel, it mounts to the solid floor and transom of hard dinghies (cannot support roll-up or inflatable bottoms) of 400lb (181kg) or less in weight. After launching, pull a few pins and the davit easily removes for storage.


Feed the fish with Oil Eradicator.

Clean Water Solutions' (888/902-4141; www.cleanwater-solutionsinc.com) **Oil Eradicator** won this year's MATTS (a marine trade show held in Las Vegas annually) award for the Boat Care and Coatings category and the NMMA Environmental award. Tablets of oil-eating microbes insert into slots in floating foam carriers, creating a biological reaction to convert hydrocarbon contaminants, such as gas and gas additives, grease, kerosene and oil, into fatty acids, which are food for fish and plants. Non-toxic microbes lie dormant for upwards of 5 years until activated with four components: water, oxygen, motion and a hydrocarbon. Being aerobic, they double every 20 minutes while they're eating, devouring a quart of oil in less than a week. Various shapes fit different size boats; the larger Grouper ($19.95) absorbs 32 times its weight and is ideal for a 40' (12m) boat. Once activated, all Oil Eradicators have a life cycle of up to 90 days, at which time you can dump the clean bilge solution on your garden or overboard (it's EPA listed).

NEAT BOATING STUFF

Props are a marketable commodity for thieves, especially expensive stainless steel ones. It takes a minute or less to remove a prop with a socket set. **SecureProp** (225/751-1428) uses a locking cover that is machine fit to encompass the entire hub, denying any access to the propeller's locking nut. Easily attached, it comes with an ABUS padlock and has a reflector for nighttime driving. Three sizes fit engines up to 300hp and there's one that fits the Bravo outdrive. Since the three things you need to operate a powerboat are ignition key, gas and bilge plug and the later means looking at the transom, it's unlikely that you'll forget to remove the lock. According to the inventor and manufacturer Jack Gremillion, if you forget to remove it, there'll be a lot of clanging but no damage to the prop. Available online at www.secureprop.com starting at US$129.

(top) Bravo model; (bottom) SecureProp theft preventative.

Garelick (651/459-9795; www.garelick.com) has launched a back-saving solution to the problem of raising much heavier four-stroke kicker engines that are appearing on boat transoms everywhere. Recipient of the Hardware, Rigging, Rope and Anchoring Equipment award category at this years MATTS, the Easy Pump (US$895) hydraulic bracket lifts up outboards up to 25hp with about 15 strokes of the lever (removable for storage). A release valve lowers the bracket and gives unlimited height adjustment within the 14" of vertical travel.

Garelick Easy Pump

Made of 20% glass-reinforced, impact-resistant Isoplast, **Turncouple** (802/877-1001; www.turncouple.com) provides an innovative method to easily install, disconnect or service hoses. Applications include: removal of hoses to check and lubricate seacocks; disconnect water, waste, bilge or fuel lines for maintenance or repair; removal for replacement of macerator, bilge or other pumps; disconnect and reconnect to a pump for emergency bilge pump; and disconnect waste hose and cap the end in no-discharge zones. Available in 1-1/2" diameter with NPT threads with barbed or threaded adapters that connect to aluminum, brass, bronze or other metals.

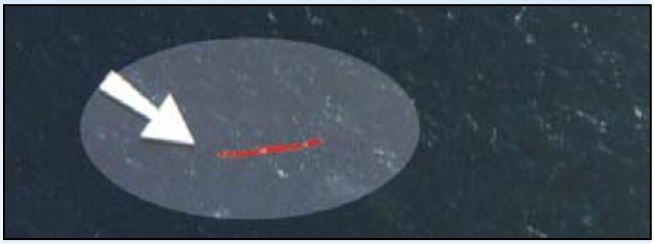
Turncouple with coupler, adapters and spanner.

First we had furling for headsails, then mains and now from **Bamar** (301/353-6962; www.bamar-na.com) we have roller-furling systems for asymmetric spinnakers, gennakers and other headsails. **RollGen** requires no sail

Easy raise and take-down with RollGen.

modification. To use, simply clip the shackle it to the deck, connect the halyard to the top swivel and raise the sail. When furled, everything stows neatly in a sail bag. Prices start at US$1,544.

If you're lost at sea, the more visible you are the better your chances of rescue. Bright orange **RescueStreamer** (www.RescueStreamer.com) is a reusable, passive signaling device



Survivor with lifevest and Rescue Streamer visible at 500' (152m).

(no batteries, chemicals or electronics) that works in daylight or nighttime. In U.S. Navy certification tests, it was visible from 1.5 miles (1.2km) away at an altitude of 1,500' (457m). About the size of a cell phone when rolled, units are available for boats, liferafts or personal use that attach to PFDs or man-overboard bags. Prices start at US$34.95.

Every boat needs an **Absorber**. After a day of boating and swimming with the family, use your Absorber to dry everything: you, your pets, seats, the boat. Better than a sponge or chamois, this super absorbent, lint-less, rubber-like PVA cloth soaks up water to instantly dry anything. Wipe dry, ring out when saturated and then store wet in the included plastic tube. When soiled, toss it in the washing machine. Nothing hurts it, not even grease, oils or solvents. DIY like this so much that we're giving them away to everyone who submits a boat-tested tip (see page 17 for details).

Tested best cleaning cloth is yours when you submit a boat-tested tip. See page 17.

Sacha

Is Lightning Prevention a Misnomer?

There is no such thing as a lightning-proof boat, rather a matter of a degree of protection. There is only one absolute about lightning protection systems on boats: if the mother of all lightning strikes takes aim at your boat, all bets are off.

By Patricia Kearns

Lightning is awesome, beautiful, frightening and deadly. Can't count the times I've been at a boat show and overheard a salesperson tell an eager, would be boater, that a boat is equipped with a lightning "prevention" system or that it was "bonded" against lightning. While these statements are usually made in ignorance of the true nature of what a boater can expect from a lightning protection system, it is misleading and a complete misnomer that can lead an owner to thinking a boat is protected against damage from lightning strikes.

You won't find the "how to" install a lightning protection system here and we're not going to explain the physics of lightning. We're just going to hit some high spots to illuminate some facts and enlighten the confused and try to keep our critics from getting hot under the collar as they defend their way of "preventing" a strike to a boat and protect equipment from damage resulting from a strike. For a best in class on the topic, we suggest you refer to "Lightning Strikes – Hit or Miss," in DIY 2002-#1 issue, which covers ABYC Standard E4, Lightning Protection, and log onto www.marinelightning.com, where you'll find the wisdom of Ewen Thompson. Another good resource is found on www.cdc.gov/nasd/docs, which has an excellent treatise by William J. Becker of the University of Florida. An article by Bill Laudeman is found in the BoatU.S. Seaworthy magazine archives at www.boatus.com/seaworthy/swlightning. Another piece of excellent enlightening literature is found at www.fishandboats.com/lightning.html. These are the resources that can take you into the theory, physics, causes and consequences of lightning phenomena.

Since you cannot capture lightning to gather test data there is only one reliable conclusion: lightning strikes where and when it wants and regardless the number of air terminals, bottle brushes or dissipater devices at the top of a sailboat or trawler mast you still can't "prevent" lightning. There is no such thing as a lightning-proof boat, only "protected" boats and even these have limitations on the potential for damage and personal injury or death from a direct hit.

There are few words in boat nomenclature that cause as much confusion as "ground," "grounding," "bonding" and "bonded." What follows is our effort to sort out the terms and their appropriate applications.

Nothing Ventured, Everything Gained

We begin with the first and final word on lightning protection. There is nothing you can do, install or invent that will persuade lightning to strike as directed and there is nothing that diverts lightning to a more attractive target than your boat or from your boat to somewhere, anywhere else. What we do know absolutely is that, if the mother of all lightning strikes takes aim at your boat, all bets are off.

The first rule of lightning protection is to avoid being a target. Stay off or get off the water when there is a threat of electrical storm activity. Such weather is rarely a surprise but it can catch you off guard when you are absorbed in fishing or other boating related activity. Okay, so you missed that warning and you are in it, big time. The only real "protection" a lightning ground system on boat is intended to provide is to minimize personal injury or death from a strike and even that has some qualifiers that depend mightily on personnel behaviors during conditions that present the lightning threat. If you put yourself in the path of the lightning strike by connecting parts of your body with the lightning ground conductors, you become a conductor (and a very fine one at that) and you could be seriously injured or dead.

Bonding conductors, the wires or equivalent, that take the current on its ride to ground, are a great value; they do multiple jobs onboard a boat. Those wires often serve double duty as lightning ground conductors in a lightning protection system and bonding conductors in a corrosion control system. There are those two words, "bonding" and "grounding," often used in what seems to be an interchangeable way.

The ubiquitous "zone of protection" is the space within a cone shape that is vertical from the plane of the water and exists on a sailboat or powerboat that has a grounded mast or other structure that acts as a ground. It's the place where the risk of a direct lightning strike is reduced. The operative word here is "reduced." Being in the zone is no guarantee that your boat or you will not be struck by lightning.

Even with the "perfect" lightning protection system installed there is no protection when the boat is out of the water because the ground plane (the water) needed to conduct lightning to earth ground no longer exists. (There are ways to establish a ground but that's another topic.) Few boats on land, including those on trailers, are provided with an alternative ground path.

There is no protection system that works for every kind of boat. Metal boats typically do not require any additional protection system against lightning as long as there is electrical continuity between the lightning protective mast and its alternatives. Small boats without masts or equivalent structures can be rigged for lightning protection as needed by erecting a temporary "mast" that is or can be connected to a ground plate or strip. Some protection is better than none at all but do it right. Lastly, very few boats are equipped with effective lightning protection systems and those that are usually suffer from lack of attention to the maintenance needs of the system's components.

What are the Chances of Lightning Striking Your Boat?

The following statistics are based on all of the BoatUS Marine Insurance claims for lightning damage over a five-year period. The percentages suggest the chances of the various types of boats being struck in any given year.

Auxiliary Sail	**Six out of 1,000**	**.6%**
Sail (no engine)	**Two out of 1,000**	**.2%**
Multihull sail	**Five out of 1,000**	**.5%**
Trawlers	**Three out of 1,000**	**.3%**
Cruisers	**One out of 1,000**	**.1%**
Runabouts	**Two out of 10,000**	**.02%**

Source: BoatUS Marine Insurance Claim Files

Know the Terminology

The following definitions are quoted from ABYC Standard E4, Lightning Protection.

"Lightning ground (plate or strip) is the metallic surface that is attached to the hull exterior that is intended to serve as the transfer point for the lightning energy that has been carried by the lightning bonding conductor(s) to the ground plate or strip so that the energy can be discharged into the water."

"Ground applies to the potential of the earth's surface. A boat's ground is established by a conducting connection, intentional (lightning protection system) or unintentional, with the earth, including any conductive part of (or connected to) the wetted surface of the hull."

By applying these two definitions and the respective functions, you can see that the "lightning ground" becomes the desired path to earth "ground." Now, insert the concept of the bond or bonding, which is what you must do to connect all the parts that are to become the continuous (established as effective by measuring continuity) path of interconnected components (wire, masses of metal, ground plate, etc.). The simplest definition for "bonded, bonding or to make a bond," is to attach parts mechanically or chemically. In the case of a lightning protection system, you are mechanically bonding (attaching, connecting, mating) all the parts that could be included in the path to ground of a lightning protection system. Many of these bonding conductors are normally not current carrying. They are there to serve when needed. Some of them serve other purposes and when they do, they must be of the size and type that meets the requirement for conductivity of the maximum current they might carry (lightning being the unmeasurable maximum).

The lightning bonding conductor is intended to provide electrical potential equalization between metal bodies (tanks, rigging, rudder stocks, seacocks, steering system components, metal tower structures in powerboats, etc.) and the lightning protection system to eliminate the potential for side flashes. In other words, the conductor is the hoped for path that lightning will take in its urgency to seek earth ground, that path being established by connecting all the large masses of metal together to achieve a continuous conductor (continuity being efficient as long as there are no points of resistance along the way such as broken, loose or corroded connections). Lightning bonding conductors are part of the lightning ground system but there are those other jobs they do as well like the job in the bonding system.

There are other areas of a boat and its systems that use bonding and grounding terminology but, in the absence of a lightning protection system, they have limited, specific functions. These include bonding systems for corrosion control, DC electrical system grounded and grounding conductors and AC electrical system grounded and grounding conductors. [Ed: Anyone designing, installing or upgrading electrical systems on boats should refer to DIY's MRT Series "DC Electrical Systems," and "AC Electrical Systems," both of which follow the ABYC standard E11, AC and DC Electrical Systems on Boats.]

Random Considerations

It's easy to see how eager salespersons, proud of their product and wanting to push a sale, would brag about the bonding system, grounding system, lightning protection system, lightning prevention system and all the other great stuff of boat shows. This assures that the prospective purchaser feels safe on their boats, not necessarily be safe. It's easy to see how terminology can confuse the well intentioned and twist the facts. It can be deadly to be wrong about lightning protection.

ABYC E4 standard takes a very humble position on the matter in its scope statement. "Protection of persons and small craft from lightning is dependent on a combination of design and maintenance of equipment and on personnel behavior. The basic guides contained in this standard shall be considered and used in designing and installing a lightning protection system. However, in view of the wide variation in structural design of boats and the unpredictable nature of lightning, specific recommendations cannot be made to cover all cases."

Do your best but don't see it as any kind of assurance that you won't need to call your insurance company about lightning damage. Just be happy that you are alive to make that call if your boat is struck. The insurance company will join you in that thanksgiving.

In the final analysis, a lightning protection system is, at best, a bonded collection of conductors and conductive materials that are arranged and connected to encourage lightning to take the path of least resistance to ground. You can talk all the techie talk about dissipaters, early streamer technology, stepped leaders, side flashes, etc., but remember this, "When the mother of all …," duck!

About the author: Besides being DIY's proof editor, Patricia Kearns is a NAMS certified marine surveyor and operates Recreational Marine Experts Group in Naples, Florida.

[Ed: For complete step-by-step instructions on installing lightning protection systems refer to in DIY 2002-#1 issue.]

Talkback Q&A

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Alternator Breakdown

Q: My 1984 C&C Landfall 43 has a 58hp Westerbeke with a heavy-duty alternator (manufacturer unknown) that was in place when I purchased the boat five years ago. While motor sailing during a cruise, the alternator came loose and the adjustable support bracket broke. This was welded, failed again enroute and has now been replaced but now the adjusting bolt continues to loosen despite lock washers, Loctite, etc. On a recent cruise, I torqued both bolts (upper adjusting and lower) tight and upon my return I found the lower bolt sheared. I have removed the bolt and am ready to install the alternator again. Note that, in the initial loosening, one blade on the alternator broke and others were bent and I straightened them.
Mike Weinstein, "Bird," Milford, Pennsylvania

A: Adding a larger output alternator many times causes problems such as short belt life, broken slide arm and destruction of the freshwater pump bearings. My first guess would be that the fit of the alternator foot is incompatible with the engine-mounting base. As a result, the foot is not fastened securely. This puts strain on the sliding bracket, with vibration added for good measure, causing the bracket to snap. If the alternator is driven by a single belt that also drives the freshwater pump, 100 amps is tops. It's imperative to align all components and secure the base. Remove the slide arm and check the alternator pulley alignment with the crankshaft and water pump pulley angles. Pulleys must be on the same vertical and horizontal planes; use a steel yardstick as a guide, laying it across the alternator pulley. Do what ever you must to get the pulley in line with the other two. Check the fastening bolt or bolts of the alternator foot. There are generally three types used: a single foot, 2" (5cm) wide requiring a 3/8" (10mm) thru-bolt; a single 1" (2.5cm) wide foot, requiring a 1/2" (12mm) bolt; and two support feet with independent bolts securing the foot. Make sure you have the correct bolt sizes and that they are all tight. You might be surprised to find a misfit bunch of bolts and spacers attempting to hold the alternator in place. Use all the right types and sizes and replace the slide arm with a nice heavy-duty piece for good measure.
— Bob Smith

Taking on Water

Q: The 140hp Mercruiser in my 1986 Starcraft Islander won't start. The batteries check out okay on a multimeter. I was told to take the plug out and crank it and when I did this, water came squirting out. How is water getting in and what am I to do next?
Kraig Clements, "Sixpac," Taylor, Michigan

A: Water can get into the cylinders from frost damage (bad winterizing job), failed exhaust riser gasket, usually after an overheat condition or from a broken water shutter in the exhaust system. Even rainwater from plugged cockpit scuppers can enter through the carburetor. Here's the fix. Change the oil and filter and verify oil level on the dipstick. Run the engine on a flush ears (or put the outdrive in a very large plastic tub) for 5 minutes, shut down and observe the oil level. If the oil level goes up, there is crack in your engine block (end of diagnosis). If the oil level does not go up, run your boat with a buddy boater ready to retrieve you if you have problems. I have seen rainwater fill a cylinder and, once the water was removed, the motor worked fine. If you continue to get water in the cylinder after the boat sits overnight, you have a leaking exhaust manifold or head gasket.
— Steve Auger

Switch Protocol

Q: I had a "1-2-Both" battery switch installed. The fishfinder, GPS, stereo, VHF radio and other electronic accessories remain on when the switch is in any of the three positions. Also, the engine starts on the same three positions. In the "Off" position, nothing works. Battery recharging is done in the "1," "2" or "Both" positions. Is this switch wired correctly? If I needed to jump-start the battery what position would I use?
Randall Bryant, "Searest," Charleston, South Carolina

A: The switch is used primarily to select either or both of the batteries to start the engine. Accessories are powered from all switch positions, except "Off" of course, so no data is lost on the electronics. To start the engine, nominate one battery, say "1" but not "Both." With the engine running, switch to "Both" so the engine charges both batteries. Dedicate the "2" position to power your accessories. When you stop the engine, turn the switch to "2" so you don't run down the start battery and won't have enough power to restart the engine. The accessories will continue to be energized off one battery and the start battery will remain full and unaffected. To jump-start with both batteries, simply turn the switch to the "Both" position. Otherwise, you will run down the start

battery as well and, come time to start, you might not have enough power. (For the scoop on battery switches turn to page 26.)
— John Payne

Hypalon Clean-up

Q: I'd like to restore our Avon Hypalon dinghy to as new condition but I can't seem to get it clean. I've heard that you can use acetone. I'm concerned it will eat away at the seams. (It does, however, work wonders on fenders.)
Jim Discher, "Jimmygobyebye," Long Beach, California

A: According to Howard Shure of The Air Works in Annapolis, Maryland, acetone won't hurt the material and is best used for spot cleaning, such as removing stains, creosote, etc. Just be sure to have plenty of ventilation, wear a respirator and protective clothing. Air Works recommends using MaryKate Spray Away, a powerful inflatable cleaner, full strength and scrub the surface with a stiff bristle brush. You need to agitate the surface to clean it successfully; just wiping it doesn't cut the dirt.
— Jan Mundy

A Sticky Solution

Q: I have tried to remove waterline tape from a fiberglass hull. The colored tape came off, but the adhesive remained on the hull. What can I use to remove the adhesive?
Everett Quackenbush, "Quackers," Morristown, New York

A: There are different products you can use, some work better than others. Some say that nail polish remover works if you have some in a home closet. You could use acetone or lacquer thinner, mineral spirits, turpentine or other solvent. These tend to transform the adhesive into liquid goo so you need to scrub aggressively to remove all residue. I prefer 3M Marine General Purpose Adhesive Remover because it works best and doesn't leave a gooey mess. One or two swipes with a rag and the residue is gone. [Ed: This cleaner is one of many DIY tested speciality maintenance products available to purchase on DIY Online at www.diy-boat.com.]
— Jan Mundy

Brass Fitting Leak Sealer

Q: The brass tee-fitting for my oil pressure sending unit is leaking oil where it's screwed into my diesel engine block. What can I coat on the threads to seal the leak and still provide good electrical contact for the oil pressure circuits?
Peter Bothner, "Isabel," Brick, New Jersey

A: I prefer using either liquid Teflon in a tube or can, or #2 Permatex on the sending unit's pipe threads. This ensures a leak-free connection along with a electrical contact. Under no circumstances should Teflon tape be used on senders. The tape is a perfect insulator and results in senders having a poor electrical connection or none at all.
— Bob Smith

Bellows Antifouling Treatment

Q: When applying antifouling to outdrives, I mask the bellows to avoid getting paint on them and making them stiff. Is there a coating or treatment for the bellows to protect them from fouling?
Kenneth Grim, "Heart Song," Channel Islands Harbor, California

A: Water-based paints have shown that they work well on inflatables but we have never tried them on bellows. Apparently, MDR Inflatable & Dinghy Bottom Coating (available at West or BoatUS) can be used to keep outdrive bellows from fouling without any damage to the rubber. It contains copperous oxide; apparently muskrats don't like the taste. MDR had a product several years ago called Outdrive Bellows Coating marketed exactly for this purpose with the formulation being very close to this product.
— Jan Mundy

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Diagnose Overheating Merc

Q: At top speed, the V-8 Mercruiser with Alpha drive on my 250 SeaRay overheats. Once I reduce speed, the engine cools down to operating temperature and runs normally. I had the engine serviced and winterized; including a new water pump, to hopefully solve this problem but $2,000 later, the engine still overheats. I'm in a long waiting line for my service marina and I'm hoping to get some insight.
Rick LeRoux, Barrie, Ontario

A: First, check for over advanced ignition timing. This should be a maximum of 30° BTDC at 4,000 rpm. If the engine has closed cooling, ensure the ratio of glycol to water is 50/50; too much glycol will overheat the engine at wide-open throttle. Now, install a clear hose in line on the water supply hose to the thermostat housing and run the engine

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at speed. If you see bubbles in the water flow, exhaust is getting into the water supply, causing cavitation in the water circulation pump and overheating at speed. These telltale bubbles are from exhaust getting into the waterflow through the water pocket cover or water pump housing in the drive unit. Lastly, check your exhaust pipe for a blockage such as a broken water shutter or perhaps a small rodent residing in your exhaust system. Don't laugh, we've seen this!
— Steve Auger

Sea-Doo Seek and Find

Q: I have a Sea-Doo Explorer that needs a reverse cable, Sea-Doo part number 271000200, a part used through the 2002-model year. The factory no longer supplies this and I can find none in numerous inquires to its dealer network. A used cable would work or a custom-made one but I have also been unsuccessful finding a source.
Pete Wolf, Cicero, New York

A: DIY contacted Cal-Jet, a Sea-Doo dealer in Ontario, and the part was still listed on its database. The dealer then contacted Bombardier on our behalf and there is a cable that will work: part 277000229 for about US$160.
— Jan Mundy

Easy DIY Changing Gear Oil

Q: I need to change the lower lubrication on my 1981 Nissan 9.9 hp outboard motor. As this is my first time doing this any help or articles would be greatly appreciated.
Michael Schwartz, "John Galt," City Island, New York

A: This is an easy job, especially on a smaller engine, and I'm surprised at how many owners don't do it themselves. Follow these instructions taken from "Outboard Maintenance and Troubleshooting" in DIY 2000-#3 issue. You'll need to purchase a manual bottle pump that attaches to the gear lube bottle. Changing gear oil is an easy, half-hour job. Tilt outboard up so that oil drains freely from housing. Remove drain/fill screw and washer (lower screw) and check for metal particles attached to screw. Metal particles may indicate gear wear and requires complete disassembly of the lower unit. Remove vent screw and washer (top screw) and let oil completely drain into a proper collection container. To refill, move outboard to fully trimmed in (down) position. Insert oil tube into drain/fill hole. Add lubricant to gear housing until excess flows from vent hole. Drain about 1oz (30ml) from fill

hole to allow for expansion. Install vent screw and washer. Remove oil tube and install cleaned screw with washer. To prevent water leaking into gearcase, be sure screws are installed with washers and replace worn ones. (Tip: Keep a supply of washers in your spares kit.) Never add oil without first removing vent screw or trapped air will prevent you from completely filling housing. Before disposing of oil (take it to a recycling depot), place some in a clear container and let settle. Oil should be clear. Milky caramel-colored oil indicates a leak, meaning water entered the gearcase either through plug washers, stripped or cross-threaded plugs, worn prop, shift shaft or water pump seals. Water can quickly rust or seize an oil-starved gearcase so this condition requires immediate servicing. A qualified marine mechanic can check condition of seals with a pressure gauge. Seals normally last 10 to 15 years but wear quickly in engines run in silt or sandy conditions. A replacement seal kit costs less than US$50 and contains all needed gaskets, O-rings and seals. Burnt, blackish-colored lube may indicate worn gears or bearings and requires disassembly of lower unit.
— Jan Mundy

Bottom Finishing Under Jacks

Q: I plan to use the Interlux system, applying one coat of Epiglass and then five to six coats of Interprotect 2000. As jack stands support the boat, what is the best way to coat underneath the stands? Continuously move them as the product cures or should I do the entire middle of the boat with all layers and then move the stands and do the two ends?
Mark Carlson, "Goda Tider," Ashland, Wisconsin

A: According to Jim Seidel of Interlux you paint the first coat of Interprotect or Epiglass up to the pads and stop the paint on each successive coat about 1" (25mm) back from the edge of the previous finish. Apply all coats, including the first coat of antifouling paint. When complete, it will look like terraces running away from the pad. Once the first coat of antifouling has dried move the pads to a painted area and proceed to paint the areas that were under the pads. You will need to sand and prep the areas for the Epiglass but if you come back over the Interprotect 2000E within two weeks of initial application, no sanding is needed. When you move the pads, put carpeting on the pad and cover with waxed paper to prevent sticking.
— Jan Mundy

Wiring Windlass Serially

Q: My 1987 33' (10m) Chris-Craft Amerosport has a Sidepower bow thruster and I'm installing an Anchorlift Dolphin 1000 windlass. Can I jump power from the positive

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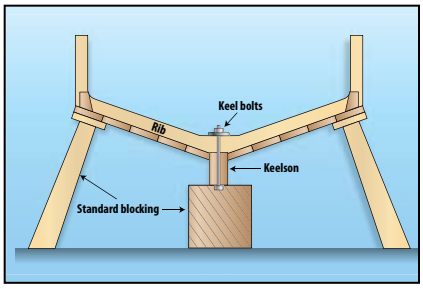
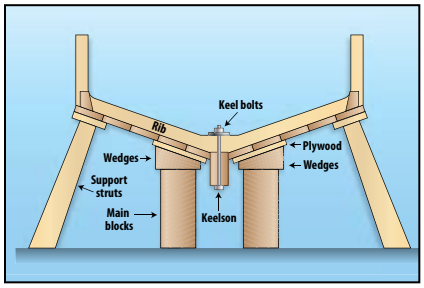
and negative contacts on the bow thruster to the windlass without having to run new AWG 2 all the way back to the batteries. The bow thruster has a slow-blow fuse already installed in the circuit.
Chuck McMullan, "Vitamin Sea," Turkey Point, Ontario

A: Although not common, this is an acceptable set up and an economical solution. Obviously, you can't operate both items simultaneously. I would suggest you place a warning label concerning the limitation against simultaneous operation near the thruster control panel. Check that windlass power consumption does not exceed thruster consumption, which is unlikely, and also the existing supply cable and the slow-blow fuse ratings as well. Be sure that cable terminations are well made with properly rated cable lugs and also properly torqued terminals where they connect to the thruster contacts as any voltage drop affects windlass performance.
— John Payne

Bracing a Woody

Q: The keelson has been bent on my double-planked wooden 34' (10m) Chris-Craft Constellation (the former owner grounded it hard on something). The bolts holding the keelson are most likely bent. How do I support the hull and keel to enable me to replace the keel bolts and retighten the keelson?
Al Perkins, "Sandy-Lou," Portland, Maine





A: Most planked woodies can be supported off the keel by carefully blocking under each rib on both sides of the keelson. This puts the load onto the same area of the boat's structure as the keel itself does but leaves the keelson hanging free for work or removal.
— Nick Bailey

Bringing GPS to the Large Screen

Q: I have a Garmin GPS 188 that I want to hook up to my computer so I have a larger screen. It comes with an unlocked map but is this needed if I'm running it from the Garmin? Are there any drawbacks to this?
Steve Camp, Athens, Greece

A: DIY contacted Garmin and received this reply: "You connect the GPS 188 to a laptop computer running our nRoute software and use the large display for navigation. Some Garmin units may only have limited capability when used with certain MapSource products, such as the GPS 18 and MapSource Americas BlueChart software. This may mean that a unit may be able to draw all the map features from the MapSource software, such as roads, lakes, nav-aids, depth contours, wrecks, etc., but the interactive capability of the maps may be limited. For example, you may not be able to find nearest marinas or look up additional text about a specific mapping feature. It's also recommended that you connect the GPS to your PC though a serial port and use the nRoute software to do real time tracking. This allows you to use the GPS signal that the 188 receives to show your location without having to buy another GPS device. With both of these options to view the detail on your PC, you will need the MapSource Americas BlueChart software installed on your PC and unlocked to your Garmin GPS device."
— Jan Mundy

Head Hunting

Q: After 25 years, our boat's Brydon MSD, model 59128-0000, has quit and it's marked "Obsolete, no spares" on the ITT/Jabsco website. Is it fit for the pit or can I do anything with it? Is there a Jabsco replacement?
Graham Collins, Halifax, Nova Scotia

A: You won't find any replacement parts for this golden beauty; time for the dumpster. Two considerations when upgrading is your budget and MSD size. You can spend $150 up to $2,000 on a MSD depending on whether it's manual, electric or vacuum operated. Selecting a replacement of similar shape, size and footprint minimizes reconstruction. A head unit equivalent to your Brydon that will work just as well is the Jabsco Par Head-Mate, model 29090.2000. It's an inexpensive manual head available at most chandleries. You can even upgrade in the future to an electric add-on.
— Jan Mundy

Unclogging Vent Line

Q: We have discovered a clogged vent hose on the waste holding tank on our Mainship 40. It's very difficult to reach the top of the hose attached to the vent. Any suggestions?
Susan Titterton, Bermuda

A: Most vent fittings on the hull are too small to send in Roto Rooter. Clogs occur at the narrowest point, which is the vent fitting itself. It may be possible to free the obstruction by blowing compressed air into the vent fitting (wear goggles). A badly clogged hose may need replacing and that task requires access to the vent thru-hull fitting on the inside. If it's completely inaccessible, it may be necessary to cut into the hull liner, make the repair and install an access port to cover the hole.
— Nick Bailey

Tech TIPS

Edited by Jan Mundy

UV Deck Wrap: Make and fit an acrylic cover (a simple triangle) that fits over the foredeck to protect the fiberglass deck from oxidizing and degrading in the hot sun's rays.
Pat Kearns, Naples, Florida

Carb Cleaning: To stop engine stalling at low speed caused by suspected dirty carburetor jets, I took the advice of a retired truck mechanic and removed the fuel-water separator filter, filled it with a carburetor cleaning formula, started the engine and, after one minute, shut it off. Waiting 15-minutes, I then restarted and idled the engine for a few minutes until all cleaner flowed through. Stalling disappeared after the treatment so I've added this to my annual engine preventive maintenance.
Doug Booth, Kingston, Ontario

[Ed: Clogged jets are the result of using automotive fuel in marine engines and the additives plug up the jets during long-term storage. Properly decommissioning the fuel system as outlined in DIY 2000-#3 issue (outboards) and 1999-#3 issue (sterndrives) before storage is the key to preventing this problem.]

Instant Washdown Pickup: When you want to install a washdown but there is no convenient or extra thru-hull available for the water intake line or you don't want to cut another hole in your boat, run the hose to an above-the-waterline thru-hull, attach a 90° elbow on the outside and connect a short length of hose that extends downwards to seawater.
Dan McDougal, Williamsport, Maryland

Lamp Tie-down: To stop hanging lamps from swinging to and fro, fashion a lanyard attached to at least two points on the lamp and secure to a padeye or handrail. Finish end off with a decorative knot.
David and Zora Aiken, liveaboards on "Atelier," cruising somewhere on the East Coast.

Recycled Sail Ties: Before discarding braided line whose outer sheathing is worn, remove the flat, soft inner core and cut into lengths suitable for sail ties.

Track-less Curtains: A neat, simple solution to hang cabin curtains without tracks, rods or cords is with common dome fasteners. They're inexpensive and make the curtains easy to remove for washing or replacement.

Easy and Smart: If you toss excess dockline in a pile only to untangle the mess later, a better solution is to chain

stitch the leftover line in a series of loops. It's attractive and lays flat on deck but more importantly, when you need to adjust or untie the line just pull the bitter end.

Clear The Deck: Sew some acrylic bags with mesh bottoms and hang from the lifelines to stow sheets.

Aluminum Tank Repair: You can repair rather than disgard an aluminum plate holding tank or hardware made of cast aluminum, magnesium, pot metal or zinc alloys with HTS-2000 fluxless brazing rod available from New Technology Products (Tel: 713/935-9292). It works with any heat source at a working temperature of just 730F (387.7C) to create a 100% metal-to-metal alloy bond that's apparently stronger than the base metal and corrosion resistant.
Bill Robinson, San Francisco, California

Grab a Handhold: A handhold placed on the windshield by a deck walkthrough is a convenience item that's nice to have, presuming, of course, the windshield is firmly mounted to withstand the heaving.

Charging Ni-Cad: To extend the life of a nickel cadmium battery as soon as the battery begins to warm up take it off the charger. Never leave it on a constant charge.

Light up the Cockpit: Don't know on what boat I was aboard when I took this photo but it's a very clever idea.

PRO SERIES

Weight Gain

The cost of replacing water-soaked foam in an older boat's hull can far exceed the market value of the boat if the work is done professionally and may only be a practical consideration as a do-it-yourself project. This description of a professional foam replacement job is considered among the best-case scenarios.

By Nick Bailey

As I sat waiting my turn in the doctor's office, I glanced at an article in a magazine warning of the health care crisis our aging population faces as it gains weight at an alarming rate. It occurred to me that humans were not the only ones suffering from the effects of excessive weight. Our aging motorboat population is getting heavier, too. We hear complaints from the owner of an older runabout or small sterndrive boat that the boat is sluggish and the source of the problem is presumed to be the engine. A compression check and tune-up don't resolve the issue and, despite a clean bottom and a healthy engine, the boat is still reluctant to plane as easily as it once did.

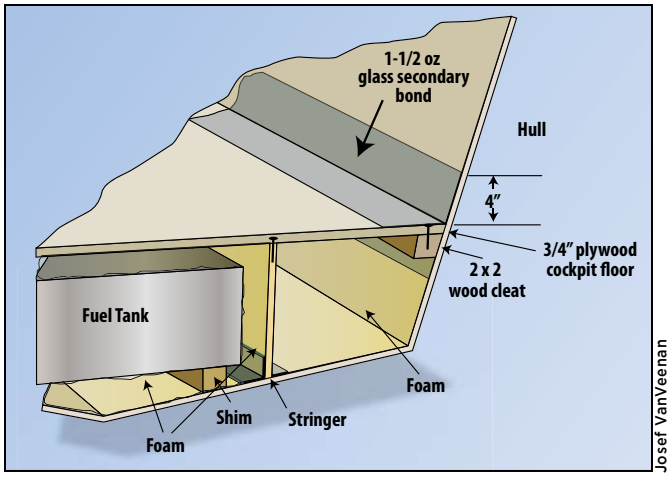
The cause of this phenomenon often can be traced to water saturation of the foam that was installed for flotation or as a structural filler at the time the boat was built.

Materials

The U.S. federal regulations are specific about the foams that are acceptable for flotation. Buoyancy (air) chambers built into the hull don't meet the mandate and the materials that are acceptable must meet strict testing requirements for resisting water absorption and degradation from exposures to fuels, oils, styrene or bilge cleaners. Non-integral flotation chambers (air bags or canisters) are allowed but the standard test procedure requires the two largest be filled with water. Canadian regulations are similar but require the individual air chambers to be less than 0.5 square feet (.046 square meters) in volume. To meet the requirements for flotation, cut plastic foam blocks or expanding liquid plastic foam that is blown or poured in place have become the materials and methods of choice for boat builders. The most common liquid foam is polyurethane, an excellent material but not totally immune to water absorption in the long term.

Buoyant Affects

Polyurethane foam varies in density depending on the installation technique. Foam that is injected or blown into a closed cavity that is rigidly held in a mold is denser, stronger and more resistant to water absorption than foam poured into an open structure, allowed to rise unhindered and trimmed to size later. "Open pour" foam density is typically 2lb per cubic foot (.9kg per .02 cubic meters).



Josef VanVeenan

Typical cross section of a runabout cockpit floor. Note strip of glass bonding the floor edge to the hull.

All foam flotation material will eventually absorb water unless it's completely sealed within a compartment. It takes a long time for water to saturate the foam and about the same relative time span for foam to dry. It's not unusual for an older boat to have gained hundreds of extra pounds due to wet foam. The results are graphic.

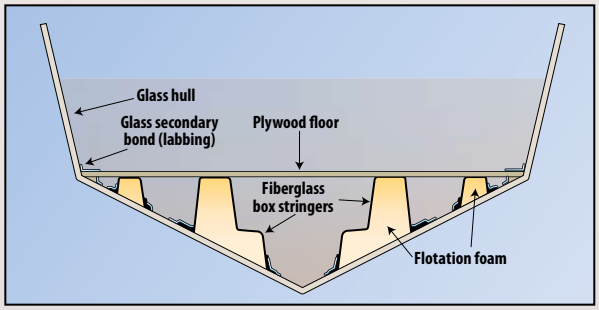
Let's say our hypothetical boat has 25 cubic feet (.7 cubic meters) of flotation foam. Given the weight of water at approximately 62lb per cubic foot (28kg per .02 cubic meters), immersing this quantity of foam displaces enough water (according to Archimedes) to produce about 1,500lb (680kg) of buoyant force. If the boat and motor weigh 1,300lb (590kg) there are at least 200lb (9lkg) of reserve buoyancy without taking into account the reduced underwater weight (due to residual buoyancy) of the swamped hull and motor. What happens if our boat's flotation is 15% saturated (by volume) with water? We lose about 225lb (102kg) of buoyancy. Now not only is the boat more likely to sink if swamped but it also performs as if there is an extra, rather large, invisible person onboard permanently. The condition advances exponentially. More water, more weight; less buoyancy, less safe.

What Foam is This?

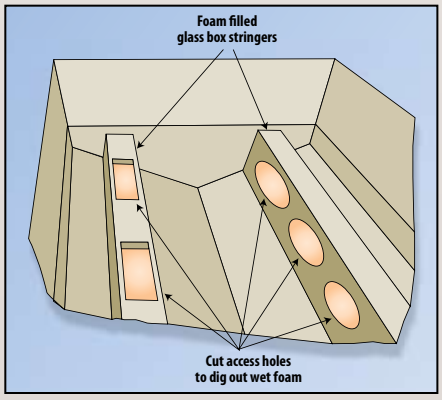
Wet foam flotation is almost always an inconspicuous problem. It is visually inaccessible under the floor, inside stringers, between the hull molding and a molded pan liner, around fuel tanks and other internal voids that were supposed to be sealed but, in reality, have been attacked by fittings and fasteners that have penetrated into the foam, enabling it absorb water. In some boats the raw foam is constantly in contact with bilge water. Serious secondary problems often arise when wet foam is in contact with plywood bulkheads and other wood product components that get and stay wet and decay from rot. Aluminum fuel tanks seldom survive contact with wet foam for long. In cold climates, wet foam freezes, its closed-cell structure is lanced open by ice crystals and the foam begins to crumble. (This is a common problem with foam-filled sailboat rudders.) The trapped moisture will also precipitate poultice corrosion on aluminum fuel tank panels, damage that could have deadly consequences. Left to its own invention, a boat that

Degraded Stringers

Many boats have foam-filled fiberglass box shaped stringers. The foam is intended primarily as a structural stiffener and any flotation benefit is incidental. These stringers are also subject to water absorption, a particular problem aft in the engine compartment as this is often the lowest point in the boat and water collects there. In the machinery space, the stringers usually serve as engine bearers and are also perforated by the fasteners securing plumbing, wiring and all sorts of other equipment. A core sample or moisture meter will tell the tale. It's a lot of work but wet foam can and should be removed from these longitudinal box beams. Access is gained by using a diamond wheel or a heavy jigsaw or sabersaw to cut open the top or create windows in the sides of the stringer. After the wet foam has been removed, the holes can be capped by fastening or clamping plastic covered (a garbage bag will do) plywood over the openings. Small openings are preserved to pour in the pre-foam liquid and vent the expanding foam. As the foam expands, it is forced along the stringer filling the void. The new foam doesn't have quite the same density as the factory original injected foam but will be serviceable. The excess foam is trimmed off and the exterior of the stringer is then reglassed with a complete new outer skin. When reskinning cutouts or recapping the stringer, the new glass thickness should be at least equal to the original thickness. [Ed: For detailed instructions on repairing wood core stringers, refer to DIY 2004-#4 issue.]



Some boats have longitudinal fiberglass covered beams filled with foam that form structural stringers. Water collects in bilge and degrades foam unless the stringers are perfectly sealed from water intrusion.



Josef VanVeenan

To get at the wet foam inside a glass stringer cut access holes every foot or so. After the wet foam is replaced these holes are glassed over and sealed.

relies on solid foam to stiffen the hull structure begins to flex excessively as the foam degrades and the adhesive bond fails. Stress cracks can eventually undermine hull structure integrity.

If you suspect your boat is burdened with wet flotation foam, the only definitive way to satisfy your curiosity is by opening the laminate (drilling a hole or holes) in an area where you know foam is present and/or taking a core sample so

Removing the cockpit floor reveals the foam filled area below. Dark areas are wet.

that you can inspect the foam close up or have it analyzed by a laboratory that specializes in fiberglass and composite material analysis. Short of those drastic measures, you might find a marine surveyor who is skilled in using a moisture meter and have him take readings as a preliminary diagnostic exercise.

Can-of-Worms Factor

What can be done with a hull filled with water soaked foam? In theory, the boat could be ventilated by drilling holes in strategic locations and stood on end in a dry, heated barn for a few years while it drained and dried. In reality, wet foam must be cut out and replaced. There is no miracle solvent you can pour in to dissolve it away.

The problem with this approach to replacing flotation foam (and most structural repairs on boats) is always access. In most cases, the cockpit floor (sole) and/or other boat structure must be cut away to get at the foam. Foam replacement is often only the beginning. When the floor comes up be prepared for major additional work such as repairing rotted wood stringers and bulkhead grids or replacing a corroded fuel tank. These discoveries usually lead to costly unexpected expense. When it comes to a foam replacement job on an old boat, including the inevitable additional work, it's not unusual for the cost of professional repairs to far exceed the market value of the boat. This might be okay if the boat is a precious family heirloom but economic reality suggests that the proverbial "can-of-worms" potential of an old boat makes foam replacement impractical if done professionally. It may only be affordable when done by a do-it-yourselfer. The following description of a professional repair can be considered among the "best case" scenarios for this kind of job.

Prep and Removal of Foam

This repair was carried out on a late '80s vintage 22' (6.7m) I/O cuddy. It began as just the replacement of a spongy plywood cockpit floor but evolved into the replacement of the wet foam discovered after the floor was removed. The subfloor foam co-existed with a system of plywood stringers and bulkheads and surrounds a center fuel tank. This style of construction allows for a fairly straightforward repair since the foam is used primarily for flotation and makes only a minor structural contribution.

First the seats and hardware attached to the cockpit floor are removed and carpet covering the fiberglass-over-plywood floor peeled back. Although only the aft section of the floor is actually spongy it's decided to replace the entire cockpit floor. So far this looks to be 16 to 20 hours work with a little help from the owner removing and reinstalling seats and hardware. Cutting around the perimeter can be done with a portable circular saw (set the cut depth to just a bit more that the thickness of the ply) but in this case the glass tabbing bonding the floor to the hull side is severed using an air driven high-speed diamond tipped cutting wheel. Heads of glassed-in fasteners are ground off and the plywood floor removed with a pry bar to reveal the foam-filled subfloor. Next, debunk, disconnect and remove the fuel tank to check for wet foam beneath. With all foam exposed it's a simple matter to dig, cut and scrape out any wet or damp flotation. It's not unusual to find some that is absolutely soaked and dripping. At this point inspect the plywood stringer and bulkhead grid that supports the floor and stiffens the hull. Any punky wood or delaminated glass tabbing requires repair or replacement before adding new flotation.

While you're at it carefully inspect the fuel tank for corrosion. Light corrosion on the outside of the tank can be addressed by sandblasting and exterior epoxy barrier coating; deep pitting indicates the tank should be replaced. [Ed: Refer to DIY 2000-#1 issue for complete details on fuel tank inspection and replacement.]

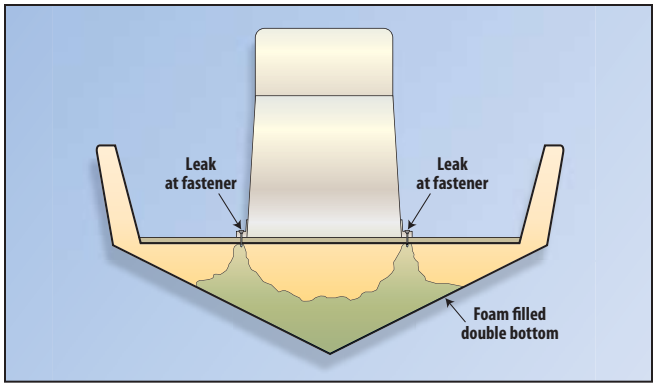
Foam Treatment

New polyurethane flotation foam is installed by the "open pour" method. Using the standard mix ratio of 1:1 about a cup (250ml) of each component is rapidly mixed in a 1 gallon (3.78L) disposable bucket. As mixing time is only about 25 seconds and working time about 1 minute, mix directly over the pour site. Disposable coveralls and rubber gloves are must-wear items. Pour the mix into the open box formed by the intersection of bulkheads and stringers. Liquid pour-in place polyurethane expands rapidly into sticky foam and rises freely above the level of the floor. A quarter gallon (1L) of mix expands to fill about 1 cubic foot (.02 cubic meter) of volume, an expansion factor of almost 30 times. The new foam has the same general characteristics as the original: a density of about 2lb per cubic foot (.056 cubic meter); 97% closed cell, and as required by the USCG it's resistant to water, gasoline and bilge cleaners. At 70F (21C) the foam is fully cured within 5 minutes. After all open subfloor compartments are filled trim the foam with a long knife and level with a 36-grit fairing longboard even with the top of the stringer/bulkhead grid so the new floor fits flush.

The newly epoxy-coated fuel tank is

Mark Yeates

Replacing water-soaked foam in a 16'3" (4.9m) bowrider. (top) Shovel frees wet foam between stringers. (bottom) Two-part urethane foam is poured into the bilge between stringers. Any foam that expands above the stringers is cut off and the excess tossed into the next section before pouring more foam.



Josef VanVeenan

The most difficult cases are boats with foam-filled double bottoms where high density foam acts a structural core to reinforce fiberglass hull becomes waterlogged from fastener leaks or cracks in hull bottom. Pour-in-place foam alone is not a strong enough replacement. Extra glass laminates applied to the inner skin as well as a subfloor structural grid may also be needed to replace the wet original foam. (inset) Cutaway of Boston Whaler hull shows foam-filled hull.

placed on 2" (5cm) plastic shims, weighted down with a few large buckets full of water and a small amount of liquid foam is poured into the cavity around the tank. The foam expands to fill the cavity under and around the tank and holds the tank securely in position. Blobs of foam that rise above floor level are trimmed after the foam cures.

An alternative to poured foam, preferable if the flotation is guaranteed to get wet is to cut and fit blocks of urethane, polystyrene or polyethylene foam that are wrapped and sealed with shrinkwrap plastic as an added water barrier. This is much more labor intensive due to the precise cutting and fitting required to ensure the foam blocks are a tight fit. Otherwise, they will need to be clamped or fastened in place unlike poured foam, which has the advantage of being highly adhesive while it is still curing.

Reinstalling the Floor

A new 3/4" (19mm) waterproof exterior-grade fir plywood floor is measured, cut, side edges are beveled and dry fitted. Stainless flathead screws, #12 x 2" (5cm) fasten the new floor to the existing wood subfloor grid. (Any old remaining headless fasteners were removed some time ago by clamping them in a drill chuck and reversing them out.)

To prep for bonding the beveled side edge of the new floor to the hull use a 36 grit disc to lightly flatten and reduce the old glass tabbing adhering to the inside of the hull. Prewet the plywood outer edge with polyester resin and to bond it to the hull apply an 8"- (20cm-) wide strip of 1.5oz mat. Also apply tabbing to join the new floor to the ends of the subfloor grid fore and aft. Finally, a single layer of 1.5 oz. mat is applied to the entire upper surface of the new floor to seal and reinforce the surface. The cockpit floor can be finished by simply painting on air-dry gelcoat leaving the weave of the mat as a cheap & cheerful non-skid surface. As a more elegant (i.e. more costly) alternative it can sanded, filled/faired, and then finished in gelcoat. Priming with epoxy and finishing with polyurethane paint also produces nice results with a bit less work that gelcoat especially when a smooth border and a nonskid interior area is the desired pattern. In the case of this particular boat the old carpet was glued down with contact cement.

Bonded Foam Repairs

There are also many boats where the flotation foam doubles as a thick structural core to create a monolithic double bottom, usually in lieu of a stringer system. The best-known examples of this style of construction are the legendary Boston Whalers. They are constructed with foam injected at high pressure while the hull and deck assembly is held in a rigid mandrill. Such construction when new is very resistant to water entering the foam but after many years any holes drilled in the cockpit floor can be an entry point for water to say nothing of accidental damage to the bottom. Some owners are cavalier about repairing damage or sealing leaking fittings because the boat is "unsinkable." That is a big mistake. If abused and neglected, these boats can and do absorb a lot of water. Unfortunately "double bottom" boats don't lend themselves to the usual aftermarket "open pour" foam replacement technique outlined above. It just can't duplicate the strength and density of the original foam. In cases where the original hull laminate was designed to be supported by rigid foam, any removal of the original foam usually requires a major re-engineering of the hull structure. Typically, the addition of a structural grid system and/or additional laminates on the inside of the hull is required to add enough strength and rigidity to compensate for the loss of the original structural foam.

About the author: Nick Bailey is DIY Magazine's repair specialist. He crews for his skipper wife on their Thunderbird, "Looney Tunes," and they won second place in the 2005 Thunderbird Worlds.

CAUTIONARY NOTE:

There is the risk that, following the recommendations in this article, a do-it-yourselfer may error and remove flotation foam that changes the boat's flotation compliance. Moreover, replacing foam can compromise a boat's Coast Guard flotation requirements since most do-it-yourselfers will be unable to properly test for flotation. Messing with flotation can alter a boat's buoyancy so that in the event of a swamping there is a loss of boat and/or life. It's important to be aware of degraded foam issues in an older boat that you are considering for purchase or in a boat you currently own. For a boat with degraded flotation foam the safest course is to consult a professional.

Flotation Facts

The following stats are quoted directly from the United States Coast Guard Flotation Compliance Guideline, which is the source for how-to on the topic and is a supplement to U.S. federal law and ABYC H8 Standard.

Subpart F – Flotation requirements for inboard boats, inboard/outdrive (sterndrives), boats and airboats.
Subpart G – Flotation requirements for outboard boats rated for engines of more than 2hp.
Subpart H – Flotation requirements for outboard boats rated for engines of 2hp or less.
33 cfr, sections 183.101 – 183.335
Revised July, 2000

1.0 APPLICABILITY

Since the regulation is divided according to boat type, the applicability for the various types is discussed in each subpart. The exceptions, however, apply to all subparts and are as follows: Sailboats, canoes, kayaks, inflatable boats, submersibles, surface effect vessels, amphibious vessels, and race boats need not comply. Following is a summary of the applicability by boat type and subpart.

Subpart Boat types	Flotation Required
Inboards, Inboard/Outdrives (sterndrives), Air Boats	Basic Flotation
Outboard boats rated for more than 2hp	Level Flotation
Outboard boats rated for less than 2hp and manually propelled boats	Modified Level Flotation

Monohull inboard, sterndrive and airboats less than 20' (6m) in length must comply with a flotation system called Basic Flotation. Section 4.0 contains the requirements and tests. Basic flotation is the simplest type of flotation mode covered in this regulation. It simply requires that the boat be manufactured with sufficient flotation material to keep it afloat in the event of a swamping. It does not, however, require that the boat remain in an upright or indeed any specific position. It may float, and usually does, in a "spar" position, the bow sticking up and the stern sunk. The requirements include some materials tests. Section 4.0 covers this type of flotation.

Outboard boats under 20' (6m) in length and rated for more than 2hp must comply with the more sophisticated flotation system called Level Flotation. The Level Flotation system requires that the swamped boat, loaded with certain weights representing weight capacity, part of persons capacity and some equipment, must float in an approximately level position and not heel past a certain angle, even when part of the passengers' weight is on one side of the passenger carrying area. Section 5.0 covers the requirements and tests to perform.

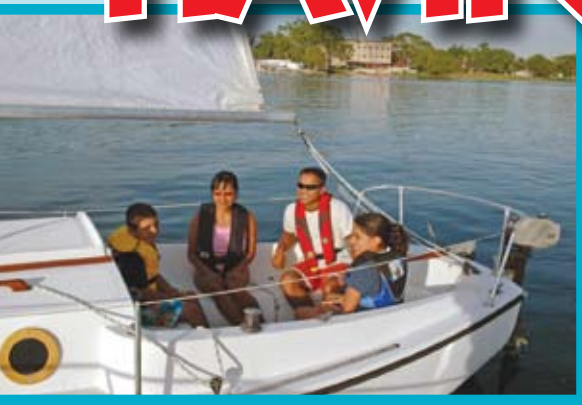
Manually propelled boats and boats rated for outboard engines of 2hp or less must also comply with the Modified Level Flotation requirements. As the name suggests, Modified Level Flotation is similar to Level Flotation, but with variations in the persons weight and capacity weight numbers. Section 6.0 discusses the calculations, tests and other requirements.

Basic Flotation: A flotation system which will keep a swamped boat from sinking when its passengers are in the water clinging to it, provided that the aggregate weight of the motor, passengers and equipment carried in or attached to the boat does not exceed the boat's maximum weight capacity. With Basic Flotation, the swamped boat may float at any attitude.

Level Flotation: A flotation system that will keep a swamped boat and a specified quantity of the weights of its motor, equipment and passengers floating in an approximately level attitude. Sufficient stability is provided to prevent the swamped craft from capsizing in calm water when one-half of the passengers are evenly distributed at one side of the passenger carrying area and allow as possible in the boat. Level Flotation does not provide a self-righting capability.

Modified Level Flotation: A flotation system that provides level flotation, as defined here, but with a reduction in the quantity of flotation required for passengers.

HAVING A BLAST



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DIESEL

A Course In Generator Plumbing

A DIY reader acquired an Onan generator and contacted DIY's Technical Helpline for assistance plumbing the fuel lines. His 1980 Sea Ray 310 Sedan, powered by two 200hp CM655-T1 Chrysler diesels, has two separate fuel tanks that have only two fittings per tank: one for feed and one for return fuel. On the return line on one tank there is a tee connection. His question was, "How do I hook up the generator feed and fuel return line?" Below is the discussion between our reader and DIY's diesel engine consultant Bob Smith of American Diesel along with feedback from the manufacturers.

Kohler gen-set shown.

Bob's answer: It's always best to install a gen-set with it's own fuel feed and return, but as with all older boats, you often must do what you can with what you have at hand. The fuel return is no problem. Hook the gen-set return to the existing tee fitting in the return line. You now must connect the fuel feed to that same fuel tank. If not, pumping fuel out of one tank and returning to the other will result in over-filling the other tank with fuel pouring out of the vent.

Supplying fuel to the gen-set is trickier. Chances are there is a tee connection on the outlet side (towards the engine) of the primary filter for the engine, which has the tee on the return. This gives the gen-set filtered fuel from the tank they were returning to. If the supply tee is not there, you will have to add one. When you do this, I suggest a check valve, to assure one-way flow, on the leg going to the gen-set. This eliminates the possibility of air being drawn back into the main engine when the gen-set is not in operation. In addition, be sure to put a valve on the tee to shut off the supply any time you need.

Again, this is not the preferred installation but, with only one pickup tube for each engine and no spares, it's the easiest. I'm surprised that Sea Ray did not install an extra feed in one of the fuel tanks. Most boatbuilders prepare boats of this size for a gen-set installation.

DIY reader replies: I've since contacted Onan and posed the same question. After some discussion, we came to the conclusion that it could be hooked up in the following manner. The gen-set has an electric fuel pump with a separate 12-volt priming switch for maintenance purposes that now connects to the return line of the port tank. By using a tee fitting and a three-way valve, the fuel return line from the gen-set attaches to the suction side of the electric pump. By using this three-way valve, I can bleed off the air by diverting it to an open line (this is required when changing fuel filters). When no more air is detected in the fuel, I then switch the three-way valve to close the bleed off and open the return line to the suction side of the pump. The fuel consumed by the gen-set is replaced by additional fuel from the tank. I realize that this may not be the ideal hook up but this seems to be the only way using only one tee connection from the main fuel tank.

Bob responds: Regardless of such assurances by Onan, if it were my boat I would not have the generator pick up from the return line. Maybe it is because on our Lehman Ford engines we always have some air in the return caused by fuel aeration, if nothing else. Our injection pumps do not require cooling or lubrication by return. It's only to return the residual air developed in moving the fuel. Add into this a chance that there can be an air leak in the primary of the engine feed for that return, which will go right back to the gen-set and it shuts down.

It's a common trade procedure for mechanics faced with generator installation and no pick up in the tank to connect to the outlet side of the primary fuel filter with a tee. You have primary filters with a feed from the gen-set to the engine. Why would you resist using this for your fuel pickup? Not only is it simple but it also supplies filtered fuel to your generator. The filter on the generator is a secondary filter, not the primary. I will not tell you that what you propose is not going to work but there is little advantage to the arrangement. If you try it, let me know after several hours of use just how well it works.

DIY reader comeback: I understand your concerns with regard to fuel cooling, lubrication, etc. However, the top of the tank has only two fittings and the boat previously had a gen-set that, I presume, was connected to the tee on the return of the port engine. I also presume that there are pickup tubes to the bottom of the tank. Onan has assured me that

Low Excitation After Lay Up

Q: I have a 10kW Onan gen-set with 580 hours use that, after starting up after winter storage, is now putting out only 20 to 40 volts AC. Do I need to replace the brushes and is this a DIY project?
Richard A Fredrickson, "Mad Maggie,"
Newport, Rhode Island

A: By your questions, I presume that the alternator has brushes and if so, then you are quite capable of removing the access covers and checking whether the brushes are moving within the brush holders and sitting properly on the slip rings. Low excitation voltage has two other possible causes. One is the automatic voltage regulator (AVR) that, if working properly before winter storage, is probably still functioning. During long lay-up periods, the second problem arises when the residual magnetism within the alternator has dropped or dissipated. To correct this often entails artificially exciting the alternator from the AVR output to kick-start the unit. You could do this with sufficient information and competence. Usually, this requires only a small flashlight battery and you'll have to know the voltage range of the AVR output. Once done, the machine generally operates correctly. If you continue to have a problem, you may require the aid of an Onan service agent.

there would be no air in the return fuel from the injector and that only the volume would be less. Once air is out of the line, it could be recycled back to the pump or, in the case of the return fuel from the engine, the same would be true. I contacted Sea Ray and it was unable to help me because of the boat's age. I've looked everywhere for additional tank fittings but none exist. So, unless there is a way of installing some without removing the aluminum tank, I have limited options to connect the gen-set.

Bob's additional concerns: It's normal for all fuel returns to connect to the top of the fuel tank without a pickup tube. This allows for hot return fuel to mix into the bulk fuel in the tank before drawn up by the fuel pickup. Although we haven't discussed fuel pickups, there are two mountings generally accepted in the industry: a pickup at the bottom (slightly raised) of the tank or a pickup tube mounted on the top of the tank, which brings the suction to the bottom. All fuel tank fittings for gasoline tanks are required by law to be located at the top of the tank but the law does not apply to diesel fuel tanks. I would expect the generator pickup to be on the feed line, not the return. You must feed fuel to the electric pump on the gen-set from a primary filter. The return line is likely to have air in it from the engine or from the tank, which would greatly effect the operation of the generator.

After supplying some 20,000 Lehman Fords, we never allow the fuel return to connect to the feed. Most gen-set manufacturers want the unit piped with a dedicated feed through its primary filter, with a separate return to the tank from which it's drawing fuel. An injection pump requires a return of great volumes of fuel to the tank because it's lubricated by the hot (return) fuel. Sucking fuel directly back to the engine results in increasingly hotter fuel, loss of lubrication and power.

ELECTRICAL

Switch Power

The master of a boat's 12-volt DC electrical system is the battery selector switch. It routes power to and from the engine, start and house batteries. Proper switch selection, installation and usage ensure a trouble-free system.

By John Payne

Four-position battery selector switches offer a simple, economical method of separating two batteries or battery banks (start and house).

Sometimes called a changeover switch, the battery master switch has become standard on boats largely due to the combined starting/charging system configuration that is used with virtually all engines. In this basic configuration, the charging and starting circuits share the same cabling from the batteries to the engine so that the engine starter motor takes electrical current in one direction from the batteries through the master switch. Once started, the alternator sends current back in the opposite direction to the batteries via the master. The negative return is also a single cable, bi-directional conductor that is installed from the engine block to the battery bank negative terminal. This same negative conductor also has an additional role as a polarizing conductor that uses the mass of the engine to do so.

The stock red multi-position master switch found on many boats usually consists of three positions and an off position. Effectively, it is two switches using a common output point. The center position, marked "Both," connects two batteries or battery banks in parallel, effectively combining all into one larger battery bank. The battery switch has three large terminals at the rear to terminate the positive supply cable from each of the batteries. Many battery switches also have an advance field disconnect switch that was originally available for connecting an alternator field circuit. When turning the master switch to the off position, this field disconnect isolated and de-energized the alternator field circuit before actual main circuit switching so as to avoid accidental damage to diodes. This feature is somewhat redundant and I have rarely seen it used as all modern alternators have integral voltage regulators. This was a practical measure when voltage regulators were separate and mounted external to the engine. In operation, when transferring from position "1" to the center position "Both" and then to "2," the main sliding contacts are "make-before-break." This means that there is no (or should be no) momentary break in the circuit that would otherwise create a diode-damaging surge.

Some boats have a simple on-off master switch. Often, two are used; one for the engine and one for the house battery supply. In these cases, a third bridging switch is used to emergency parallel the battery banks. This configuration usually has the input side of both switches bridged together. This does create problems in the charging of the batteries. Battery distribution clusters from BEP Marine include a voltage sensitive relay module (a.k.a. battery combiner) to allow charging of different battery banks from each engine.

(across) Basic on-off selector switch; (bottom) BEP battery distribution cluster simplifies installation of outboard engines without auxiliary output and a built-in battery isolator (VSR) allows charging of start and house batteries.

Power Ratings

A battery master switch, like all electrical equipment, is selected based on the current demands to be applied to it. It is also rated to at least the rating of the cables that are connected to the switch. Switches generally have standardized current ratings and, nominally, most switches are continuously rated at 250 amps to 300 amps with short-term intermittent ratings of 600 amps. Heavy-duty rated switches have ratings around 600 amps and 1,000 amps respectively, and some also quote a higher current cranking rating for a shorter period. The short-term rating generally applies to the heavier current that is applied during engine starting. The continuous rating generally applies to the battery alternator charging current. In reality, master switches rarely have the nominal continuous rating applied, which is generally less than 100 amps even on comparatively large engines.

Switch current ratings are specified as a function of time and at a nominal temperature. The standard for rating battery switches is Underwriters Laboratories (UL) standard 1107. The voltage rating for most battery switches is 32 volts to 48 volts, though some may be lower at 24 volts and it's rare to see a 12 volts rating.

Proper Multi Position Use

The simple boat power configuration is one start battery and one house battery (bank), the latter often consisting of two batteries (a bank). For this example, let's assume that

Payne's Five Switch Perils

Operating the Switch Under Load. You have to use caution when operating a changeover switch under charging load conditions. If the contacts don't make correctly or you accidentally switch to the off position, the surge created, several hundred volts for just several milliseconds, is enough to probably destroy the alternator bridge diodes.

Damaging Surges. Many people parallel both batteries in the "Both" position to start an engine. Often a boat is set up with one battery (house) supplying power to electronics and other house loads. Applying a large current load to that battery during engine starting can damage the sensitive electronics by the surge or "brown out" that is created when voltage first drops and then suddenly increases.

High Circuit Resistance. In most cases, cables are routed from batteries to the switch location and back to the starter motor. This has the effect of introducing unwanted voltage drops into the circuit. Cheap switches have long had a notorious reputation as being unreliable.

Switch Left in "Both" position. A very common mistake is to inadvertently leave the battery switch in the "Both" position. This has the undesirable effect of draining both house and start batteries simultaneously.

Poor Quality Switches. I have frequently come across battery switches that are hot after engine starting or during or after a charging cycle. This is due to an internal high resistance across the sliding contacts which has the effect of reducing starting current and making the engine hard to start or reducing the charging voltage due to the voltage drop so batteries do not charge properly. You should always opt for a quality battery master switch from reputable suppliers such as BEP, BlueSea, Guest and Perko.

the start battery connects to position "1" on a three-position switch and house battery connects to "2." To start the engine, always turn the selector to "1". It's always good practice to allow the start battery to recharge for 15 minutes if possible. Any electronics will also be supplied from this source in this case and the alternator is supplying the load. Next, switch to "Both" for dual battery charging. When you reach your destination or are stopping, you should switch to the house battery, position "2". This way, power for house loads comes off the house battery and the start battery is not drained.

This setup has a start or cranking type battery and a deep-cycle battery for house loads. Deep-cycle batteries are not designed for starting engines so starting the engine on "Both" unnecessarily stresses the house battery as well as impresses a large surge on the electronics power supplies. Also be aware that the paralleling of a heavily discharged battery and a fully charged one during charging can sometimes cause some power instability. The fully charged start battery begins to equalize to the house battery and discharges it. After a period using the house battery, it's good practice to start the engine on "1" (start battery) then switch to "2" (house battery) so that it rapidly recharges by the alternator.

Installation Dynamics

One of the major limiting factors with battery switch installation is the requirement to run heavy gauge electrical

(top) Blue Sea (www.bluesea.com) electronic solenoid switch automatically connects battery banks during the charging cycle and disconnects under discharge. (bottom) To eliminate long battery cable runs and resulting voltage drop on larger boats, BEP Marine (www.bepmarineinc.com) offers a 300-amp remotely operated electric battery switch with optional on-off key switch mounted on at the helm.

cables to the switch. For boats with long cable runs, this introduces voltage drops into the circuits. In many smaller boats, the master switch is generally located close to the batteries, but the problem often becomes finding a protected location away from water and spray. A high quality switch, rated for such conditions, is essential to its endurance in the wet environment. There is always a compromise involved between cable lengths and protection.

The termination of cables to the switch terminals is also one that requires careful thought. The cable lugs should fit neatly onto the switch terminals, I have seen plenty that don't, resulting in poor contact . Many switches don't have the recommended washers or spring washers. The routing of cables through the relatively small cutout is often very difficult as heavy cable is not easy to bend. It is important not to stress the terminations. Applying stress to terminals often causes distortion and I have seen cases where this stress has caused terminals to move creating poor internal contacts on some of the cheaper units.

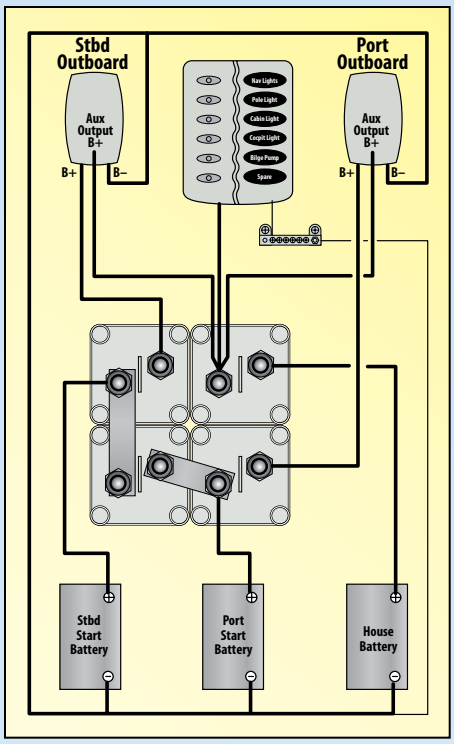
Wiring configurations are generally related to the various charging and starting arrangements and some of these are displayed on the facing page. In all of these configurations, the battery switch serves as isolation switch for the batteries, a battery source switch for supplying power to start the engine or supply house power to the boat systems and, finally, to select the direction for charging current to go to the selected batteries.

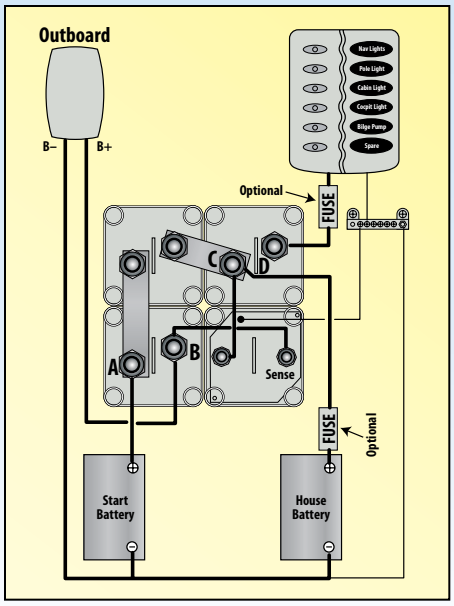
Remote Control

Remotely operated master switches are becoming quite common. These are essentially solenoids with a remote control switch to energize the coil and switch on the power supply. The major advantage is a significant reduction in the cable lengths required to run to the switch and back. This device also allows the isolation to be close to the battery where it belongs and also has less of the common problems of mounting and operating the switch. This configuration does require some re-engineering and requires the complete separation of both the battery charging and engine starting circuits, which does away with the bidirectional arrangement or circuit sharing and provides two unidirectional circuits.

About the author: John Payne, DIY's electrical consultant, is author of "The Marine Electrical and Electronics Bible" and "Motorboat Electrical and Electronics Manual," (Sheridan House).

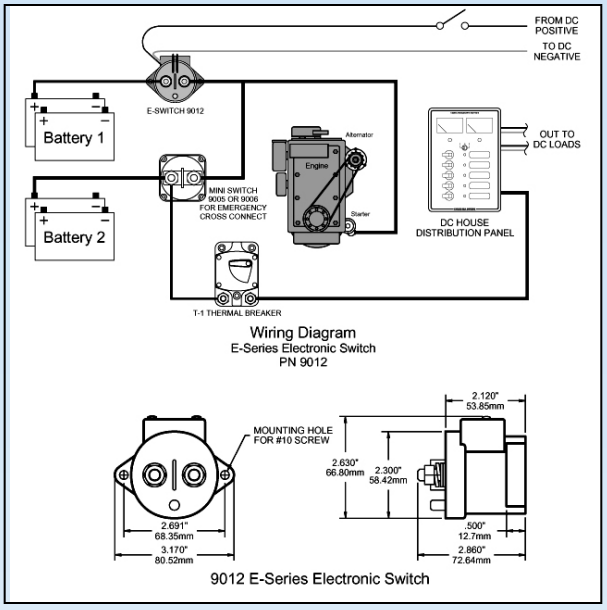
Sample Installations with Single and Multiple Switches

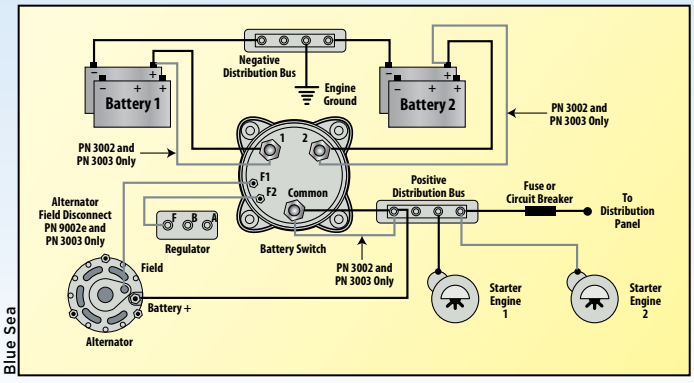




BEP Marine

(across) Twin inboard engines: when it is not practical to have both alternators in parallel because of the types of regulators used, DC power is managed by BEP Marine 718 battery distribution cluster, which consists of four on/off battery switches and a 100 amp voltage sensitive relay (VSR). The VSR allows for two batteries to be charged at the same time. When the engine is started and the start battery reaches 13.7 volts, the relay closes, combining the port start and house battery banks and allowing them to be charged simultaneously. When the engine is stopped and voltage drops to 12.8 volts, the relay opens separating the batteries. This system eliminates the possibility of draining the wrong battery and protects sensitive electrical equipment, powered from the house battery, from harmful engine start up spikes. (bottom left) Dual battery charging is easy on boats with a single outboard or inboard engine. A BEP 716 battery distribution cluster consists of an on/off battery switch for each battery or battery bank and a 100 amp voltage sensitive relay (VSR). Operation is the same as the 718 above. (left) High amperage, electronic solenoid switches allow shorter cable runs and eliminate manual switching. Shortened cables save material costs, reduce weight and exposure to short circuits and most importantly, permit high circuit voltages. (bottom) Four-position battery switch with alternator field disconnect. This field disconnect isolates and de-energizes the alternator field circuit to avoid accidental damage to diodes on engines with externally mounted voltage regulators. When moving the switch from "1" to "2," always move the selector through "Both" (not through "Off") to insure a constant supply of power.





Blue Sea

Note: The above illustrate generic systems and are not intended to be detailed wiring instructions.

The Fine Points of Docking—Without Injury

A skipper on Chesapeake Bay became something of a legend at his marina simply by putting on a great show whenever he docked his trawler. The excitement typically began building as his boat approached the end of the gas pier; he would begin by barking orders to his harried spouse, who stood rigidly on the bow like a conscript facing a firing squad. The skipper's bellowing would alert other boat owners, who, depending on their proximity to the approaching trawler, would either grab boathooks and fenders to protect their own boats or sit back to enjoy the spectacle.

On one memorable occasion, "Captain Crunch" bellowed at his spouse to use the "!@##!*boathook to grab the !@##!* line" that was strung between the fuel dock and the outermost piling of the adjacent slip. She complied. The boat, meanwhile, continued gliding forward while she dutifully kept a death grip on the nylon dock line. The spouse stretched until she could stretch no more and finally let go of the boathook, which shot into the air and through the cabin window of a large yacht. The fleet of onlookers burst into applause.

Let's face it; your ability to handle your boat at the dock is the key to your reputation as a boat operator. Never mind that you just crossed the Atlantic using only a sextant and one-armed clock to navigate. If, upon arrival, you bounce off pilings and plow into the dock, that's what other skippers will see and remember.

The correct way to bring a boat into a dock involves the use of engines, spring lines and maybe fenders; the crew might slip lines over pilings but, if you're really good, their role is minimal. A charterboat skipper, for example, will often bring the boat "magically" into the dock using only the throttles. Wind and current don't seem to matter. This sort of showmanship takes experience, lots of it, which many skippers never get because they have come to rely on technique number two — *crew muscle!*

To be fair, charterboat skippers are on the water week after week. For the rest of us, learning to dock a boat effortlessly in all conditions can take years. And considering that many boats only have one engine and are in slips that are impossibly narrow, it's likely that the crew will have to be called upon to lend at least a little muscle bringing the boat safely alongside the dock. The key word here is *safely.* Until your boat docking skills are perfected, here are five rules, taken from real accidents in the BoatU.S. Marine Insurance claim files, to make sure nobody gets hurt.

Reprinted from the quarterly Seaworthy *magazine. Subscriptions are $10 per year. For more information, go to BoatUS.com/Seaworthy or call 703-823-9550, ext. 3276.*

Painless Docking: *Five Rules for Avoiding Injuries*

Rule #1: Make sure everyone understands what he or she will be doing before you begin docking. The corollary to Rule 1 is that ***you*** should be aware of where your crew is and what each is doing. A woman in California was securing a spring line to a cleat when the skipper suddenly backed down hard with his twin 200-hp engines and she got her fingers crushed. Another man was standing on the dock holding onto a trawler's bow pulpit when the skipper gunned the engine and yanked him into the water. In both claims (and many others) the skipper and crew were acting independently.

Rule #2: Discourage crew from making Olympian leaps onto the dock. This is one of the most common types of accidents. A California man, to cite one example, broke both his heels when he landed on the dock after jumping from the bow of a large sailboat. Whenever possible, hand dock lines to someone on the dock. If that isn't possible, wait until the boat is safely alongside the pier before instructing someone to ***step*** ashore. Your crew shouldn't have to make daring leaps across open water to make up for sloppy boat handling.

Rule #3: Keep fingers and limbs inboard! As a boat gets close to a dock, passengers tend to gravitate toward the rail and drape fingers, legs and arms over the side. If the boat suddenly swings into a dock or piling, the consequences can be painful. A woman in Solomons Island, MD, lost a finger when a passing boat's wake slammed her boat into a piling.

Rule #4: Make sure everyone is seated or has something to hold onto. The owner of a 20-foot runabout asked his inexperienced nephew to jump onto the dock with a bow line. The young man eagerly climbed out of his seat and stood precariously on the bow as the boat was approaching the dock. A few seconds later the boat glanced off of a piling, only slightly, but without a handhold the nephew lost his balance and fractured his elbow.

Rule #5: Don't use bodies to stop the boat. A Florida man suffered a separated shoulder when he tried to keep a 38-foot sportfishermen from backing into a piling. Slow down, ***way down,*** and use fenders.

— By Bob Adriance

A Simple Approach to Lube Diagnostics

Monitoring gear oil levels and condition lets you instantly diagnose sterndrive problems before components fail. Use these step-by-step instructions to install a remote gear lube oil monitor. It's a practical and inexpensive step you can take to prolong the life of your drive unit.

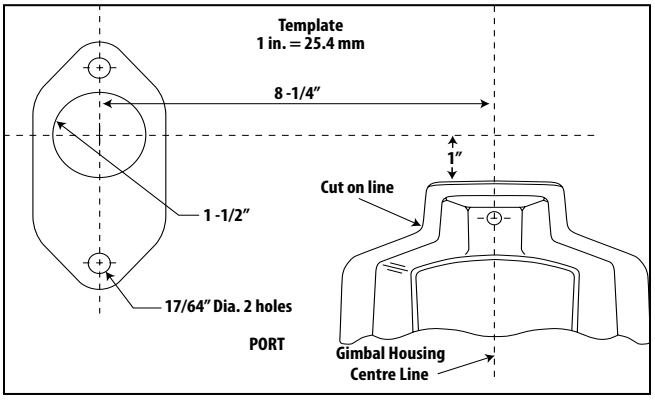
By Steve Auger

"An ounce of prevention is worth a pound of cure," quite literally defines the benefit of protecting the expensive components inside a sterndrive unit. These components can fail due to a lack of lubrication, a problem easily remedied by installing a sterndrive gear lube monitor. This monitor fits Mercruiser I series sterndrive units, more commonly known as Alpha One, from 1991 to as old as 1970. Refitting the reservoir requires only general hand tools and can be completed in an afternoon with the boat blocked up or on a trailer.

A kit, costing less than $200, consists of an oil reservoir and bracket that attaches to the inner transom, an inlet fitting to be installed on the outer transom and a combination stainless-steel braided rubber oil line that runs from the reservoir inside the boat to the sterndrive unit vent.

Start by draining and refilling the oil in the drive unit using normal maintenance procedures. Use the template included in the kit to locate the inlet cover in the correct location on the transom. Tape the template to the transom in the proposed location. Inspect the inside of the transom in the area you are going to drill for any wires or hoses that may need to be moved. Drill a 1/8" pilot hole for the bulkhead fitting and make a final inspection of the inner transom for clearances. Using the 1-1/2" holesaw, cut the access hole in the transom. Drill holes for the two bulkhead fitting fasteners using the 17/64" drill bit.

Gear Lube Monitor kit fits 1991 and prior Alpha One series sterndrives.



Included template facilitates locating the precise mounting location.

Materials and Tools

- Mercury Mercruiser Gear Lube Monitor Kit, part number 69622A7
- Standard screwdriver set (#2 drivers)
- Standard (SAE) open box wrench set
- Standard SAE socket set
- 0 to 100 foot pound torque wrench
- 1-1/2" holesaw
- Electric drill with 1/2" chuck
- 1/8" drill bit
- 17/64" drill bit
- Black electrical tape
- Gear oil, .5gal/2L (includes drive oil change)
- Mercury Perfect Seal or liquid pipe thread sealant
- Marine-grade silicone sealant
- Dish soap
- Safety glasses

Next, install the rubber grommet onto the hose. Use electrical tape to wrap the hose where the rubber hose meets the stainless hose. This eases installation of the rubber grommet. Coat the rubber end of the hose with a solution of soap and water to make it slippery. Do the same to the inside and outside surfaces of the rubber grommet and slip the grommet onto the rubber end of the hose with the large end of the grommet towards the stainless end of the hose. Position the grommet over the swaged area of the hose where the stainless and rubber hoses connect.

Wrapping electrical tape around the hose simplifies grommet installation.

Proper placement of grommet on hose.

Mount the inlet cover on the transom and then install the grommet.

Install the hose with the lubricated grommet into the inlet cover and install the inlet cover onto the transom with the provided gasket and fasteners. I find installing the grommet into the inlet cover with the cover installed on the transom to be more DIY friendly than installing the grommet into the inlet cover prior to installing the cover on the transom. This eliminates fighting with both the grommet and getting the long screws past the hose once installed into the inlet cover. Be sure to use marine silicone sealant on the mounting screws to

Mount bracket in a highly visual location.

Lube reservoir bottle mounted on bracket.

prevent any water leaks that, over time, damage a cored transom.

Mount the reservoir bracket on the transom or on a bulkhead higher than the inlet hole in the transom where the reservoir can be observed and maintained easily yet is within the limits of the rubber hose from the sterndrive unit.

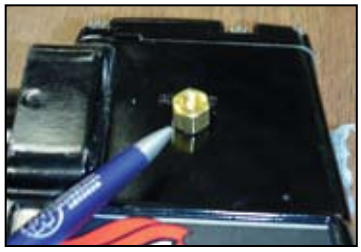
Apply a few drops of gear oil to the brass check valve and install the valve in the cap. Apply a thin coat of Mercury Perfect Seal (or liquid pipe sealer) to the threads of the barbed fitting and the 1/8" NPT pipe plug threads and install them (just snug) in the base of the reservoir. Attach the hose with the provided clamp and install the reservoir into the bracket.

Remove the vent screw and sealing washer from the top of the sterndrive. Apply a thin coat of Mercury Perfect Seal on the bronze fitting threads and install the bronze fitting and sealing washer into the vent plug hole and snug with a wrench.

Remove the top two nuts and washers from the port side of the sterndrive to bell housing studs and discard the washers. Install the hose retainer and reinstall the two nuts on the studs and torque to 50 foot pounds. Route the hose through the retainer and install into the bronze adaptor in the vent plug hole and tighten snug only at this time.

Fill reservoir to full line with gear oil and then go back to the fitting at the drive and loosen the fitting until gearlube runs out of the hose. Reinstall fitting into drive and tighten securely. Top off gearlube reservoir to full line. (Note that the recommended lubricant for all production Mercruiser sterndrive units is Mercury High Performance Gearlube. This lube provides superior protection for gears and bearings verses a hypoid 80/90 gearlube.)

Now, before each trip, you can easily monitor the oil level and the condition of the gear oil by inspecting the reservoir. If the level continuously drops you have an oil leak in the drive. If the lube changes color, you have a contamination or overheating problem with the drive that you can deal with as a preventative measure instead of being stranded on the water with a broken drive.



Bronze fitting threads into vent plug hole on top of sterndrive.

Braided hose retainer mounts to bell housing studs.

Hose connected to bronze fitting

TIP

If your engine is equipped with a Mercury audio alarm system part 86047a21 (all models except 3.7L) or part 86047a15 (3.7L only) you can upgrade the reservoir bottle to a 19743a4 bottle. This accepts a low gear oil indicator switch, part 19742a1.

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

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ELECTRONICS

In The Zone

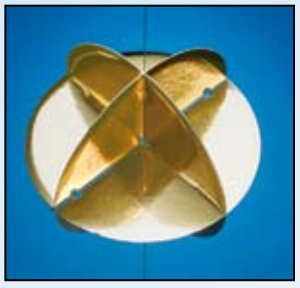
Radar reflectors are touted as essential safety devices that make your boat visible to other boats and commercial ships. Boats are equipped with radar reflectors because boaters believe that a reflector is critical to avoiding a collision at sea. The question remains as to how well they actually work. DIY's electronics specialist discovers that some are about as effective as a gaggle of geese.

By John Payne

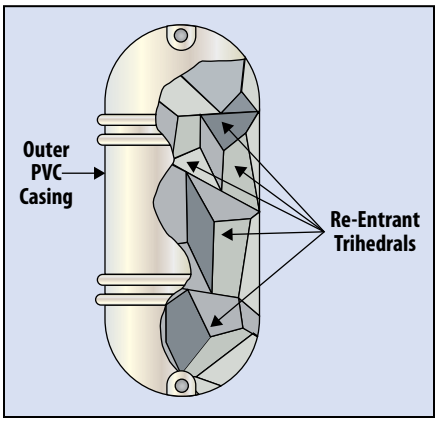
I spent several years in the Merchant Marine and have been on the bridge of fast merchant vessels voyaging up the English Channel, through the Caribbean and along the U.S. East Coast. Most professional mariners keep an eye out for motorboats and yachts, as many are virtually radar invisible. Even for those offshore cruising there is still a need to be visible. Being outside the shipping lanes still demands that the recreational boater be cautious as the term, "shipping lanes" applies solely to the designated or customarily transited areas of the sea where there is frequent commercial traffic. The truth is that commercial vessels ply virtually all waters and regularly divert from common and expected routes and courses for many reasons, not the least of which is weather. Why bother with a radar reflector? The assumption that no one is keeping a lookout is flawed. These days virtually all ships are equipped with X and S band radars with Automatic Radar Plotting and Avoidance (ARPA) collision avoidance tracking and alarm systems. To work, the radar must be able to lock on to a consistent signal and, without that, the ship's radar cannot compute and track approaching vessels and alert watchkeepers. It's really important to remember, that with large and fast boats, the earlier your presence is detected and your course and the collision risks assessed, the earlier the other boat can take action to alter course and avoid potentially hazardous close quarters situations. Many boaters refer to close encounters as near misses and, in most cases, they are exactly that. The ships deliberately alter course to avoid a collision. That having been said, a large tanker or container ship is daunting when passing close.

Reflective Beams

A boat's radar transmits thousands of radar beams. When one or more of these radar beams illuminates or paints a target some of that signal is reflected back. In an ideal world, the signal would be reflected back on a reciprocal course to the radar for signal processing to give both range and bearing and display it on the screen. In practice, however, the radar beam does not simply bounce back off an object. This is because some materials are more reflective than others, while others have a tendency to absorb the signal. The best reflective structures are made of steel and aluminum. Materials such as wood and fiberglass are non-reflective. In fact, fiberglass



(top) Davis Echomaster and Emergency octahedral reflectors have three circles that intersect at right angles; (middle) West Marine Tri-Lens is a Luneburg-type reflector that mounts on deck or a mast; (bottom) Marconi-Firdell Blipper 210-7 consists of an array of precisely positioned re-entrant trihedrals.



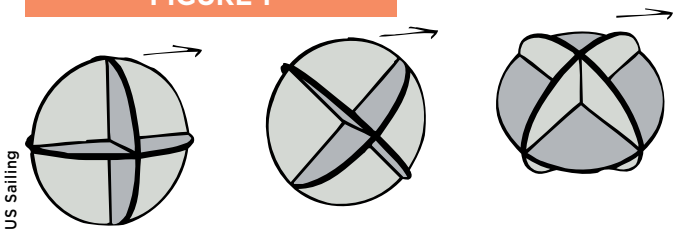
absorbs around 50% of the radar signal energy. In practice, there is always some reflection off most materials. These reflected beams tend to be erratic in direction and also are quite minimal so they are not detected and no consistent signal return can be monitored.

Reflection Consistency

Consistency is one of the major requirements of a good reflector. By "good" I mean a metallic structure, normally aluminum, with surfaces placed 90° to each other. This is called a re-entrant trihedral. If a beam is directed to the center of a re-entrant trihedral, parallel to the centerline, it will reflect around and emerge back on a reciprocal course back to the radar scanner. A re-entrant trihedral is simply a corner with three sides, such as the corner made up of two walls and a ceiling. The basis of understand-

ing radar reflectors comes from the following theory. The centerline of the corner points in a direction that is approximately 36° to each of the sides making up the trihedral. The more the angle increases away from the centerline from a radar beam, the less radar signal returns back.

FIGURE 1



US Sailing

A octahedral reflector (left) edge on to the radar, (middle) the double chain rain position and (right) the catch rain position.

Basic radar reflection standards are set down in a number of specifications and you shouldn't waste your money on a reflector that does not comply with them as a minimum. A peak echoing area of 107.6 sq. ft. (10 sq.m) is defined as the equivalent to a metal sphere of diameter approximately 12' (3.65m). With radar reflectors, size matters!

Reflector Types

Several radar reflector types are available in today's marine marketplace and they are designated by their array orientation and shape: octahedral, trihedral, optimized array, stacked array and Luneberg type reflectors.

The standard octahedral reflector is an aluminum structure consisting of eight re-entrant trihedrals. For optimum reflective effect, the reflector must be hoisted with the proper orientation and this is called the "catch rain" position (**Figure 1**). Many reflectors are suspended from just one corner and my own survey shows this noticeably reduces reflectiveness. The reflector structure has only six effective corners, each pointing alternately up and down. The remaining corners angle directly up and down so they are of little use. The effectiveness of this reflector (and other types) is plotted as a horizontal polar diagram (**Figure 2**). These are used by manufacturers to represent radar reflector performance and depict signal returns plotted for all points around the azimuth. On the 8" (20cm) octahedral polar diagram, the lobes where peak reflection occurs are clearly visible and the peaks clearly exceed the peak echoing area of 107.6 sq. ft. (10 sq.m). The most noticeable characteristic is the large areas between each of these lobes and this is where minimal reflection occurs or less than the minimum required by the International Maritime Organization (IMO) standard of .2 sq. ft. (2.5 sq.m). These blind spots total up to nearly 120°, which is far from ideal. The smaller reflective peaks do not affect the result much. When the reflector is tilted or heeled to 15°, these blind spots increase to nearly 180°. The overall efficiency of the signal return is decreased further when part of the signal, after reflecting off the sea surface, cancels out another beam traveling directly to the reflector.

The Cyclops 1 reflector comprises trihedral reflectors that are facing in a fore and aft direction with biconic reflectors

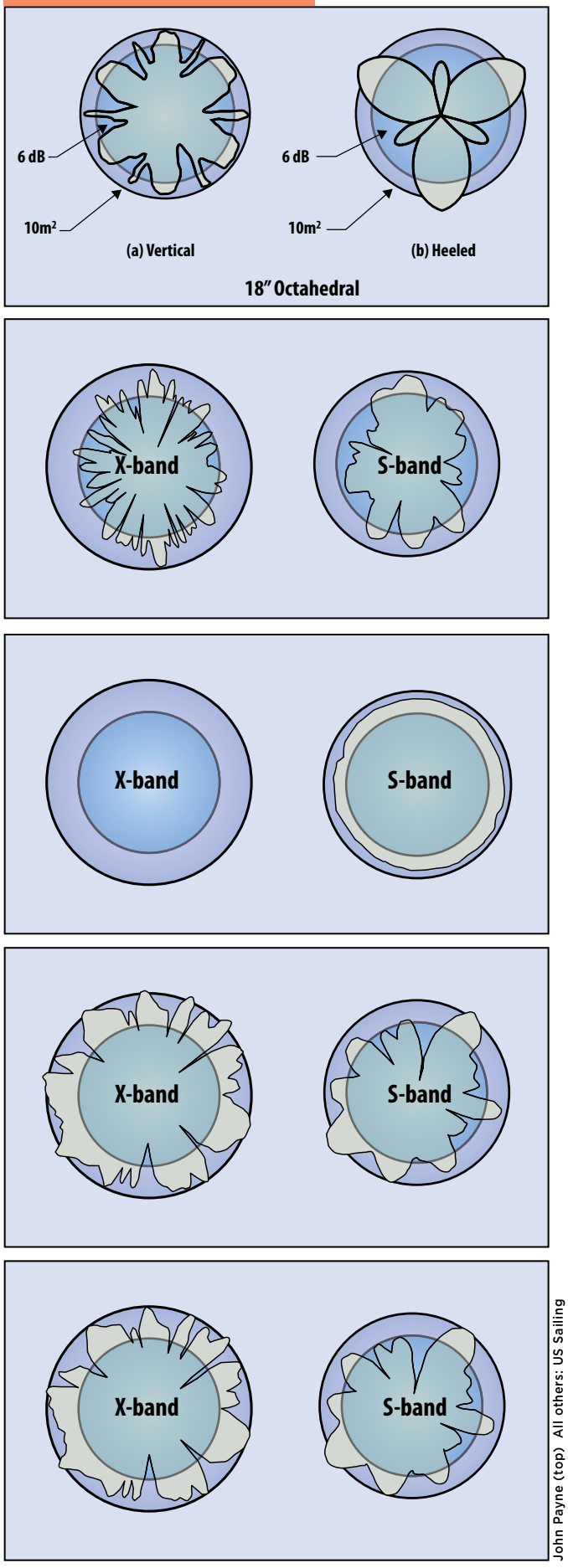
facing athwartships. The High Gain Rotation reflector comprises an 8" plastic sphere with a gimbaled quadrahedral reflector inside. The principle is that it is designed to allow the reflector to remain vertical through 360° of pitch and roll.

The Marconi-Firdell Blipper 210-7 typifies an optimized arrays reflector. It consists of an array of precisely positioned re-entrant trihedrals designed to give consistent 360° coverage and through heel angles up to 30°. A boat usually moves in a typical three-dimensional motion. As it does, each of the reflective corners moves in and out of "phase" to the radar signal. One corner reflects signal back directly and the remaining corners give partial signal returns, thus providing a consistent return at all times. These reflectors have a reputation as meeting and exceeding all published standards and the numbers mounted on yacht masts is testament to this, particularly in the U.K. and Europe. The Blipper 210-7 also has a NATO stock number. I have used this type on two boats now and performed regular radio checks with boats to verify visibility with positive response each time.

Stacked array reflectors are tubular reflectors that resemble a fluorescent tube or rolling pin. I have seen boats with several of these installed on stays. They consist of an array of tiny reflectors housed in a transparent plastic case. I have read many assessments of these types and the test reports show that reflective capability is generally confined to a near perfect vertical position. At any angle of heel, at 1° or above, the signal return decreases to virtually nil. At the best tabulated positions, at 0° azimuth, the radar cross-section area (RCS) is 6.05, heeled to 1°, it falls to 1.46, and to 0.18 at 2°. I inherited two of these units aboard a wooden boat and did frequent checks with radar-equipped boats, and I was not visible on any occasion.

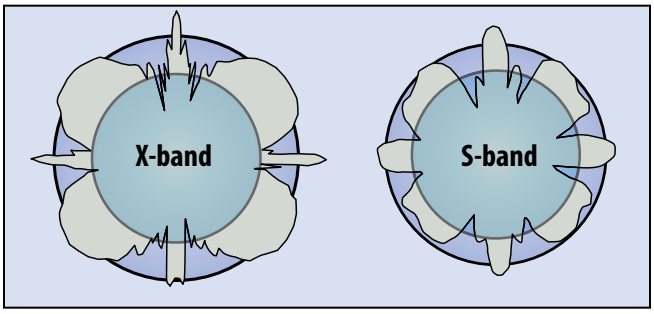
Luneberg type devices resemble two half spheres mounted back to back. They are normally fitted to the masthead in a fore and aft configuration but they are rather heavy. The Lensref is a sphere 8" (20cm) in diameter that comprises layers of plastic that vary in their refractive index ratings. The radar signal is focused on a reflective band located around the center of the lens and then reflected back on a reciprocal path back to the radar energy source. The many criticisms leveled at this reflector type include that the opinion that the signal return was fore and aft but none from the side, creating a quite large and dangerous blind sector. These devices do not meet the minimum standards of RCS requirements with only around .08 sq. ft. (0.8 sq.m). Mounted on the masthead, it also had Fresnel (explained on next page) effect issues that further reduced effectiveness. A gimbal mount would certainly improve the Lensref's RCS. An improvement of this style is

FIGURE 2



(top to bottom) Radar cross section (RCS) plot for a 18" octahedral reflector in the vertical and heeled position. Remaining RCS plots are at 0° heel: Mobri tubular reflector is essentially invisible; Lensref Luneberg type reflector is a good choice for boats that don't heel; marginal performance of the Marconi-Firdell Blipper; and radar flag ranks high provided it remains on a vertical plane but, add wind and it becomes invisible. White space in diagrams is the area of no radar visibility. The larger the performance plot, the better the reflector.

John Payne (top) All others: US Sailing



US Sailing

Radar cross section plot of a stationary Davis Echomaster with 0° heel in the double catch rain position. Contrary to the author's findings, tests conducted by US Sailing rate this reflector, mounted in this position, as one of the best of all devices tested.

the West Marine's Tri-Lens radar reflector, which consists of three Luneberg lenses.

Installation and Zones

There is an effect in radar where radar signals self cancel and this occurs either in the transmission or return path. This problem is related to a variety of factors that includes radar height, target height, sea and earth surface conditions and radar range. These regions where the signal cancellation occurs are called Fresnel or extinction zones. Such zones can be up to a mile in width. When these conditions occur, the radar signal reaching the radar reflector may be relatively weak, with a correspondingly weak return. The result is very little to no signal return to the radar occurs or is so weak that it is not processed and is radar invisible. The notion that a reflector should be mounted as high as possible, such as a mast top, is not the ideal. A Fresnel table shows that, for the typical 35' (10.6m) mast, a relatively large cancellation zone exists. Passive radar reflectors are best mounted on the top of a pilothouse or flying bridge, or around the first set of spreaders on a sailing boat, which is about 12' to 15' (3.6m to 4.5m) above deck.

Radar target enhancers are active reflection devices. When they receive a transmitted radar signal, circuits amplify the radar signal and then re-transmit it back to the source. The effective increase in radar visibility is quoted as around 600%. The Sea-Me device, for example, operates on an X-band radar signal.

The subject of passive radar reflection and reflectors has been one of continuing controversy with a constant stream of so called reflective safety devices being launched into the market. Most of the controversy about the performance of each reflector often revolves around the testing methodology, with claims and counter claims. The bottom line? Purchase a quality reflector, mount it properly and test it by "swinging ship," as done when calibrating a compass while asking radar-equipped boats for a signal check.

About the author: John Payne, DIY's electrical consultant, is author of "The Marine Electrical and Electronics Bible" and "Motorboat Electrical and Electronics Manual," (Sheridan House).

Further Reading

West Marine conducted tests of radar reflectors mentioned in this article in 1995 and the results are posted online at www.ussailing.org/safety/Studies/radar_reflector_test.htm.

Boatyard **Affairs**

There may come a time when a boat owner must hand a maintenance job, daunting repair or installation task over to professionals. So do-it-yourself or do-it-for-me owners don't run hard aground in service red tape, DIY has compiled these guidelines to the who, what, where and how of getting your boat into a competent service facility.

By Patricia Kearns

Taking a break from cruising for some seasonal maintenance. Owners get full value for their money at highly regarded, full-service boatyards providing they know the "rules."

In the "good 'ole days" a well-to-do yacht owner would bring his yacht to "the yard," often the same one that built the boat, to undergo all maintenance needs. That relationship was often established on little more than a gentleman's agreement, a handshake with the implicit trust that all would be fair and well and it usually was. Times have changed. Now there are contracts to be made and performance expectations are set in black and white to be agreed to by all parties. It's business, the boat business, sometimes big business.

Today's boat owners come from virtually every social and economic strata with the average Joe being more in the majority. It may also mean that many boat owners, especially those owning fiberglass boats, subscribe to the "just add water and have fun" concept of taking care of a boat. When the boat needs service or repair, some owners adapt nicely to DIYing for all or part of the tasks and many boaters derive great personal satisfaction from maintaining their own boats. All is fair and well until they encounter a project or repair that takes them into deeper waters and requires professional help. DIYing is a matter of degree that relates to individual skills, motivation, vision, resources, passion, etc. Ultimately, sooner or later, one or all of those DIY requisites will limit even the most devoted amateur and then, when the time comes, even the smartest DIYer will acknowledge the need to hand a daunting repair or installation task over to professionals. Even the brain surgeon doesn't do surgery on his own brain. He finds a better brain surgeon to do the job.

That's when the appeal goes out for the who, what, where and how of getting your boat into the hands of a competent marine service facility, the modern euphemism for the "boatyard."

This is a businesslike relationship that must be established and nurtured to achieve the desired physical, mechanical, aesthetic and fiscal outcome. It's a relationship that demands all the same attention to expectations, needs, entitlements, demands and satisfaction as any other business relationship striving for a successful conclusion, which, in this case, means a boat is restored or elevated to a condition of serviceability with services and skills that are exchanged for an agreed sum of money. If you think this is no big deal, read on. For too many of these relationships there is a squall line of misunderstanding that can wreak havoc on the parties to seemingly reasonable presumptions. Note that I have not used the word "assumption." If you are assuming anything about a budding relationship with a boatyard or its service equivalent, then you are probably in for a voyage into very rough seas. Assumptions can only be reliable if they are based on experience.

Would-be Expectations

"My car's in the shop." "My boat's in the yard." "We're remodeling the kitchen." What do these three statements have in common? They share the potential for tremendous disappointment. Why? It's all about expectations. Your expectations might include: presuming that repairs or maintenance or upgrades are accomplished as needed; that boatyard personnel are able to assess the cause, nature and extent of the problem;

(top) Nauticat 43 ketch being prepped for launching by Marco River Marina, Marco Island, Florida, a first class, full-service yard. (bottom) If you're looking for bargains in boatyards, you'll probably get what you deserve.

there are available skilled craftsmen, materials and equipment required to perform the needed work; and you will pay a fair price for the work.

We are accustomed to the fairly reliable standard approach to getting our cars serviced. In the service departments of many car dealerships there are published policies, prices for parts and labor, even package pricing for routine jobs. No work is done without your approval and there are rules of conduct expressed in the work order. It wasn't always that way and the nasty reputation for service rip-offs took a long time for the auto service industry to shake. It had to build and rebuild consumer confidence by taking important steps that the recreational marine service industry is aggressively addressing to deliver a hassle-free routine service experience to the boat owner. Drive into most established auto dealerships with good reputations for service and you'll likely be greeted by an immaculately clad service manager who listens to your story, records your concerns, tags your keys, directs you to a comfortable waiting room or is willing to lend you a courtesy car so you can go about your business. That waiting room might even be a wireless haven where you can get some of your own work done. Your car seat will be covered with protective material and the floor will be papered to protect the carpet. That kind of approach to the service business is still the exception for boat yards. I'm not saying that there are no expert, reliable and reputable boat service yards. There are many of them and their success is steeped in their reputation for outstanding work and exceptional customer service. What I am saying is that you need to put your DIY skills to work in finding the boatyard that makes customer satisfaction "job one."

State of Affairs

Picture this. You have made arrangements to bring your Woopteedo 32 to the boatyard for some routine maintenance on the two sterndrive engines. The boat is two years old, engines have about 100 hours on them and you want to make sure that, following winter storage, the boat is ready for your annual spring club cruise. The boatyard tells you to bring the boat on Monday but, since you have to be at work, you ask permission to leave it at the dock on Sunday afternoon after your weekend onboard. "Okay with us," says a company rep. You tie up the boat on the fuel dock, drop the keys in the mail slot in the yard office door (or hide them on the boat in one of those secret places that is no secret to anyone) and you leave a note that you'll call the service department on Monday morning. Pretty typical scenario and not too different from dropping your vehicle at the car dealership. Same routine? Not really as there are some big gaps here that are bound to lead to some moments of deep regret, yours and that of the service people you have engaged to help solve your engine problems. Here's where the boat fixing and service migraines begin but may not end. What follows are a few precepts that you'll need to master so that you can plan that club cruise in confidence.

Service Appraisal

Reputation is the watchword and you usually get what you pay for. Visit the yards you are considering and ask for references. Talk to other boat owners you meet there to find out how they feel about their experience with the yard. Good boatyards are rapidly becoming administratively sophisticated and are adopting the customer service advantages of current communication's technology (email, cell phones, digital cameras, special software for job costing and inventory, etc.). Often, you can interpret this level of sophistication as evidence of a yard that is or is working toward leading the pack. "Good," however, does not necessarily equate to the size of a boatyard. It equates only to high quality service. It's the people and the work product that define "good, better, best." Size and experience do matter if you are having your boat's topsides painted, an engine repowering, replacing the standing rigging, buying all new electronics and having a bow thruster installed and you want all those tasks done in the same facility. In the case of a complex work order, make sure the yard of choice is not using your boat as a learning experience. Be sure the yard has the physical resources and diverse skill sets required for complex projects. If the guy who answered the phone runs the lift, does the electrical work and also fixes engines, you may not be in the right place. The day of the "jack of all trades" in the boatyard is long gone

TIP: WINTERIZE WHAT?

This year when you tell a yard to winterize your boat don't assume they will not only winterize engines but also cover the boat, pull the drain plug or routinely inspect the boat. Everything that needs to be done should be spelled out in a written contract. —*JM*

Some boaters think grubby yards are humble and inexpensive, quaint with local color and staffed by experienced old salts. I would run fast from this yard.

as it is in most other professions. The guy who's the acknowledged expert on Saab, for example, might be lost under the hood of a Grand Wagoneer. The age of specialization has arrived in the boatyard, too.

Competence Checks

Look for evidence of current certifications of technical expertise and good stewardship of the environment. If the yard is constantly striving to qualify for these awards, you'll see that in a clean, green facility with certified management and technicians. Some of the acronyms to look for are CMM (Certified Marina Manager), ABYC and ABBRA (technical skill training and certifications), Clean Marina status and other designations that attest to a facility's commitment to attaining recognition for excellence on every level.

My ideal boatyard would have a service writer whose sole purpose is to communicate with the boat owner and be the liaison with the service department. It would include a service manager whose sole job is to manage the service team, not to fix boats. Finally, the technical team would include specialists who are fully certified in their area of expertise. If this is not what you see or hear, ask why. If the answer is, "We've always done it this way … never had a problem," run, run away, run fast. What would you do if your doctor told you he was doing heart surgery the same way he did it 10 years ago?

Get it all in Writing

A well-developed work order (WO) is the most fundamental tool for every job, large or small, for you and the yard to rely upon at the beginning, middle and end of a job. It's the course with the chart and all the waypoints toward successfully completing the task at hand. It is the place to record, in writing, the scope of the job, its subsections, estimates, its status, change orders, anomalies encountered along the way, materials needed, special requirements, warranty issues (if any) and all the yes, no and maybes that need qualifying or clarifying.

Just what is a WO? Often, when I'm involved with a group of boaters discussing this issue, I'll do a little role-play exercise with them. I ask for a volunteer to play a yard employee and then I turn my back and walk away. When I turn around, I pull my ring of keys from my pocket and toss the keys to the employee as I pretend to exit the yard, while gaily shouting, "Fix it, please. I'll be back on Friday." Is that a work order? What happens if the yard ignores this boat owner's idea of a work order? It's not a pretty thought. From the written WO ensues all that follows until the job is finished and the bill is paid. There are some basics that must be common to all WOs.

Every WO must be in writing. The WO is a contract and a verbal contract is worth only the paper upon which it is written. Simply calling the yard and ordering engine service is not sufficient. What service? What if something is found to be wrong beyond the original concern? Every WO must be signed by all parties. There should never be "I thought you … presumed that … we knew you would …" language in any imagined WO. Get it all in writing!

Every WO must have provisions for the scope of the job, changes, additions, deletions, start and completion dates, cost estimates and cost overruns, accepted delay and cost overrun factors, etc. Get it all in writing! A large project WO must have a provision for status updates, such as routine reporting to the boat owner on the status of the job. This is the secret to avoiding ugly surprises when it's time to pay the bill. Get that in writing, too! A boat owner placing a large, complex project WO should consider engaging an independent project manager to oversee the flow and quality of the work in progress.

The Rule Book: Yours, Theirs, Mine, Ours

All parties involved in the transaction must understand the limitations of access. There are many seemingly simple repairs to a boat that become incredibly difficult (and expensive) because it's necessary to disassemble the boat to gain access to the relatively inexpensive component that needs to be replaced or repaired. Most boatyards would put a high value on employees who were very tiny people with 5' (1.5m) long arms and an IQ that entitled them to Mensa status and vision that enabled them to see clearly in dark and remote places, behind panels and inside deck laminates.

Plan to meet all the players involved in your project. There's little more valuable as personalizing your boat with your countenance. If you want to enrich the pot by offering a completion bonus, offer it to the yard and request that it be shared (if earned) with all those whose efforts made the project a success. Never offer completion bonuses directly to yard employees. Before you sign the WO, know the financial terms before you go. Most yards have a "no cash, no splash" policy. It's pretty reasonable for the yard to expect to be paid in full before you remove your boat from their premises.

Provide the yard with any boat hauling/lifting information or experience you have about your boat. Include warranty records of any equipment that is under warranty and provide marine survey reports that contain information that relates to the work included in the WO. For repairs that are part of an insurance claim, advise the yard of that condition but remember that you are in charge of the WO, satisfactory completion and payment of the invoice. Your relationship with

the insurance claim manager is not the yard's responsibility or concern. It's your boat the yard is fixing and the yard is accountable only to you. [Ed: For insurance "rules of the road" and claims information refer to DIY 2003-#4 issue.]

Understand the reluctance of the yard to install equipment that you have purchased and provided to them for installation. Why? You got a good deal at the marine equipment discounter. Why should you pay retail at the yard? Here's why. You bought it, the yard installs it, then it doesn't work. You want the yard to act on the warranty but it didn't buy the equipment. You did. So you take it out, return it to the store and deal with the warranty issue. Still a "good deal"? Think about it. This is where the term "full service" comes to roost.

Watch the weather. Inclement weather is a huge factor in completing a project on time and it has to be accepted that some bad weather is a given on any project done outdoors. If you put your boat in the yard during hurricane season, know that an impending hurricane will divert the yard personnel's attention to securing the facility and everything in its care and pending WOs will fall low on the priority list. The same goes for snow and ice, working during summer thunderstorms and during temperature extremes.

It's the norm for outside contractors to not mix well with your yard's policies. Know what is permitted before you send your next-door neighbor's teenager to the yard to compound and wax the topsides while your boat's in the yard for engine repairs. It's not just about limiting work done in the yard to yard employees and the extra revenue gained. That might be part of it but it's always about liability. That nice kid's dad might be a lawyer and you know what that will mean when he falls from the rickety ladder he brought along for the job. Respect the yard for being astute in these matters. That's probably one of the reasons you chose it in the first place. Many yards invite selected outside contractor expertise to work in the yard to fill a void or voids in the yard's own qualifications for a particular job. Of course, if the yard is contracting work on your boat, that should be part of the terms of the WO.

Take precautions to prepare your boat for time in a boatyard. The nature of the work generates dust, messes, etc. Make sure you know how your boat is to be protected during the work that is being done on your boat and any others nearby. Make sure you have made it clear that you expect your boat to be returned to you in the same condition as before you left it at the yard. Respect for other people's property is not always paramount to a technician who must work in a hot, confined and dirty engine space. The yard should be responsible for cleaning up the messes it makes.

Lastly, keep the communication lines open and establish your expectations up front. If the yard doesn't keep you informed on a regular basis, find out why. You don't want any surprises at bill paying time when the yard can hold your boat hostage while you work out a problem that could have been resolved early in the process.

If all else fails and you still run hard aground in the boatyard, remember what a wise boat yard operator confided in me, "He with the most documentation wins!"

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

POWERBOAT RIGGING

Prop Of A Different Twist

DIY tested a conventional prop against a Ring Prop, the U.K. built ringed propeller. Though ring props aren't new, this patented hydrodynamic design proved a good contender and rates top marks for thrust, handling while cornering and reduced steering torque.

Story and photos by Roger Marshall

Ring Prop's integral aluminum ring around the blades helps protect swimmers and marine life with minimal impact on boat performance.

Recently, I tested a conventional open-blade prop against the aluminum Ring Prop, a patented propeller with an integral ring around the blades. The folks from Ring Prop and its U.S. distributor Ocean Marketing ably abetted me. It was a perfect day in Guilford, Connecticut, with the air temp at 86° and a 4-knot southerly breeze just strong enough to kick up small waves. The differences between the two propellers were obvious and very revealing. Straight-lining at wide open throttle (WOT) in the Boston Whaler Sport 115 powered by a 115 hp Mercury and propped with a 14" diameter, 14" pitch conventional prop, the speedometer registered 25.4 knots. The same set up with a Ring Prop topped at 23.4 knots. WOT straight-line speed is not what Ring Prop seeks as one of its benefits. Out on the water, Carl Morley, Ring Prop's R & D Manager, took great delight in ramming the throttle to WOT and slaloming the Whaler into hard lock-to-lock turns. The conventional prop lost thrust quickly and Morley had to slow down to get it to bite again. With the Ring Prop, he simply straightened up and the boat took off again without touching the throttle. In high-speed turns, the Ring Prop certainly had greater pulling power with less torque steer and ventilation.

What happens when you accidentally run over that "submerged object" is the real beauty of the Ring Prop. With no exposed blade tips it skims over submerged objects. "In Australia we took a sheep carcass and wrapped it around a buoy," Morley said. "By putting a long rope on the carcass, we could adjust its height in the water so that it was just slightly below the surface, like a swimmer or a manatee might be. We then fitted a Ring Prop and ran over it at various speeds. We found that we had to really slow down and poke the carcass into the prop to get any effect at all. In most cases the carcass simply hit the ring and bounced clear, causing what would be a good-sized bruise. When we put a conventional prop on the boat and ran over the carcass, we chopped into it seriously and in one case we went through the ribs and hit the buoy. For a conventional prop hitting a swimmer, that would be a life-threatening injury," Morley explained. He paused as he threw the boat into more lock-to-lock turns. "In Britain we did a similar test with a great big sausage. We had to feed the sausage into the ring prop to do any damage to it. With the conventional prop we chopped it into patties fairly quickly."

Bushing allows the Ring Prop to fit a variety of outboard brands.

This is the crux of the Ring Prop's claim to fame. It is far safer than a conventional prop when operating in areas where swimmers, fish or manatees might be present. It is also almost as fuel-efficient as a conventional prop at cruising speeds. According to manufacturer's data a 50-hour run using a 15.75" diameter Ring Prop got 0.98 nautical miles per .26 gallon (1 litre) of fuel, while a similar conventional open-blade prop got 1.15 nautical miles per .26 gallon (1 litre). Both props were running at an average speed of 19 miles per hour. A prop with a prop guard got only 0.67 nautical miles per .26 gallon (1 litre) at a speed of 16 knots.

Changing a Ring Prop is very easy. Simply remove the prop nut and pull the prop off. The Ring Prop has a bushing constructed of Hytol (a material similar to nylon) that fits inside a punch-extruded, light-metal bushing. By changing the Hytol bearing or bushing, the prop fits Honda, Mercury or Yamaha outboards up to 50 hp. There are several prototype props in the works (the gray ones in the photos) that will allow Ring Props to be fitted on engines up to 150 hp. These are slated for introduction during the 2006 season.

In short, the Ring Prop is slightly less efficient at WOT than a conventional propeller but is almost equally efficient at moderate speeds with marginally better fuel economy. It's far safer when operating near anything that floats as well as delivering better handling when running a serpentine course. Don't buy a Ring Prop if your primary goal is to go fast. For the highest speeds, you want no propeller at all. That's right, no prop. You use a jet drive, not a waterjet, but a real airplane jet drive. That's because propellers create drag and as speed increases so prop drag increases, along with the lower unit drag (in the case of an outboard), or the shaft, bracket and rudder drag (in the case of an inboard). The more wetted area to the propeller, the higher the drag. Because the Ring Prop has more wetted area than a conventional prop, at high speeds, it can't help being a little bit slower by a knot or two. Ring Prop (800/343-8294; www.ringprop.com) is available at West Marine, Defender and Overtons.

Readers' Boats

1987 Bertram 33 Sportfish "Island Time"

I've owned boats of various kinds and conditions since I was 12 years old. Over the past few years, we have steadily upgraded in boat size and condition and recently had a jet boat and a 23' (7m) Pro-Line. We caught the offshore cruising and fishing bug with the Pro-Line. Once we'd finished our many upgrades to the Pro-Line, we decided that it was too small and wanted a boat that we could pour our hearts (and wallets) into and that would be large enough to keep us happy for many years.

We had settled on Bertram as the brand of choice because of a good friend who has a classic Bertram 31 and from whom we had heard many times (and then later from many others) about the superior construction and sea-keeping abilities of these boats. With that settled, we zoomed in on the 33 Sportfish, with diesel engines and, after months on an Internet search, we found our baby, a 1987 33' (10m) Sportfisherman with 3208T Caterpillar diesel engines.

We finalized the purchase of our Bertram in October 2004, following a hurricane season that destroyed many boats and marinas throughout Florida. The purchase settlement was delayed for months because no insurance company would underwrite the boat while a "named storm" was approaching Florida. (Hurricanes marched toward Florida relentlessly in 2004). We brought the boat from Fort Lauderdale to Melbourne in October, hugging the coastline on a five-hour trip that was also a tour of coastal hurricane devastation. That day, the winds picked up and I was very happy to learn that the 5' (1.5m) choppy seas were no challenge for our Bertram. It plowed right through them at 21 knots in confidence and relative comfort.

From our course about 5 miles offshore and parallel to the coast, we could see wrecked boats and buildings everywhere. The last leg of our trip from Sebastian Inlet to Melbourne, via the Intercoastal Waterway, was a nautical minefield of sand bars, sunken boats and floating dock debris. I felt guilty pulling into the marina that evening in Melbourne, proud owner of a new (to me) boat that still floats, while so many other boat owners were busy trying to raise their sunken vessels in the various states of devastation all around us. We managed to get through it all unscathed and tied up in our slip, right next to a submerged 40' (12m) Carver.

The previous owner of our boat had kept it in good cosmetic condition but he wasn't as vigilant with mechanical issues as I would have liked. Every time I stuck my head in a hatch or bilge space to plan an upgrade, I was distracted by many other newly discov-

A surprisingly large and well-equipped interior for this size boat.

This model has a large cockpit, a must for fishing and cruising in Florida, where boaters spend most of their time outside.

ered problems. Unfortunately, our surveyor, who had no trouble identifying the obviously rusted rattletrap, albeit still functioning generator, missed many of these conditions so we were left with unpleasant surprises. [Ed: For detailed information on selecting a surveyor and doing your own presurvey checklist refer to DIY 2002-#2 issue.]

Upgrading the boat's outdated electronic equipment was our immediate interest. I settled on a Garmin chart plotter and big VGA color screen model 3010C and installed a depth-sounder/fishfinder, satellite weather system and 36-mile (58 km) radar. I chose the integrated system because one screen shows everything, including the weather and radar, all on the same map with our position. The various network components were installed in the space under the bridge. The old and still functioning electronics are now our hard-wired backups. We also upgraded the stereo system on the boat. I installed a Clarion marine system, with separate switched amplifiers for the bridge and the cockpit speakers. That way we can have music on either or both and turn each on or off by a simple toggle switch at the helm.

The original rusted 8kW Onan generator developed a fuel leak at the pump so it was another major project. Knowing that the generator was probably not reliable and that parts and service would be expensive, it just didn't seem worth fixing. Removing the generator led to one of the most time-consuming upgrades that I've recently completed and one that no one will ever see or appreciate unless they have been through it themselves — the boat's bonding system. [Ed: For complete details on testing bonding systems also the what, why and where of anodes refer to DIY 2003-#2 issue.] The bonding system connects all below-water metal components together and to the sacrificial anodes. Most of the individual bonding conductor (wire) contacts to the ship's bonding system (to the two copper strips that run the length of the hull) were under the generator. After removing the generator and cleaning out the 18-years' worth of bilge sludge that lived underneath, it became clear that all the original bonding wires were probably not capable of doing their job and were making poor contact, if not broken loose completely at their terminal connections. Worse yet, only the rudders and shafts had been provided with zinc anodes but these were all wasted and not directly connected to the bonding system anyway. I knew that an investment in this system was key to protecting vital boat metal components, such as rudders, shafts, props, thru-hull fittings and valves, etc., from corrosion. Thus began the long process of completely reworking the ship's bonding system. I also installed new zincs on the shafts, rudders, swim platform struts, trim tabs, a big plate on the transom and connected them all to the bonding system. We settled on an 8kW Kohler generator. This was easily installed once the new bonding system was in place.

(top) Flying bridge with updated electronics. Chart plotter mounts on Navpod. (bottom) Network components mount underneath the bridge helm.

Plenty of helpers expedite the refit: oversize bonding plate is mounted on transom while hull receives new antifouling paint.

(top) Removing the old, rusty gen-set exposed an inadequate bonding system and resulted in a labor-intensive upgrade. (bottom) New 8kW Kohler fits the hold.

The engines were dirty and rusting so we gave them a badly needed cleaning and repainted them. My wife Rachel deserves all the credit for this job. She did 95% percent of this hard and dirty work by hand, cleaning and degreasing with acetone and rags. All loose rust was wire brushed and scraped away and surfaces treated with Ospho (phosphoric acid). Finally, several coats of Caterpillar white paint decorated the effort.

While underway during some cruising time between projects, the high-temperature alarm on the port engine transmission sounded. We have the freshwater-cooled transmission oil coolers, which I'm told are rare. Anyway, this alarm led to the discovery that there was a small coolant leak on that engine, which eventually restricted the cooling-water flow to the transmission oil cooler. When I opened the cooling system on the port engine, rusty, cruddy water poured out indicating an existing, probably neglected problem. After fixing the coolant leak, found using a

(top) Engine before cleaning; (bottom) White paint does wonders for an old engine.

pressure tester, I moved on to flush the inside of the freshwater-cooling system on that engine. First I added flush solution, ran the engine for several hours, and then fully flushed the engine with water three times to remove all traces of the flush solution. There are a total of 10 plugs to remove to fully drain these engines and most require that you turn yourself into a human pretzel to service them. I'm sure that to dock spectators, it looked like I was performing some unnatural act atop my engines in order to get at these plugs. After completing this difficult task four times, which meant handling each plug eight times, I was finally able to put in the new coolant. Luckily, the coolant on the starboard engine was still clean but to put both engines on the same maintenance schedule, I flushed that engine once with only water and then re-filled it with new coolant.

We also replaced the fuel injectors and water pumps on both engines, not because they were bad but because we wanted to know they were dependable. Now both engines have freshly maintained cooling and fuel systems and we can start our summer Bahamas cruises with confidence.

I wanted the entire cooling system in good order, so I decided to clean the raw-water side of the heat exchangers on both engines. Online, I learned of a method to do this in-place, which I decided to use because the exchangers are very hard to remove on this boat without tearing apart the boat interior. I could get my finger into the zinc plug holes and feel old zincs rattling around in there and, after removing the end caps, could see the crud they left behind. I cleaned the exchangers in place by pumping an acid/water solution directly into the exchanger through the zinc plughole, using a drill-operated pump and a barbed fitting. I let the acid sit and cook the crud away for about 20 minutes and then reassembled the plug and flushed out the acid by running the engines. After installing the new zincs, my cooling system is like new.

The tips and information in *DIY boat owner* magazine and archives were very helpful through all of the projects. I would also like to thank Captain Patrick McCrary for his help, experience and his website: www.bertram31.com. It's full of technical information and access to helpful, experienced Bertram owners. There is also a website for the Bertram 33 by David Sumich at www.bertram33.com. These websites are a haven for do-it-yourselfers. After buying this boat, I suddenly found myself in a community of Bertram owners that freely share valuable knowledge and experience and the group meets for Bertram rendezvous all over the U.S.

Next on our project list is an autopilot, which I have just begun. Following that is much needed attention to the anchor windlass. I'm sure there will be many more satisfying projects to complement the boat and enhance our pride and joy of ownership. I seem to like working on the boat as much as I do using it. The Bertram is a great boat and it deserves to have the best.

— Sean Burlingham was 12 when he bought his first boat and has since owned "at least 10 boats, probably more." Most of the early boats were works in progress or as he wrote, "pieces of junk to put it correctly." Tired of loosing money on each boat upgrade and wanting to move up to something much larger and higher quality that would not depreciate 40% after launching, his search lead him to the Bertram 33. He and his wife Rachel, shown sitting together on the aft bench, keep "Island Time," in Melborne, Florida.

[Ed: "The Bertram Doctors Are In … and they have the prescription if you hit a snag in your Bertram refit." These words are quoted from a recent issue of Soundings (August, 2005) and bring exciting resources to classic Bertram owners and would be owners. Lee Dana and Jerry Solderholm recently set up a consulting group to provide Bertram model information, help track hard-to-find parts and offer refit consulting and engineering services for Bertrams built before 1996. Dana is a former Bertram executive and vice-president of engineering and Solderholm was manager of Bertram's parts and service department before each respectively retired. You can reach Lee Dana in Vero Beach, Florida at 772/2345211.]

SAILBOAT RIGGING

Sailing Without Brakes

PYI

A low-drag propeller is key to achieving optimum performance when under sail or engine power. If you're considering a replacement prop, here's everything you need to know to select the right one for cruising or racing.

By Jan Mundy

Even the most ardent of cruisers wants to arrive at their destination as quickly as possible. Adding a knot or two to your boat speed could mean the difference between comfortably sitting at dockside after outrunning a squall or riding it out at sea on your "ear." A low-drag feathering or folding prop improves sailing performance, especially in light to medium air.

You're sailing to weather, you tack the boat and the crew madly scrambles to crank in the sheets to adjust the sails and regain boat speed. A fixed blade prop reacts like a drogue behind the boat, slowing the boat, so you must bear off to gain speed. With a low-drag prop, in theory, you would tack the boat and hold a much higher sailing angle. There's no need to bear off to regain speed. This added control and power is apparent in lighter winds; obviously, strong winds minimize any performance differences in prop design but heck, who likes to sail in a gale.

(top left) Martec, the original racer prop. (bottom left) Slipstream has a "bump" stop, which eliminates some of the shock loading on the shaft and clanging sound when blades open. (right) Most of the newer folding props have gears to make sure both blades open.

If low-drag props are so good, why do few production boatbuilders offer them as standard equipment? (The industry standard is a three-blade fixed prop.) One reason only: cost. If a folding prop is the Buick of props, than a feathering one is the Cadillac, costing 10% to 30% more, or roughly the price of a new genoa. Let's forget airfoils for a moment and consider hydrodynamics. Under sail in light air, a three-blade feathering propeller replacing a three-blade fixed prop can increase boat speed by three-quarter to a full knot. It offers better maneuvering at the dock, particularly in reverse, a clear advantage for props in apertures. (Efficiency of a two-blade folding prop in reverse is comparable to a fixed blade prop.) Some props even increase fuel efficiency, a good motive for buying one with the soaring fuel prices these days, especially for boats with limited fuel capacity. If you're more interested in boat speed than handling and on a budget, then you might choose a folding prop. Differences between feathering and folding props are mostly performance linked. Which one you choose depends on your boat and the type of sailing you do.

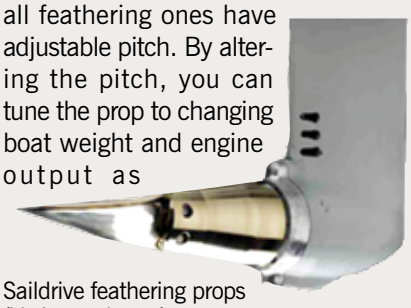
Performance Differences

Folding props are modified fixed props and like their cousins are essentially uni-directional devices. Twisted blades are concave on one side, convex on the other and cambered. Like a fixed prop, the blades have a non-adjustable pitch. This results in an efficient prop shape when moving forward but in reverse, a two-blade folding prop compares to an airfoil traveling backwards. With blades now dragging the boat backwards, efficiency is just slightly better than a fixed blade. One exception is the Gori three-blade prop. Blades swivel inside out so it has exactly the same profile in reverse as in forward. This eliminates prop walk and increases thrust. ("Fixed" propellers produce a paddlewheel affect in reverse that creates side force to pull the boat to one side, known as propwalk.) Folding props use centrifugal force to open and water flow to close. Controlling the prop under power in reverse calls for high engine rpm to take full advantage of the centrifugal force, typically more than a fixed prop. Under sail, folding props present the lowest drag profile of all props. With no protruding blades, you are less likely to catch undesirables, an important consideration when dodging crab pots in the Chesapeake.

A feathering prop is bi-directional. Blades appear flat and are symmetrical, thus creating the same profile in forward as reverse. While slightly less efficient in forward than a uni-directional propeller, probably the biggest advantage a feathering prop has over any other prop is a

Gori: Racing prop resembles a clamshell when folded and must be routinely checked for marine fouling, which could prevent blades from opening. Cruiser-racer models have a wider gap between the blades to ensure they open in reverse.

powerful reverse. Blades rotate through 180° to generate the same efficiency in forward and reverse, providing the best possible stopping power, control and steerage without excessive engine rpm. This reduces prop walk so the stern isn't pushed to port or starboard. Instead, the boat goes in the direction of the rudder just like it does in forward. If you've ever backed your boat down a narrow channel you can appreciate this value. Increased maneuverability is particularly nice on boats with scoop sterns or when docking stern-to. Unlike folding props, all feathering ones have adjustable pitch. By altering the pitch, you can tune the prop to changing boat weight and engine output as



Variprop

Saildrive feathering props (Variprop shown) typically have a longer hub and require a rubberized bushing to absorb the initial torque at start up.

needed. Under sail, a feathering prop aligns the blades behind the aperture or shaft log and, while drag is a little higher than a folding prop, it's still less than a fixed one. Feathering props operate on torque. Spin the shaft and within three-quarters of a turn it opens. Even with encrusted marine growth, it's still going to open. When shifting from forward to reverse gear, these props generate less shock load on the shaft than folding ones. Because a feathering prop minimizes prop walk, you'll have to adjust your boat handling skills for close quarters maneuvering to take full advantage of this benefit.

Variprop

Feathering blades align like a knife blade with the keel when under sail.

Of Hulls and Blades

Every folding and feathering prop is a mixture of cast aluminum, bronze, manganese and nickel alloys (i.e. Nibral, the name for nickel, bronze, aluminum) and with two to four blades. Models are available for shaft mounting or saildrives. Within the two types, folding or feathering, most models are similar when comparing drag (i.e., two blade versus two blade). Since the projected area of a prop pivots off the shaft angle, the steeper the angle, the more drag a folding propeller has, the flatter the angle, the more drag a feathering prop has. On a boat with a prop aperture, your only choice may be a feathering prop if the fore and aft space is too tight for a folding prop.

Blade number relates to area ratio, engine horsepower and gear ratio. On a cruising boat, a two-blade prop is as a rule reserved for slower, lower horsepower engines; larger engines need a three-blade prop as do heavy displacement and full-keel boats that benefit from better maneuverability and increased acceleration, particularly in strong winds and rough seas. If racing is your primary interest, you'd likely select a two-blade prop. (Of course, the fewer the blades, the cheaper the price.) Three blades are recommended for aperture mounting so you can swing a smaller diameter propeller. For example: A 30hp engine with a 2:1 reduction gearbox ratio requires a 16" (41cm), three-blade prop, which fits nicely in the cutout and is just under the suggested

Quick Facts: Folding vs. Feathering

Propellers, like most things in life, are a compromise. There is no single propeller type that would be the best for all sailing yachts. Below is a list of the most important variables you need to consider. Use this as a comparison tool when propeller shopping.

Parameter	Folding	Feathering
Cost	Less expensive	More expensive
Boat types	Racers, cruiser-racers	Pure cruisers, and deep-water yachts
Saildrive or shaft	Saildrive	Normal prop shaft
Forward thrust	Best provided blades are correctly designed	Slightly less than the best folding props
Reverse Thrust	Generally lower with exceptions (see article)	Same thrust as in forward reverse pitch if adjustable can be reduced independently to eliminate prop walk in reverse
Prop walk	Same as a fixed prop	Minimal to zero provided the prop's reverse pitch can be independently adjusted
Adjustable pitch	Fixed pitch in forward and reverse	Most are adjustable
Fits in apertures	Not always as requires space for blades to swing aft to fold	Not always due to hub length. Variprop might due to short hub
Maintenance	Keep it clean. No lubrication needed. May fail to open fully when gears are loaded with barnacles. Routine zinc inspection and replacement. Slipstream requires new bearings every 10 years.	Routine lubrication of bearings and/or gears. This can be done underwater on models with grease fittings. Routine zinc inspection and replacement.

12% to 15% tip clearance. A comparable two-blade prop requires an 18" (46cm) diameter prop, much too large for the aperture.

Spin Doctoring

Between the key suppliers, these props are all competitively priced and similar in function. The differences are minor; each supplier offers a twist on a similar theme.

As mentioned above, all feathering props have adjustable pitch and adjustment mechanisms differ between manufacturers. Italian-made J-Prop has an easy system that uses an external, graduated and notched cone. "This provides a baseline so you can compare performance notch by notch as you tune the prop to the boat in terms of speed and comfort," says Willem Boon of J Prop (800/300-3113; www.bomon.com). Autoprop from the U.K. is the only feathering propeller with automatic variable pitch. Pitch angle changes according to engine rpm to create the most favorable thrust based on shaft rpm and water flow. Says Steve Armitage of AB Marine (401/847-7960; www.AB-marine.com), which also handles Gori: "It will not go any faster or perform any better than any other propeller at the designed maximum engine rpm but at cruising rpm it's much faster. Because of the variable pitch, it has a fuel efficiency that is 25% better than any low-drag prop." Another Italian product, Max-Prop, has been on the water since the '70s and is distributed by PYI (800/523-7558; www.pyiinc.com). Adjusting pitch requires disassembling the prop, setting it to a given value and reassembling. "A 17" (43cm) Max-Prop, for example, is adjustable anywhere from 5.5" to 18.5" (14cm to 47cm) of pitch so you've got a broad range to work within, though the most common setting is around 11" (29cm) of pitch," explains Fred Hutchinson. German built Variprop has a patented, easily accessible external bolt with lock-

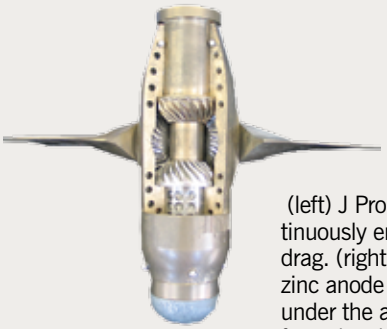
PYI

Nearly flat and symmetrical blade profile of this Max-Prop is typical of all feathering props.

For a 15% premium, you can have a Max-Prop V.P. feathering prop with an external pitch adjustment on the hub.

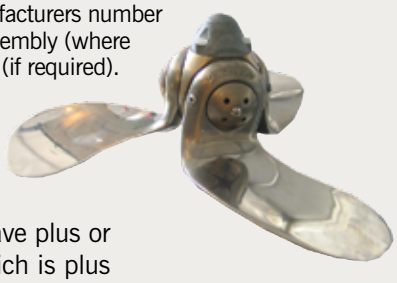
Gori three-blade folding propellers do not produce prop walk in reverse, a common problem with two-blade folding and fixed props.

To adjust pitch on a J-Prop, simply pull the cone and rotate the hub. Graduated notches provide highly visible reference for fine-tuning.



(left) J Prop's helical gears are continuously engaged, which reduces drag. (right) Using an Allen key, the zinc anode is simple to replace. A nut under the anode removes the prop from the shaft without a prop puller.

Autoprop and other manufacturers number the blades to facilitate assembly (where needed) and replacement (if required).

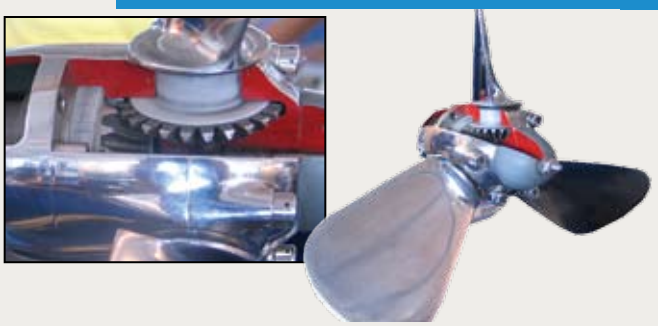


nut for adjusting pitch to your sailing requirements. "Adjustments are centered so you have plus or minus 3° of pitch, which is plus or minus 600 rpm engine correction," says Michael Adler (the "Adler" in the Adler Barbour Cold Machine) of Variprop USA (www.varipropusa.com). "When you receive the prop, it's correctly pitched for your boat. Years later, when you load the boat for a world cruise and the boot top disappears 4" (10cm) below the designed waterline, you just turn the screw to reduce forward pitch." Variprop also features a built-in braking system to eliminate the familiar clanking sound when going from forward to reverse.

Better known as racing props, Martec (562/435-4494; www.martec-props.com) folding props have equipped racing boats since 1964. The only prop made in the U.S., newer designs don't suffer from the non-opening problems of the originals. A slim hub design offers the least drag. Also handled

Variprop

Like all feathering props, blades on the Variprop rotate through 180° to generate the same thrust in (left) forward and (right) reverse.



Autostream feathering props have a Delrin bearing at all wear points to eliminate wearing away of metal gears. Suggested replacement is every 10 years. Pitch on this prop is adjustable in reverse. Setting reverse pitch slightly flatter gives better throttle response in reverse.

by Martec are Autostream feathering props and Slipstream folding props. Built in Australia, they are the only stainless-steel low-drag props. Autostream props have an external adjusting system that allows forward and reverse pitch corrections independently from each other. Danish-built Gori props are available with both two and three blades. The three-blade prop has the same blade shape in reverse as in forward. This eliminates the poor performance in reverse common to all two-blade folding or fixed props. "This propeller has all the flat blade, feathering prop advantages, low drag and excellent reverse thrust," says Armitage. Also from Denmark are two and three-blade Flex-O-Fold props (781/631-3190; www.flexofold.com). These feature urethane shock absorbers to reduce opening stress.

Most prop suppliers have a database of boats, engine horsepowers, gearbox ratios and the corresponding propellers. This removes any anonymity when purchasing a low-drag prop. If you have a custom or one-off boat, the supplier needs to know the boat's displacement, waterline length, beam and engine make, model, horsepower, rpm, transmission and reduction gear ratios, shaft diameter, either SAE or metric, and blade tip clearance if in an aperture. You'll find information and spec sheets on most manufacturers' websites.

Installation

Surely the biggest headache when retrofitting any low-drag prop is removing the old one. Corrosion of the prop to the shaft, key to the shaft, etc., can extend this job into an afternoon of banging and cursing. Cutting the shaft to reduce taper length, mainly on American-built boats, to accommodate the new hub also complicates the job. (This is necessary for most feathering and folding props except Autoprop and Variprop.) Some props also require assembling; J Prop and Variprop do not.

Still not convinced? Ask owners of boats with low-drag props. Ask the boatbuilder and consider this paradigm. You own a 40' (12m) boat sailing to Hawaii from San Francisco Bay. On average your low-drag prop increases sailing speed by 15% or almost a full knot. You'll reach your destination one and a half days sooner than you would if you had a fixed prop. That's a lot of extra time in paradise.

About the author: Jan Mundy is editor of DIY.

PROJECTS

BE SEEN AT NIGHT

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

9

The safety factor of being visible in an anchorage is only one reason for displaying an anchor light. Here's an automatic LED anchor light you can build from a few easily obtainable and relatively low-cost parts, complete with the circuit theory for those who just have to know how something works.

By Harry Hungate

The author's anchor light in service aboard "Cormorant," beautifully illuminated with the parliament house at Port Vila, Vanuatu (in the background).

Take a look around your anchorage some evening and note how many boats don't display an anchor light. Each boat owner probably has a rationale for not keeping the light lit: light consumes too much power; forgot to turn it on; light doesn't work; it's not legally required in this anchorage, etc. Even though each excuse may be truthful, an anchor light not only makes it easier for others to avoid your boat at night, it also can help you find your own boat when returning from shore on a dark night. With the recent availability and affordability of high intensity light-emitting diodes (LEDs), you can build your own automatic anchor light. This fully automatic light offers very long life and extremely low power consumption. You can convert an existing anchor light or build a new one from scratch and enjoy the bragging rights.

Look over the list of components and suppliers, round up the parts and get to work. The simple circuit on page 52 provides some guidance for those of you who are electronically challenged. If your soldering skills need developing, practice on a few pieces of wire before using up your electronic components. Concentrate on using as little solder and heat as possible while making a good bright joint. I suggest that you purchase enough parts to build two or more lights. The extra parts will be handy if you make a mistake building your first light and, if all goes well, the spare fixture that you build will make a great gift to a boating friend.

Housing Construction

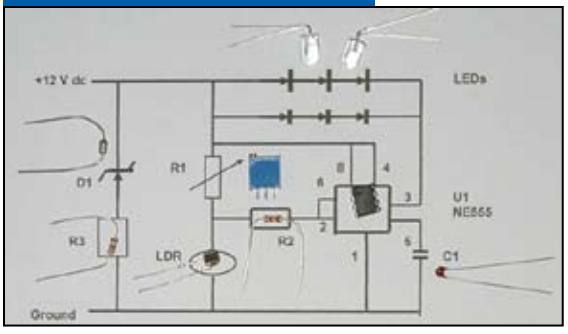
Referring to **Figure 1**, begin by laying out the parts on the schematic to gain familiarity with them. Carefully note the terminals on R1 (the potentiometer), LEDs and U1 (integrated circuit), as you will need to identify these without error. Then completely coat LDR (calcium sulphide photocell) with clear epoxy to seal out moisture. It's not waterproof and is very susceptible to saltwater corrosion. Mix up enough epoxy to fix the small eyebolt into the top of the Fresnel lens or anchor housing. [Ed: A glass canning jar makes a good substitute for the Fresnel lens.] The top of the Fresnel lens may be quite thin and a puddle of epoxy around the eyebolt (on the inside of the lens) provides extra strength. Set both aside while the epoxy cures.

Adapt the PVC pipe cap base to the Fresnel lens by sanding or grinding down the threads in the pipe cap. A rotary (e.g., Dremel) tool makes quick work of this but go slowly and make trial fits to avoid removing too much. The goal is to get a nice snug friction fit so no fasteners are required to hold the Fresnel lens and pipe cap base together. If the fit is loose, an O-ring or a wrap or two of vinyl electrical tape on the threads of the Fresnel lens will restore the snug fit. Drill a hole in the center of the pipe cap base or lowest part of the anchor light housing for the power cable. Make the hole slightly larger than the cable to allow condensed moisture to escape. It's impossible to make the housing watertight, so don't even try, just let it breathe.

Electrical Assembly

Prepare the power cable (Raymarine SeaTalk cable or marine grade two-conductor, stranded tinned cable of 18 to 20 AWG) by installing a Marinco or other good quality 12-volt power plug on one end. (If you are using Raymarine SeaTalk cable make the

FIGURE 1



The electronic components on the schematic. This drawing must be followed without exception!

The author soldering the components together.

red wire positive and the yellow wire negative and trim the bare wire flush with the outer insulation.) Without fail, put a .25 (6mm) amp fuse in the circuit, either in the power plug or an in-line fuse. Then strip off 2" (5mm) of outer insulation from the bitter end of the power cable and trim the bare wire out of the way. Strip off about 1/4" (6mm) of insulation and tin the ends of the two conductors to prepare them for soldering to the completed circuit board. Thread the bitter end of the power cable through the hole in the pipe cap base and place a nylon wire tie around the outer insulation of the power cable about 3" (76mm) from the bitter end to serve as a strain relief. Clearly mark the positive lead. Set the power cable and pipe cap base aside for now.

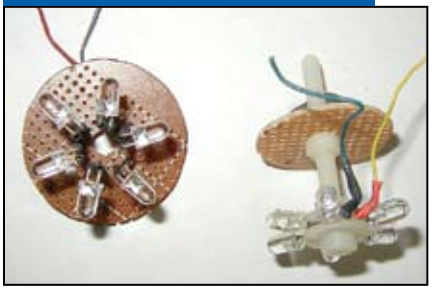
Cut out a circuit board to fit inside the Fresnel lens. This is very easy to do with a holesaw, especially an adjustable one. Smooth the edges with sandpaper and modify as necessary to fit your anchor light housing. Cut out a second circuit board about 3/4" by 7/8" (19mm by 22mm) for the integrated circuit U1.

The T1 3/4" (5mm) diameter white LEDs of 5,000 millicandelas (mcd) or more are arranged in a circle of six LEDs to provide acceptable illumination. Most high-intensity, white LEDs have a forward voltage drop (Vf) of 4 volts, so two parallel circuits of three LEDs each are required. The idea is to establish sufficient supply voltage to provide rated Vf to each LED. Under-voltage means decreased light and over-voltage means shorter LED life.

Mounting LEDs

There are two ways to mount the LEDs. Bend the leads 90° and solder the leads directly to the circuit board or a neater and easier way is to use a small nylon bolt as a center post and clamp the LED leads between two nylon washers. This method provides for a more precise positioning of the LEDs at the center of focus of the Fresnel lens, thus maximizing its effective illumination. As the nylon bolt may be hard to find (hobby shops or acrylics suppliers usually have them), both methods are explained.

FIGURE 2



(left) Method 1: All components except the Zener diode and R3 are mounted on the top of the circuit boards. The copper side faces down and the component leads are soldered to the copper pads. Your finished product should look reasonably close to this. (right) Method 2: Nylon bolt mounting method for LEDs.

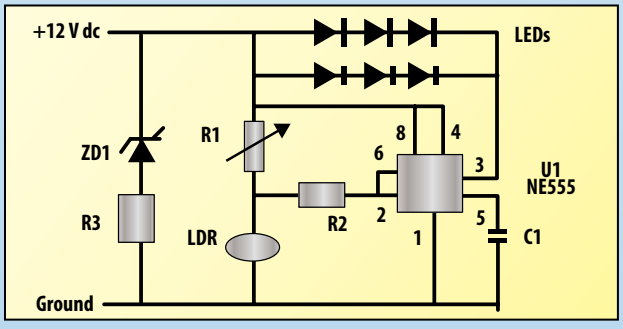
Method 1 involves soldering the LED leads directly to the circuit board. As you are building two series circuits of three LEDs each, remember to bend the leads of three LEDs to the left and three to the right as shown in **Figure 1**. The positive lead (anode) of each LED is easily identified, as it's slightly longer than the negative lead (cathode) and the lens has a flat side next to the cathode. Prepare the LEDs as in **Figure 2** by bending the

Circuit Theory

Skip this if you really don't want to know but it's good to refer to for trouble-shooting later on. Because an LED produces a very narrow beam of light (between 13° and 20°), a minimum of six is necessary to fully illuminate the Fresnel lens.

Voltage calculations are straightforward. Your boat's power is about 12.5 volt DC. Subtract 0.5 volts loss across U1, leaving 12 volts for the LEDs. The circuit arrangement is determined by dividing 12 volts by the specified forward voltage drop (Vf) of one LED, which is provided with the specification sheet that comes with the LED. If your LED's Vf is 4 volts, then two parallel circuits of three LEDs each are required without the need for an energy-wasting voltage regulator or series-dropping resistor. The trim potentiometer (R1) allows you to adjust the on-off point to suit your individual preference and to compensate for the very wide variation in values of the several types of light dependent resistor (photocell or LDR) that are available. The LDR varies in resistance from several hundred ohms or less in bright daylight to perhaps as high as 25 megaohms in total darkness. This ability to vary in resistance from light to dark is the key to the operation of this simple light-activated switch.

On the schematic below, locate R1 and LDR, which form a voltage divider. Any voltage from supply voltage to 0 volts can be obtained at the junction of these two resistors by changing their values. Thus, the voltage at the center of the voltage divider is dependent on the value of R1 (fixed) and on the amount of light falling on LDR (variable) and this voltage is connected to pin 2 (trigger) of U1 through the current limiting resistor R2. In daylight, LDR has a very low resistance (much lower than R1), so the voltage developed at the center of the voltage divider is too low to turn on U1. The task of the builder is to adjust R1 to a value sufficient to establish two-thirds of supply voltage (between 8 and 9 volts) on pin 2 of U1 when the sun goes down. Now, a word about U1. A rugged device, it's an NE555 integrated circuit most often used as a timer. It's also a handy solid-state switch with the ability to source or sink up to 200 milliamps with a working voltage varying between 5 and 15 volts; it requires only a microamp or two on pin 2 to turn it on or off. The switching voltage is based on a ratio of supply voltage (on above two-thirds and off below one-third supply voltage), so supply voltage variations have no effect on the switch point. R2 protects U1 from overcurrent and C1 protects U1 from nuisance switching caused by noise on the power leads. As the timer function is not used, there is no connection to pin 7. The Zener diode ZD1 and R3 across the power cable leads limit the supply voltage to 13 volts and thus protect the LEDs from damaging overvoltage. I learned this the hard way!



Note: Pin locations on U1 are shown for drawing clarity only. Refer to the specification sheet accompanying U1 for actual pin locations.

leads at right angles to the lens and then slip a piece of heat-shrink insulation over each lead. The length of the heat-shrink insulation should be just long enough to position the LED at the center of the Fresnel lens while leaving about 1/8" (3mm) of bare lead to solder to the circuit board. Trial fit one LED to obtain the correct spacing to the center of the Fresnel lens. Connect the LEDs in two series circuits of three LEDs each, negative of one to the positive of its neighbor, spaced equally around the circle. The positive leads of the first LEDs of each circuit are joined, as are the last two negative leads of each circuit. Solder the LEDs in place at this time. A neat trick is to solder the positive lead of each LED to the circuit board first and then to solder the shorter negative lead to its longer positive neighbor. Be very careful when soldering the LEDs as excessive heat will destroy them. A heat sink of wet tissue applied to the LED lens while soldering helps to prevent excess heat from damaging them.

Method 2 uses a nylon bolt center post. As in Method 1, two series circuits of three LEDs each are arranged in a tight circle, the diameter of which is determined by the inside diameter of the Fresnel lens. The LED leads must be cut off short enough to clear the nylon post. As the flat spot on the lens can identify the LED cathode, maintaining correct polarity is easily accomplished. Use a small piece of modeling clay to good advantage in holding the LEDs in position when soldering the leads together. Again, use a piece of wet tissue on the lens to help prevent excessive heat from damaging the LEDs when applying solder to the leads. This is especially important in this method as the leads are very short. Solder a connecting wire to the two joined anodes for the positive power lead and a connecting wire to the two joined cathodes for the negative power lead. Slip two nylon washers up to the head of the nylon bolt, follow with one nylon nut and carefully arrange the LEDs evenly spaced in a circle between the two washers. Tighten the nut sufficiently to hold the LEDs in place and trial fit the assembly into the Fresnel lens. Adjust the LEDs as necessary. Use two nuts to fasten the nylon bolt into the center of the round circuit board and adjust the nuts to position the LEDs precisely at the center of focus of the Fresnel lens.

The potentiometer R1 has three terminals: high, wiper and low. Connect your ohmmeter to low (the terminal nearest the adjusting screw) and wiper (the center terminal) and adjust R1 to midpoint (25k ohms). Note which direction gives increased or decreased resistance. This way you will know which way to turn the adjustment screw to increase or decrease resistance; it's usually clockwise to increase the resistance. Write it down now as you likely won't remember it later! Position R1 on the circuit board such that an LED does not block screwdriver access to the adjustment screw and connect high to wiper. A short jumper wire from the low terminal of R1 to the positive leads of the first LEDs will be required. Solder R1 and the jumper wire in place now.

When the epoxy has hardened on the LDR, slip a piece of heat-shrink insulation over each lead and install the LDR

facing out but close to the circuit board. Remember to use a piece of wet tissue as a heat sink when soldering the leads.

Carefully determine correct polarity of the power cable and solder its two leads to the circuit board. For this connection, remember that it's positive-to-positive (anode) and negative-to-negative (cathode). Again, the LEDs are polarity sensitive, so make sure that you have this correct.

While not essential to the operation of the circuit, if there is the slightest possibility that your anchor light will receive in excess of 13 volts (such as when charging your batteries), install a 13–volt, 1 watt, Zener diode ZD1 in series with a 220 ohm, 1 watt, resistor R3 across the two power cable leads at the circuit board with the anode to negative and cathode (the end with the band) to positive. Refer to the schematic in **Figure 1**. Remember, as a Zener diode operates in breakdown mode, it's installed "backwards." The Zener diode and the resistor can be soldered to the bottom of the circuit board for convenience. Use heat shrink insulation on the leads to prevent the occurrence of short circuits. This is the over-voltage protection — the Zener diode will only conduct when the voltage at the circuit board exceeds 13 volts and the resistor will limit the current so the quarter amp fuse will not blow. This will protect your LEDs from damage by limiting the supply voltage to them at 13 volts.

Again referring to **Figures 1** and **2**, install the socket for U1 on the small square circuit board. Be careful to insert all eight pins through the holes in the circuit board, leaving a row of holes on all four sides of the socket. With the board and socket held such that the notch in the socket is up (in the 12:00 position), install the interconnecting wires and jumpers, R2 and C1. Color coding of the interconnecting wires greatly assists in creating an error-free circuit. Make up your own colors or follow my colors in the next paragraph. Route the jumper wires around the socket so as not to interfere with the installation of U1. Keep the jumper wires as short as possible and route them neatly. Note that pin 1 is on the upper left corner, pin 4 on the lower left corner, pin 5 on the lower right corner, and pin 8 on the upper right corner, across the notch from pin 1. Complete all the solder connections to both boards at this time. Do not install U1 in its socket at this time.

Wiring Preflight

Double-check your completed wiring. Even if you are quite competent in electrical assembly, it pays to have someone else check your work as there is no such thing as a second chance in electronics. Let's review the connections one more time. Check each one off as you complete it.

First, there must be a .25 (6mm) amp fuse in the power cable or power plug. Positive lead (red) of power cable connects to positive leads (anodes) of first LED in each circuit, to low terminal of potentiometer R1 and to the red wire going to pin 8 of U1. R1 wiper and high terminals connect to one lead of LDR and to the blue wire going to resistor R2. Resistor R2 connects the blue wire to pin 2 of U1. Grey wire to pin 3 of U1 connects to negative leads (cathodes) of last LED in each circuit. Green wire to pin 1 of U1 connects to the other lead of LDR and to the negative lead of the power cable. Capacitor

Component Sources

Here are some sources and catalog numbers for the electronic parts for those readers based in the South Pacific. If you are not so familiar with electronic parts, the store personnel or a ham radio operator friend can usually be relied upon to guide you to the correct components. Some other sources are: www.radioshack.com, www.mouser.com, www.digikey.com, and www.gigaparts.com.

Item	Quantity	Dick Smith	Jaycar
R1 50k ohm multi-turn trim pot .5 watt	1	R1903	RT-4654
R2 220k ohm .25 watt resistor	1	R0632	RR-0624
R3 220 ohm 1 watt resistor	1	R1458	RR-2558
ZD1 13 volt 1 watt Zener diode	1	ZR-1413	
C1 0.1 microfarad Mylar capacitor	1	R2001	RG-5125
LDR (CdS photocell)	1	Z4801	RD-3480
LEDs (white) 5mm (T1 3/4) 5,600 mcd	6	Z3981	ZD1780
U1 NE555 timer integrated circuit	1	Z6145	ZL-3555
8-pin DIP socket for U1	1	P4080	PI-6500
Circuit board, perforated, copper clad one side	1	H5607	HP-9552
Heat-shrink insulation 1/16" (1.5mm)	1' (3.5cm)		
Nylon bolt, 3/16" x 1-1/2" (5mm x 38mm)	1		
Nylon washers	2		
Nylon nuts	3		
Resin core electronic solder	1 roll		
Clear epoxy resin	1 tube		
Interconnect wire 20 to 22 AWG, 4 colors or more, 6" (15cm)	1 lot	W4010	WH-3025

(An old computer parallel or serial port cable is an excellent source of interconnect wire)

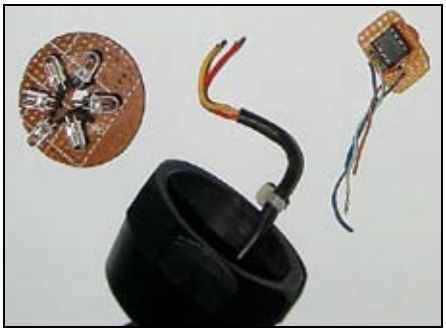
[Ed: For readers that are electrical-challenged Davis offers the Mega-Light, a self-contained two LED light with Fresnel lens that uses .11 amp of power and has a photocell that automatically switches the light on at dusk and off at dawn.]

The remaining items can be found in a marine store and the PVC pipe cap from a hardware or plumbing supply.

Fresnel lens (Perko makes a good plastic one)
Base: 1-1/2" (38mm) PVC or ABS threaded pipe cap
Small eyebolt and a nylon wire tie
Power cable: Raymarine SeaTalk cable or any good two conductor stranded tinned cable 18 to 20 AWG of length to suit your application.
Power plug: Marinco 12 volt or equivalent with .25 amp fuse

Or purchase a ready-made anchor light assembly.

C1 connects between pin 5 and pin 1 of U1; a short jumper wire aids in making this connection. The LEDs are arranged in two series circuits of three LEDs each, connected negative (cathode) to positive (anode) of its neighbor. A jumper wire connects between pin 8 and pin 4 of U1 and another jumper wire connects between pin 2 and pin 6 of U1. There is nothing connected to pin 7 of U1 as the timer function is not used. Lastly, a 13-volt, 1-watt Zener diode ZD1 and a 220-ohm, 1-watt resistor R3 connects across the power cable leads at the circuit board. The negative end (cathode) of the Zener diode connects to the positive power lead (red) and the positive end (anode) connects to the 220-ohm resistor, which connects to the negative power lead.



Assembled LED array (left), integrated circuit U1 (right) and (bottom) PVC pipe cap with power cable.

Auto Fine Tuning

When you and your circuit reviewer are certain that all connections have been made correctly, apply power to the circuit. With a voltmeter, measure the voltage between the positive and negative leads of the power cable. It should measure positive 12 volts or more (boat's DC power). Then measure between pin 2 and pin 1 of U1. Adjust R1 to obtain between 5 and 8 volts as you move the LDR between light and dark. If you're not getting those readings, disconnect the power and go over the wiring again until you find and correct your error. When you are sure that everything is perfect, disconnect the power and install U1 in its socket. Carefully install the pins of U1 as they are easily bent. Make double sure that U1 is fully inserted in the socket and the mark near pin 1 is closest to the notch on the socket. Warning: Do not look directly into the LEDs — the light is intense enough to damage your eyes!

Apply power again and measure the voltage between pin 2 and pin 1 again. Adjust R1 until approximately 9 volts are present and satisfactory switching occurs. Power up. If the light turns on, increase the resistance until the light turns off (in the daylight) or decrease the resistance until the light turns on (in the dark). Be patient and turn the adjusting screw on R1 a quarter turn at a time, alternating the anchor light between light and dark (put your hand over it) until you are happy with it. Do not decrease R1 below approximately 2k ohms, as damage to it is very likely.

When satisfied with the operation of the light, make a final alignment of the LEDs. They should be equally spaced around the circle, exactly at the center of focus of the Fresnel lens and at right angles to the circuit board to insure optimum distribution of their light. Coil the 3" (75mm) of power cable up into the pipe cap base, insert the circuit boards into the

(continues on page 57)

(continued from page 55)
lens and the lens into the cap. The coiled power cable acts as a spring to hold the circuit board with the LEDs in position. The nylon wire tie on the power cable serves as a strain relief to prevent the power cable from pulling out of the pipe cap base and ruining your hard work.

Light Upgrades

Your new anchor light can remain powered up continuously, as the current drain in daylight is only a few microamps and, at night, the LEDs consume a miserly 60 milliamps total (that's only 6/100 of an amp). Finally, make a distance check on a dark night to admire your work and to confirm that youranchor light meets the COLREGS visibility requirement of 2 nautical miles. If the light circuit quits working at some time in the future, try replacing LDR first, as it's more susceptible to saltwater damage than the other components. If, in spite of your best efforts, the LEDs don't seem to be fully illuminated, measure the voltage drop across each individual LED. If the voltages are uniformly low, replace U1, as it may be damaged. If the voltage drop across one LED differs greatly from the others, replace it. Finally, for long-term corrosion protection, spray a seal coat of CRC Soft Seal on the circuitry. Be careful not to coat the LEDs and the LDR.

This circuit is very robust and dependable. My prototype has given trouble-free service for over a year. When we are at a marina, we often hang the anchor light in the cockpit to serve as a night light. The number of LEDs can be safely doubled to make a brighter light, as U1 is rated at 200 milliamps. Simply stack a second LED array below the first. Safe anchoring.

— Harry Hungate and his wife Jane quit their jobs in 1997, moved aboard a Corbin 39 and left Annapolis, Maryland for points south. Eight years later finds them in Whangarei, New Zealand, waiting out the southwestern Pacific cyclone season.

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Fixing a Delaminated Bulkhead

Water damage from a leaking chainplate threatened to separate the chainplate from its attachment bulkhead and the time had come to stem the tide and repair the delaminated bulkhead and wet deck adjacent to the chainplate. [Refer to DIY 2004-#4 issue for more on this topic.]

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Story and Photos by Sandra Turney

Years of service combined with a cavalier attitude toward keeping the aft chainplates for the standing rigging from leaking had finally taken a toll on the after deck where the chainplates pass through on their way to their attachments to the aft cabin bulkheads. It was now time to pay the piper and make the needed and deserved repairs to "Santana," our Chris Craft 35 Caribbean ketch. We were faced with four major steps in the repair process that included removing and replacing the chainplate, fixing the delaminated bulkhead, repairing the wet deck surrounding the chainplate passage below and the reassembly to restore the standing rigging to serviceability.

I had planned ahead and purchased all the supplies necessary to fix the bulkhead in Brunswick, Georgia, before journeying to Luperón in the Dominican Republic for the hurricane season. The list of materials was long: West System epoxy resin and hardener, syringes, fiberglass cloth, mat, woven roving, a laminating roller, acetone, scissors (to cut dry and wet fiberglass), black marker, tape, waxed paper, stir sticks, yogurt containers for mixing, plastic squeegee, latex gloves, Dremel tool with sander and cutting wheels, drill and bits, 12-volt vacuum, rags, paper towels, work clothes, paint, brushes, hand cleaner and 3M 4200 for caulking. It turned out that everything was available in the DR but the 4200.

The biggest step in the project was to fix the delaminated wood. I originally thought of cutting out the rotten area, scarfing in a new piece of wood and covering with fiberglass. Unfortunately, this would have ruined the faux wood grain veneer that covered the aft cabin "joinery" (that '70s look) and that would have turned one job into two. Injecting the delaminated wood with epoxy seemed the only way but gravity was against me and I knew the resin would flow down the vertical bulkhead. Certainly not as easy as injecting epoxy between two horizontal laminates to fix a soft deck. Luckily, we met another Chris-Craft 35 Caribbean ketch owner in the Bahamas that had the same problem. He had fixed this bulkhead by injecting epoxy into the delaminated wood. I decided to do the same but I would have to poke around once the chainplate had been removed to plan my repair strategy.

Tapping ("percussion sounding" in marine surveyor lingo) on plywood helped to determine the extent of the delaminated area of the port bulkhead.

Plywood Prep

The port side structure appeared to be in a more advanced state of decay and it was the more difficult access due to the obstruction of the refrigerator compressor installation. After removing all the gear from the lazerette, turning off the compressor and covering it with a plastic bag, I removed the stay from the chainplate and the chainplate from the bulkhead. I knew that the deck around the chainplate was wet and found the plywood core disintegrated to about 1-1/2" (38mm) extending out from the chainplate bolthole. A previous deck repair (by injecting epoxy into the soft deck) had stemmed most of the plywood degradation. I scraped out all the rotten plywood within reach and let the deck dry out for three days in the hot tropical sun, while picking at the wood everyday with a small chisel to loosen and remove any plywood residues.

While the deck was drying, I worked on the bulkhead. The fiberglass tabbing at the top had obviously delaminated from the bulkhead and I could easily shove a screwdriver underneath it. The chainplate and bolts were bedded at the bulkhead with sealant; a method I don't like (more on this later). I tapped on the bulkhead with the handle of my chisel (I don't have a nice resin mallet like surveyors have) to determine what areas of the wood were delaminated. A dull thud usually indicates delamination and wet core; a bright solid sound suggests a good bond and healthy wood. After marking a line around the area suspected of delamination, I peeled off the painted veneer (easily by hand) to examine the damage and determine my next step.

Following the veneer pull off, the first layer (one of five) of the plywood came off easily by hand and mostly disintegrated at the touch. Nothing of this layer could be saved. Due to the condition of the first layer, I knew I had to remove the old tabbing that held the bulkhead to the deck. I covered the compressor opening in the bulkhead with waxpaper and taped over any other holes to control the dust that might intrude into the aft cabin as I used the Dremel with cutting wheel to cut and grind off the old tabbing. A small sanding bit was used to grind the edges of delaminated plywood under the tabbing and to rough up the surfaces, including the underside of the deck to prepare for new fiberglass. I then drilled four 1/8" (3mm) holes into the bulkhead, being careful not to go through to the faux wood grain veneer, to see whether the epoxy resin injection would work with the four remaining layers of plywood. I mixed only one pump of West System 105 resin with one

pump of 207 hardener and then sucked up the liquid with my syringe. You can also pour the liquid into the syringe but I find this very messy. I injected the wood with the epoxy but I was unsure whether it had penetrated into the last layer of plywood.

At this point, I removed the next two layers of plywood by cutting the ply near the edges of the delaminated area. These layers came off in larger pieces that I saved for later use. I noted that most of the injected epoxy test had reached the fourth layer. I suppose I could have left the four layers together and injected epoxy but I didn't know this before cutting out the two layers. I drilled numerous 1/8" (3mm) holes into the remaining plywood about 1-1/2" to 2" (38mm to 50mm) apart, again, careful not to puncture the veneer on the other side. I used extra waxpaper to protect areas from dripping resin.

Curing in Epoxy

I mixed epoxy in small batches of about two pumps each of the resin and hardener so that I had at least 15 minutes of working time in the 100F (37.7C) heat. I slowly injected the epoxy starting at the top and working from right to left. I injected one hole until the epoxy oozed from another hole and I continued this until I was convinced all wood was saturated.

After saturation, the next step was to bond the larger pieces of plywood from the third and second ply layers back onto the bulkhead. I used four pumps of the 105 resin but this time, switched to 206 hardener adding colloidal silica and microballoons to thicken. Working time is much less with this hardener so it was necessary to mix smaller batches. This goop has the consistency of ketchup, so it squeezed into all the holes, cracks and crevices easily with a flat plastic squeegee (available at paint stores). A thick layer of goop went on both the bulkhead and the back of the plywood piece on each layer and I pressed the wood onto the bulkhead. After both layers were secured, I used screws to hold the upper layers together and smoothed out the epoxy to fill any holes in preparation for fiberglassing; clamps held the bottom layer. Fillets (pronounced fil'it) were created at the corner joint where the bulkhead met the deck to provide a smooth curved surface for the fiberglass. Increasing the surface area structurally reinforces the bond. All was then left to cure.

Ply layers epoxy glued back onto the bulkhead.

No matter how smoothly I try to spread the thickened resin there are always sharp bits protruding. A regular hand sander worked well to smooth the large surfaces and I used the large sanding accessory on the Dremel on the fillet. After vacuuming and a wipe-down with acetone, the bulkhead was ready to fiberglass.

Priming the Glass

To make things easy, I created a paper template of the area I needed to fill in with fiberglass. The outline was traced onto the fiberglass pieces and cut: two cloth, two mat, one woven roving and one extra big piece of cloth to cover the edges of my working area. I also had two small pieces of mat ready to place where the chainplate would go in case the fiberglass was not as thick as the original 3/4" (19mm) bulkhead. The width needed to be the same or the chainplate would not fit properly.

Just before fiberglassing, I checked to make sure I have everything ready: cover the area with waxed paper and tape to protect from dripping epoxy; epoxy resin and hardener within arm's reach; fiberglass pieces lying ready; a little acetone poured into a yogurt tub; paper towels ripped off from the roll; all-metal scissors to cut off bits of wet fiberglass; laminating roller to remove air bubbles and help the resin soak into the material; stir stick; a cheap bristle brush to apply the mixed epoxy; many latex gloves; respirator with an organic vapor cartridge to protect my lungs (and brain) from the toxic fumes; safety goggles to protect my eyes from splash; a long-sleeved shirt and pants to protect my arms and legs from epoxy; and resin removing hand cleaner ready at the sink (never use solvents to remove any coating from your skin). I make sure I have everything I need so I don't have to strip off my gloves and go looking for something as I trail fiberglass strands throughout the boat while my new pot of epoxy is kicking.

I always orient the fiberglass layers from the inside out with the top layer next to the bulkhead so that I can just grab the top piece and keep on working without fiddling with cloth and my sticky gloves. The pieces were placed on the bulkhead in this order: cloth, mat, woven roving, mat, cloth, small pieces of mat (if necessary) and then the large piece of cloth over the edges. Using fiberglass cloth on the outside gives the bulkhead a finished look and absorbs any excess epoxy.

Putting down the Layers

Once ready, I consider the tropical heat and use only two pumps 105 resin to two pumps 206 hardener to start. I'm always cautious at the beginning because I never know how much epoxy I'll need to cover the area and I don't want the epoxy to kickoff in the pot before I use it — a waste of product and money. I brush a coat of unthickened epoxy on the bulkhead and then lay the first layer of cloth over it using my hands and sometimes a brush to put it in position. It sticks to the vertical bulkhead easily if there is enough epoxy brushed on. Having the cloth stick to the overhead area, however, takes patience and sometimes more epoxy. I dip the brush into the epoxy and dab the brush into the fiberglass. I don't use a painting motion as this moves the fiberglass cloth out of place. Once the first piece is on, I wet out any white areas with the brush soaked with epoxy. This saturates the fiberglass and turns it translucent.

The second layer is mat. I place it on the bulkhead, dry, with my hands and it sticks nicely. This type of fiberglass contains a kind of sizing that combines all the random chopped strands into a sheet. Epoxy doesn't easily saturate the mat because of this sizing and I really work at wetting out this layer. After mixing up more epoxy, I push the epoxy-laden brush into the mat to saturate it. Once laden with epoxy, I use the laminating roller to remove the sizing and the air bubbles. While being rolled, the epoxy turns a creamy color as it picks up the sizing. The more rolling, the better to remove it and turn the mat translucent. [Ed: Fiberglass mat is not typically recommended for use with epoxy due to incompatibility with sizing in the fabric, and usage should be avoided, if possible.] The third layer is woven roving. The original tabbing included it and that is why I decided to put in a layer, as well as to add thickness to the bulkhead. After placing it on the bulkhead, I use the dip and push method with the brush to wet out the woven roving (mixing more epoxy when necessary) and then roll it until it becomes translucent. Sometimes the thick strands of the roving, near the edges, get caught in the roller and I have to cut the strands off with all-metal scissors, which I can dunk in acetone later without the fear of having the handles dissolve.

The next two layers are mat and cloth and are applied using the same techniques. After five layers are in place, I lay a straight edge over the chainplate area to see if the fiberglass is thick enough. I'm still not sure so I add two small pieces of mat over the chainplate area, using the same wetting and rolling techniques. I would rather have the area thicker rather than thinner; in this situation it's easier and faster to grind off a layer rather than add one.

Finally, I cover the entire area with the last layer of cloth, which covers the edges of the other layers of fiberglass. There

(left) Bulkhead sheathed in fiberglass and epoxy. (right) Wear a respirator with organic vapor cartridge when working with epoxy.

is usually enough epoxy in the last layer that I don't have to add much to wet out this final layer. After wiping up any major drips around the edges, I'm finished with this stage and have to wait until it cures. I immediately wash tools in acetone and clean up the work area.

Chainplate Resizing

Now it's time to fill the deck around the chainplate hole. I plugged the underside of the hole with duct tape and insert the waxpaper-wrapped chainplate into the hole. This method allows me to reduce the amount of epoxy used, the amount of sanding needed and helps position the chainplate where it was originally. I prop up the chainplate with duct tape and a chisel. Mixing one pump of resin with one pump of 206 hardener and thickening slightly with micro-balloons and colloidal silica, this mixture is sucked up with a syringe and squirted into the hole. I let the thickened epoxy set up slightly to plug the hole so that, when I add more epoxy, it doesn't leak down and create a bulge under the tape or leak out. After mixing a couple of pumps of epoxy, I fill the syringe and add enough epoxy to fill the hole.

Once epoxy in the deck has hardened, the waxpaper covered chainplate is easily removed. I can now work on sanding out the chainplate hole and fitting the chainplate to the bulkhead. I use a 3/8" (10mm) bit to drill through the solid epoxy at the bottom of the hole. I drill at each end of the hole and then connect the two holes by drilling more holes in the middle. I also use this bit to redrill the boltholes in the bulkhead using the outline of the holes from inside the aft cabin.

After puncturing through the epoxy, I use the Dremel with the small sanding drum to smooth out and clean up any rough edges in the hole, working from both the topsides and under deck. After fitting the chainplate in the hole and aligning it with the boltholes, I discover that there are too many layers of glass on the bulkhead. The two extra pieces were not needed; instead, I've created more work for myself. After a heavy sigh of regret over the unnecessary extra work, I trace the chainplate on the bulkhead. The Dremel's large sanding drum grinds off the unnecessary layers of fiberglass.

The chainplate fits better now but the hole needs more adjustment. My method is to dryfit the chainplate, sand the hole, fit again, sand the bulkhead and so on until I am satisfied with the alignment of the chainplate. I also cut and grind off the hardened, needle-sharp fiberglass strands that remain on the bulkhead. Hand sanding with 60-grit paper removes any hidden sharp edges. A wipe down with acetone and a

(top) Chainplate prepped for deck filling. Author used duct tape, a risky maneuver for, if it's left on for more than a few hours, it becomes a sticky mess. (bottom) Deck around chainplate filled with thickened resin and sanded.

layer of white EasyPoxy paint finish the bulkhead, which needs a day to dry.

Reassembly

The bulkhead and deck are now repaired but reassembly is needed to complete the portside. Tape surrounds the chainplate hole on deck to reduce the amount of mess when using 3M 4200 adhesive sealant. I've already cleaned the corrosion powder off the original aluminum backing plates and shined them up. I don't really like the idea of aluminum backing plates with stainless-steel chainplates and stainless bolts but the plates are original and have lasted for 30 years with only a little corrosion at the very top where water leaked in and sat on the metal behind the aft cabin molding.(Ed: It's a good idea to use an electrical barrier material between the aluminum and the stainless steel to prevent corrosion.)

(top) Bulkhead drilled and ready for chainplate mounting. (bottom left) After reattaching chainplate, bulkhead gets a new coat of white paint. (bottom right) Deck plate is thoroughly bedded in 3M 4200.

Corrosion at top of stainless-steel chainplate.

The point where the plate meets the deck receives a liberal dose of 4200 all around and then the plate fits in until it lines up with the chainplate holes. My helper inserts the bolts from the other side and I put on the original lock washers and nuts. On the bottom bolt, I reattach the copper bonding (for lighting protection) strip that has been polished to ensure good metal-to-metal contact. I quickly push more 4200 into the chainplate hole from the topside and then slip on the thin stainless plate that fits around the chainplate and then screw it in. My helper and I then tighten up the chainplate bolts, tightening each nut a bit at a time and going over them three or four times to ensure that all nuts are equally tight, evening distributing the chainplate load on the the bulkhead. It's almost impossible to clean up 4200 in this heat, as it becomes tack free in less than 10 minutes. I wait an hour for it to fully dry and then cut and peel off the excess. After a few hours of curing, I attach the backstay.

Sealant goes around only the top portion of the chainplate hole; not on the underside of the hole, not on the backside of the plate and not on the bolts as was done originally. If the chainplate is leaking you want to see the leak dribble down the chainplate so you can fix it sooner than later. This seems obvious enough but I've seen many chainplates completely sealed up from the bottom so that if there was a leak the water would seep into the deck core rather than through the deck.

Starboard bulkhead before repair. Note bonding strap attached to lower chainplate nut.

I'm quite satisfied with the result and consider the portside of the bulkhead stronger by removing the second and third plywood layers rather than just injecting them with epoxy. The bulkhead is certainly now stronger than new. Unfortunately, as I was finishing up, I broke a small copper end pipe on the compressor, which caused the R134a refrigerant to leak. Getting this fixed in Luperón was easier than we thought and I was now able to start fixing the starboard side of the bulkhead.

Repairing the starboard side was essentially the exact same process as used to repair the portside. The starboard bulkhead was easier to do than the port side because the delamination was not as extensive, although it had spread further out from chainplate. I also didn't have the compressor in the way.

This involved: removing the stay and chainplate; scraping out all the wet plywood core around the chainplate and letting it dry in the tropical sun; removing old tabbing from the bulkhead; sanding areas for new tabbing; marking area of delamination; removing top layer of painted veneer and then removing the top two layers of delaminated plywood and numbering each piece. After drilling injection holes, I filled them with epoxy

Plywood pieces removed from bulkhead and numbered.

Series of holes drilled in bulkhead will be filled with epoxy resin. Fourth layer of ply shows as darker wet-looking areas in the photo.

Digging out the wet deck from inside the cabin.

Paper template provides pattern for cutting fiberglass layers: cloth, mat, woven roving, mat and one more layer of cloth.

It was necessary to grind out chainplate portion due to too much fiberglass (again!).

and glued the plywood back on and formed fillets along the edge.

As is often the case with the completion of successful projects, there is more work to be done. Due to the mess of sanding and fiberglassing, I had to remove the lazerette floor and clean, oil and grease the steering system and autopilot. I also found cracks in the backstay swages (along with a few other stays) when inspecting them before attaching them to the chainplates and the list goes on.

— Sandra Turney is no newcomer to repairing fiberglass boats. Articles of her Contessa 26 rebuilt have appeared in back issues of DIY.

TIP: Wave-Speed Ratio

How do you tell how fast a boat is going when there is no speedometer and you only know how long the waterline is? You simply count the waves along the hull. For example, a boat with a 36' (11m) measured waterline has three waves along its hull. If it were to have one wave its maximum speed would be 1.34 times the square root of 36 equals 8.04 knots. If there are three waves along the waterline the speed is 8 knots divided by three (waves) equals 2.68 knots. For two waves, 8 divided by two equals 4 knots.

View from the Stern

Physics Rules Speed

To calculate a boat's obtainable maximum speed you must first consider the factors that cannot be changed.

By Roger Marshall

"It goes 40 knots," you might hear a powerboat owner say or from a sailboat owner you might hear the statement: "Under full sail it goes 7 knots." Why do some boats go fast and others go slower? Is it the size of the engine? The beam or the sail area? Or the weight of the boat or the boat's length?

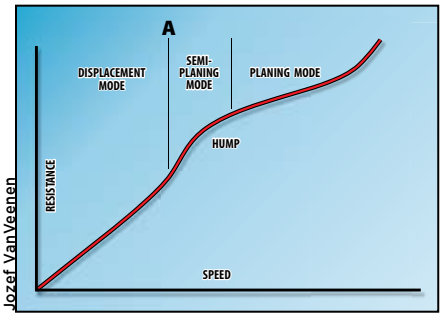
The truth is that all of the above factors affect the speed of a boat. However, each parameter affects only certain aspects of boat speed. A displacement hull moves through the water, forcing it to move elsewhere. As it displaces the water such a hull can only go at a speed proportional to its waterline length. Most sailboats operate only in the displacement mode, while some boats may have the capability to operate in any of three modes: displacement mode, transitional mode and planing mode. Each mode imposes certain conditions on the boat.

Displacement Mode

Most large ships operate only in the displacement mode. They are simply too heavy to get up and plane. Likewise, many sailboats operate in displacement mode, again because they are too heavy to plane. All boats operate in the displacement mode when they first get underway, but some boats can climb onto a plane. Still others cannot quite make it onto a plane and operate in the semi-displacement mode; that is, halfway between planning and displacement condition.

If you look at ships and boats that remain in the displacement mode, they have several things in common. They are usually heavy, have moderate beam and have a stern shape designed to allow the water to flow easily past the boat.

A displacement hull operates at a



As a boat accelerates, the resistance increases until the hull is supported on a bow and stern wave. As the boat starts to climb up the bow wave and into the semi-planing mode, resistance increases even more and a "hump" is reached. As the boat moves into the planing mode, the hump decreases and resistance increases more slowly.

speed relative to its waterline length. In 1896 William Froude (pronounced Frowd) determined that the maximum speed of a displacement boat would be about 1.34 times the square root of the waterline length, with the hull being locked into a wavelength equal to that dimension. In actual fact, the length is more like 1.5 x square root of the length on the waterline or load waterline (LWL) because the boat usually has overhangs that contribute to added length.

Transition Mode

As a powerboat starts to plane, it trims up by the bow. If the boat's buttock lines (the rounded part of a boat's stern) are fairly flat and the hull is light enough, it will have the potential to plane. But before it gets onto a plane, it will operate in the transitional or semi-planing mode. At this point the boat is moving at two to three times the square root of LWL. The semi-planing mode is the steepest part of the power/resistance curve and is when the boat uses the most fuel. Moving from the transitional to the planing mode can often be assisted by setting trim tabs down a little to bring the bow down.

Planing Condition

By increasing power a little more, a powerboat starts to use dynamic lift to help it rise out of the water and onto a plane. In the planing mode almost all of the boat's weight is supported by dynamic lift, and it might be moving at up to five to eight times the square root of the LWL. At this point throttles are eased back slightly, trim angle drops slightly, fuel consumption drops, the stern wave becomes minimal and the boat moves in a full planing condition. In order for the boat to get onto the plane it needs to have sufficient beam (basically, the wider the beam the easier it is for a boat to get on a plane). It also needs to be of a reasonably light weight, and it needs to have buttocks that run aft straight from amidships.

Once the boat is on plane there is very little to stop it as long as the engine has enough thrust to keep up acceleration. High-speed boats such as XXX, a deep-vee powerboat from Outer Limits, can attain a speed of 150 miles an hour (241km-h). To go faster than this, boats need a little more help to get them farther out of the water. To accomplish this, ultra-high-speed boats, such as the unlimited hydroplane "Miss Budweiser," are supported by hydrodynamic and aerodynamic lift so that very little of the boat is in the water.

From a naval architecture perspective, the easiest way to make a boat go faster is to reduce the amount of propeller and rudder in the water. A propeller and rudder can account for up to half the drag of the boat underway. That is why high-speed boats often have small rudders and use a surface-piercing propeller where the lower half of the propeller blade is in the water. By removing the rudder altogether and making the surface-piercing propeller steerable like the Arneson Drive (www.arneson-industries.com) does, eliminates rudder drag. Ultra-high-speed boats may be propelled by a jet with no appendages in the water.

About the author: Roger Marshall is a boat designer and author of 12 books.