

During recent meetings and gatherings we've been asking your opinion on ways to broaden the appeal for this newsletter. Several folks have suggested that articles on various marine systems or boat maintenance may be beneficial. Hopefully, this column will be a forum for sharing the vast range of practical experience accumulated by our membership. It is also intended to be the place where you, the reader, can submit technical questions and either obtain answers or direction to appropriate reference material.

As I mentioned in the first "Tech Tips" article, I hope to present six topics related to marine electrical systems. These are: electrical wiring, alternators and regulators, batteries, grounding and bonding, radios and antennas, and instrumentation (depth, speed, GPS, LORAN, etc.). In the last article we talked a lot about marine electrical wiring, but because I got a little long winded, we never covered the various methods for connecting the wires to anything. So in this "about a page" long article we'll look at the connectors, terminals and battery clamps that let the electricity get where we want it to go.

There are all sorts of ways to connect wires together or to electrical devices. Most of us have seen really great examples of the wrong way to make these connections. Funny thing is that you always find them on other peoples boats. They range from the wires that are jammed between the battery post and battery clamps, to the mega-bundle of wire that's twisted together and held by single (and usually loose) wire nut. Admittedly, this is an extreme example, but hopefully you get the point. Doing things the wrong way sets you up for a "Murphy's Law" calamity.

The last article pointed out the right way to lay out a wiring system and chose the correct size circuit breakers, fuses and wire. This time we'll look at the right way to fasten things together. If we have everything sized correctly, we can deliver the electrical current from the source to the load devices with very little voltage drop. However, we can only do this if we have everything connected with the appropriate size and type of wire terminals and connectors.

Usually the largest wire "terminals" used on a boat are the clamps at the ends of the starting battery cables. We don't give them a whole lot of thought until something doesn't work. That's usually the starter motor. And according to Murphy, it usually happens just when you need it most. The clamps must be capable of conducting high current to the starter with a minimum of voltage loss. The amount of contact area between the surface of the clamp and surface of the battery post is critical to the voltage drop (loss) across the connection under high current conditions. If the surfaces are dirty or the clamp is loose, the contact area between the clamp and post is reduced. The lack of surface area causes a resistance to the flow of current. As the starter current increases, more and more voltage is dropped across the bad connection. This represents a power loss since power is equal to current times voltage ($P=IE$). Under high current conditions the power available at the starter

won't be great enough to crank the engine fast enough to start it.

The best way to keep this "Murphy's Law" scenario from happening is to keep the battery connections clean, tight, and protected from corrosion and dirt. After tightening the clamp coat it with some of the products designed for protecting battery connections. You can find them in any chandlery or auto parts store. Do not use greases or light oil-based corrosion preventive compounds. These products can penetrate the area between the clamp and battery post, and decrease the contact area. They can even cause a cascade effect, potentially leading to a fire or explosion. I witnessed a fire on a boat that was caused by ignition of the grease used to "protect" the battery terminals. Continuous cranking of a stubborn diesel caused a poorly connected clamp to overheat enough to melt the grease. The grease burst into flame and ignited the hydrogen gas being produced by the battery. It was not a pretty sight.

On a far smaller scale, the type of terminals and connectors that you use on other wires on the boat and the method you use to install them can be the difference between a great system and one that causes you continual grief. In an ideal world, all wires run directly from the electrical source to the load device with no connections except for the necessary circuit breakers and fuses. Ok, but how do you attach them! Personally, I like to use ring terminal lugs in combination with terminal strips where appropriate.

Ring lugs have the advantage of not falling off the screw they are attached to if it loosens up for any reason. If the device or terminal strip you are attaching them to is in an awkward position they can be hard to attach, but the safety factor of not having electrically hot wires hanging loose greatly offsets this inconvenience.

All sorts of ring terminals, or lugs, are available. I like to use the type that crimp onto the wire with a crimping tool and have an insulating vinyl sleeve over the barrel that the wire slips into. On the better made lugs the insulation is tapered on the inside so that the multi-strand wire slips right into the hole. These provide a good mechanical and electrical connection between the wire and the lug if you choose the right size. No matter what type connector you use make sure that you get the size that matches the wire's size. If you don't, the crimping tool will distort the barrel end of the connector. Although you may have succeeded in getting the lug mechanically fastened to the wire, you more than likely don't have the correct electrical contact area between the lug and wire. Using the wrong size crimping tool or a pair of pliers to crimp the lug will create the same effect. Combine this poor connection with a little dirt and salt corrosion and you have a good source for future problems.

The insulating vinyl sleeves on the lugs are usually color coded to match the colored dots on the crimping tools and the size of the wire for which they are designed. Red colored lugs are made to go on 22 -18 gauge (AWG) wire. Blue coded lugs

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are for 16 - 14 gauge wire. Yellow coded lugs are designed for 12-10 gauge wire. Better quality crimping tools have the terminal size labeled right next to the machined crimp face. In many cases, they also have a colored dot corresponding to the color code for the lug. These color codes also apply to the in-line splice connectors and other types of terminals. You don't have to be a rocket scientist to do the job correctly.

In general, avoid using spade lugs or bullet terminals if you can. I avoid them because they can be pulled apart too easily. Of course, in some applications that's what you want, but inspect them routinely if you have to use them. This type of connector uses the spring tension of the outer shell to hold the inner part in place. In a marine environment, they seem to be more prone to corrosion and rapid deterioration. A ring terminator screwed to a terminal strip provides a better electrical and mechanical connection that is relatively easy to clean.

To establish a good electrical connection I always use tinned copper lugs and solder the wire to the lug after it's been crimped. This may seem like overkill (and in anything other than a marine environment it would be) but after several years, corrosion between the wire and lug can become a problem. Careful soldering not only prevents this from happening but also establishes a superb electrical connection between the lug and wire. If you are careful, quick, and have the right heating element on the soldering iron, you can melt the solder to the wire and lug without melting the vinyl insulation. If you haven't had a good conversation with your soldering iron lately, forget you read this paragraph and go buy a good crimping tool! Properly crimped and insulated lugs will last a long time.

Speaking of insulation, you can get lugs and line splices that come with heat shrinkable insulating sleeves. They form a good moisture seal between the insulating sleeve and wire insulation when heated with a heat gun or hair dryer. The seal will keep the salt corrosion at bay as long as it is not disturbed. You can also use products like "Liquid Lectra Tape" or other brush-able insulating material to seal up the insulation. Again, you don't have to go to this extreme, but may want to consider it if the terminals could be exposed to salt spray.

Another good idea, that should be part of your annual maintenance, is to spray all of the electrical terminals, except the batteries, with an anti-corrosive spray that is designed for electrical connections. There are many, many products to choose from. "Practical Sailor" ran an article not too long ago on the subject of corrosion preventive products. I like to use CRC and Boshield, both of which fared well in the "Practical Sailor" comparison tests. As I pointed out earlier there are many excellent references on the subject of marine electrical systems. "The 12 Volt Bible", "Boatowners Illustrated Handbook of Wiring", and other books are available from most good chandlers and catalogs. Gordon West's articles in "Sail Magazine" are excellent references, and well worth reading. "Practical Sailor" has a good article on electrical wire crimpers on page 24 of the June '98 issue.

Hopefully this "about a page" long article has stirred up some questions. Certainly your electrical system should not be viewed as a "monster". With a little knowledge and occasional tender loving care you can easily tame it and save yourself some money in repair bills.