If ever there were a corner of the nautical universe shrouded in mystery, mystique, and just plain lies and misinformation, it has to be the galaxy labeled marine corrosion. Contrary to popular belief, this really isn’t witchcraft, and it can all be explained by employing some fairly basic science.

Whether corrosion is a problem or not is largely a function of time. If an acceptable service life has not been reached before the material fails, then there’s a problem. Time is also the key factor in determining which of the three major types of corrosion is occurring and what you have to do to fix the problem.

You’ll notice that I will never use the term “electrolysis” in this article. That’s because electrolysis has become a catchall phrase that is not specific enough to be helpful. In this article, we’ll put to rest some common misunderstandings by looking at the different types of corrosion that can occur on boats, how to protect your boat’s metals from corrosion’s effects, and how to recognize if you have a serious corrosion problem.

Continued on page 4
inch-diameter pumps, the size of the discharge manifold must be at least two inches. “With multiple pumps, the required diameter of the discharge manifold can ‘grow’ pretty quickly.”

Captain Lanier (incorrectly) assumes that the size of the manifold pipe must be the pump discharge size multiplied by the number of pumps that are manifolded together. In other words, if a pump has a one-inch discharge diameter connection, for two pumps you need a two-inch manifold pipe, for three pumps you need a three-inch diameter manifold pipe, and so on. This is absolutely not the case! Following the captain’s advice results in using unnecessarily large (and expensive) bilge pump piping. The reason is that the carrying capacity of pipe or tubing does not increase linearly with diameter; it increases by much more. Note that ABYC H-22 also requires the use of a check valve (a one-way only valve) for each pump. These are a good idea even if only one pump is used.

Gary Adams
Jacksonville, FL

Fuzzy Bilge Pump Math

I must take at least a small issue with Captain Lanier’s reply in the last issue. He stated that if you have two one-inch-diameter pumps, the size of the discharge manifold must be at least two inches. “With multiple pumps, the required diameter of the discharge manifold can ‘grow’ pretty quickly.”

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Gary Adams
Jacksonville, FL

BEWARE THE BOOM

As a lifelong sailor with strong opinions about safety at sea, I was surprised to find no reference in your excellent “Boating Safety Review” in the April 2015 issue to boom-related sailing accidents. I am a strong believer in the habitual use of preventers whenever sailing off the wind. In my view, a fast-moving boom represents an ever-present danger to unwary or distracted persons on deck.

Fred Hallett, USNR (Ret.)
Arnold, MD

Our anecdotal experience sailing offshore supports your contention that the boom is a danger to those aboard. The most serious injuries we heard of were generally related to the boom or to the running rigging attached to it. But boom-related accidents made up only about 1.5 percent of total accidents in our claim files, and 4 percent of accidents on sailboats. We would always recommend that you use a preventer when sailing off the wind. But based on our data, which is largely inshore and coastal, you are far more likely to be injured on a sailboat in a collision, by falling down a hatch, or by tripping over a lifeline getting on or off the boat than you are by the boom.

COLREGS

Just to make a quick clarification on the navigation rules in the April issue concerning two power-driven vessels in a crossing situation (Rule 15). The rule states that when two power driven vessels are crossing so as to involve risk of collision, the vessel which has the other on her starboard side, shall keep out of the way. The author likens the red port light you would see on the boat to your right, or starboard side like a traffic light, which means when you see red, you stop.

This is a good analogy; however, the article goes on to say “if a boat is off your port side, then you would see their green light, which means you can proceed safely.” This could be a bit confusing to some, because if you saw just a green light, then you would be looking at the starboard side of a vessel under sail alone, therefore, the powerboat seeing just the green light would have to give way because he was encountering a vessel under sail. It is the white masthead light that indicates the boat is under power! So, in essence, in a crossing situation with two powerboats, the boat off to your port side would have a green side light and a white masthead light indicating it’s under power.

Capt. Joanne Clark
Willimantic, CT

Hurrah hurrah! This article was dead on point. I am the captain of a large luxury yacht, and hardly a day goes by that I don’t see somebody doing something that is really crazy. Most collision avoidance is just plain old common sense, but an awful lot of boaters don’t seem to have any of that. I hope some of those people take the time to read this article. Thank you for putting the rules into a context that people can understand easily.

Capt. Jeff Fredrich
Hollywood, Florida

Check valves are not recommended by ABYC as part of a typical bilge
pump installation. Per ABYC H-22 they “may” be used in the discharge line of a single pump to prevent cycling due to back-flow discharge from the line; however, check valves are prone to failure and clogging due to trash, etc. and should not be used as part of a typical bilge-pump installation. The correct way to prevent back feeding is to have the discharge hose for our bilge pumps rise up a suitable height above the manifold, then drop down and enter the manifold (i.e. a riser loop).

OIL SAMPLE ANALYSIS
Why bother writing an article like this if you’re not going to at least give a ballpark price on the cost? You gave a price for the kit. Why not the analysis?

Don Currie
Marina Del Rey, California

Several readers wrote to tell us the same thing. The information was in the article but not easy to find. Toward the end of the article, the author said: “The cost for an OSA kit at my local Caterpillar dealer is about $17, which includes processing the sample and sending me the analysis of the results. That’s a bargain by any measure.” If you do a Google search for your area, you should be able to find a couple of local shops, as well as online companies, that can do this for you. Prices seem to be around $25 for mail order.

LIGHTNING STRIKES AGAIN

In the most recent issue of Seaworthy, one writer asks what to do if you need to use your wheel during a thunder and lightning situation. One solution that I have used is to have a thick pair of heavily insulated rubber gloves that electrical workers wear when working in dangerous situations. I put the gloves on and touch the wheel as little as I need to in order to maintain control of the boat. You usually have some warning that a storm is near, so on our sailboat, the sails are dropped and secured, the engine is on, and everyone else is down below. So far, no problem. Is this a controlled scientific experiment? No. However, you could probably test out this approach in a lab.

Jack J. Adler
Larchmont, NY

ODDS AND ENDS

The “What Could Possibly Go Wrong” piece brings up a pet peeve. Several years ago I was working on a rewiring project and went to the ABYC website to get my information "from the source." I learned that they make it difficult and expensive for an individual to find what the ABYC standards are. I ended up relying on manufacturer’s information — good but not direct. Anything you can do to ease access to this information would be a blessing. Again, thanks for a great magazine.

John Meskauskas
Oriental, NC

John Adey, president of ABYC: First and foremost, standards and safety costs money. Our organization is only about five to seven percent funded by grants and donations. The rest is primarily membership and education revenue. We have a free five-day demo on our website located here: http://abyc.rulefinder.net/freedemo.html. This is a read-only copy and it is there for precisely this purpose. Those who need info for a project or a survey are invited to use this link, and can use it repeatedly if needed.

LIFT SAFETY

I read the Lift Safety Alert in your latest issue and was compelled to mention another aspect that may be overlooked by owners with boats in lifts. As the wind blows against your boat as it is raised (and against the lift itself, if the boat is not in it), the boat and lift will oscillate. The degree of movement will vary according to wind, boat windage, and lift-cable length, but the point is there will be some friction generated where the cable meets lift components, mainly at the attachment points, pulleys, and at the spool.

It seems to me that if a boat is lifted to a certain point and left there for some time—say, over the winter—and if that particular height is one that the owner often uses, the cables will suffer some damage. For example, if in the face of an expected storm an owner raises his boat to a certain level each time this occurs, and of course the higher wind speeds cause greater movement of the boat and lift, at some point the cables may be damaged to the point of failure.

I have made a practice of periodically moving my lift, with the boat in it or not, up or down a foot or so, just to spread the area of contact out a bit. When a hurricane is in the Gulf, I pull or anchor my boats, but I still raise the lift platform as high as I can, and lash it to the pilings so as to reduce movement. Maybe the cables would hold up anyway, but it seems like a prudent precaution.

A boat at a nearby dock was left on its lift in a storm a couple of years ago, and one of the cables snapped, leaving the boat bow-down in the water. The cabin flooded, but of course the bilge floats never came on, since there was no water in the aft section until well after the electrical system shorted out and the boat was too far sunk to be pumped and saved.

Frank Milhous
Floros, FL
The differences between the types of corrosion we experience on our boats has to do with how the corrosion occurs and how quickly the metal is compromised.

- **Simple corrosion** is the degradation of metal as molecules on the surface combine with oxygen to create a more stable metal oxide. Over time, almost all metals will corrode to some degree with exposure to oxygen in the presence of moisture – think of the red discoloration of rusted iron or the gray dust that forms on bare aluminum. In some cases, with aluminum and stainless steel, the metal oxide coating actually protects the underlying metal by stopping oxygen from reaching the base metal beneath. Simple corrosion takes years or decades to weaken the metal, and it is generally not considered problematic. A bronze propeller that slowly corrodes over 30 years of service is not a cause for alarm.

- **Galvanic corrosion** occurs when two metals with different electrical potentials are connected together and submerged in a common electrolyte pool. Examples include anything from a stainless steel bolt threaded directly into an aluminum mast regularly doused in saltwater, to a bronze propeller on a stainless steel shaft immersed in seawater. In both situations – and dozens more on boats – dissimilar metals in a common electrolyte create a battery with an anode and a cathode. Which metal is the anode and which is the cathode depends upon their relative electrical potential, or voltage, when submerged in seawater (Table 1). The metal with the more negative voltage has an excess of electrons relative to the other metal, and it will act as the anode, sending negatively charged ions to the cathode, the metal with the higher (less negative charge) voltage. Over time, that ion flow will result in the loss of material in the anode. How quickly this occurs depends upon how large the difference in electrical potential is between the two metals, or how far apart they are on what is called the galvanic series of metals. The farther apart, the faster corrosion occurs. So platinum will do a number on zinc in no time at all. To be comparable, electrical potential has to be measured using the same reference cell (a silver-chloride electrode) with a standard digital multimeter. Over time, that will do a number on zinc in no time at all. To be comparable, galvanic corrosion can cause serious damage in a matter of months, so your boat must be protected against it by using sacrificial anodes as described in the next section.

- **Electrolytic corrosion**, more commonly called “stray current” corrosion, adds an external electrical source to the corrosion equation, rapidly accelerating the reaction. It occurs when metal with an electrical current flowing into it is immersed in water that is grounded (which would include any lake, river, or ocean). This can happen if a short develops between an external current source (almost always the 12-volt electrical system on your boat or someone else’s) and some part of the electrical system that is tied into the boat’s underwater metals. The stray current will exit the

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**Table 1. Galvanic Series Of Metals In Sea Water With Reference To Silver/Silver Chloride Reference Cell (Sea water flowing at 8 to 13 ft./sec., temperature range 50 degree F (10 degree C) to 80 degree F (26.7 degree C))**

<table>
<thead>
<tr>
<th>Metal/Alloy</th>
<th>Anodic or Least Noble Potential Range in Millivolts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zinc</td>
<td>-980 to -1030</td>
</tr>
<tr>
<td>Aluminum</td>
<td>-760 to -1000</td>
</tr>
<tr>
<td>Cadmium</td>
<td>-700 to -730</td>
</tr>
<tr>
<td>Mild Steel</td>
<td>-600 to -710</td>
</tr>
<tr>
<td>Wrought iron</td>
<td>-600 to -710</td>
</tr>
<tr>
<td>Cast iron</td>
<td>-600 to -710</td>
</tr>
<tr>
<td>13% Chromium Stainless Steel, Type 410 (active in still water)</td>
<td>-460 to -580</td>
</tr>
<tr>
<td>Ti-8 Stainless Steel, Type 304 (active in still water)</td>
<td>-460 to -580</td>
</tr>
<tr>
<td>Ni-Resist</td>
<td>-460 to -580</td>
</tr>
<tr>
<td>Ti-8, 3% Mo Stainless Steel, Type 316 (active in still water)</td>
<td>-430 to -540</td>
</tr>
<tr>
<td>Inconel (78% Ni, 13.5% Cr, 6% Fe) (active in still water)</td>
<td>-350 to -460</td>
</tr>
<tr>
<td>Aluminum Bronze (95% Cu, 8% Al)</td>
<td>-310 to -420</td>
</tr>
<tr>
<td>Nickel (81.2% Cu, 4% Fe, 4.5% Ni, 5% Al, 1.5% Mg)</td>
<td>-310 to -420</td>
</tr>
<tr>
<td>Naval Brass (65% Cu, 35% Zn)</td>
<td>-300 to -450</td>
</tr>
<tr>
<td>Wellow Brass (65% Cu, 35% Zn)</td>
<td>-300 to -450</td>
</tr>
<tr>
<td>Red Brass (85% Cu, 15% Zn)</td>
<td>-300 to -450</td>
</tr>
<tr>
<td>Muntz Metal (60% Cu, 40% Zn)</td>
<td>-300 to -450</td>
</tr>
<tr>
<td>Tin</td>
<td>-310 to -330</td>
</tr>
<tr>
<td>Copper</td>
<td>-290 to -370</td>
</tr>
<tr>
<td>50-50 Lead-Tin Solder</td>
<td>-290 to -370</td>
</tr>
<tr>
<td>Admiralty Brass (71% Cu, 28% Zn, 1% Sn)</td>
<td>-290 to -360</td>
</tr>
<tr>
<td>Aluminum Brass (78% Cu, 22% Zn, 2% Al)</td>
<td>-290 to -360</td>
</tr>
<tr>
<td>Manganeese Bronze (35.8% Cu, 39% Zn, 15% Sn, 1% Fe, 0.3% Mo)</td>
<td>-270 to -340</td>
</tr>
<tr>
<td>Silicon Bronze (96% Cu, Max 0.8% Fe, 1.50% Zn, 2.00% Si, 0.75% Mn, 1.00% Sn)</td>
<td>-260 to -290</td>
</tr>
<tr>
<td>Bronze Composition G (85% Cu, 2% Zn, 10% Sn)</td>
<td>-240 to -310</td>
</tr>
<tr>
<td>Bronze ASTM B62 (Thru-Hull) (85% Cu, 5% Pb, 5% Sn, 5% Zn)</td>
<td>-240 to -310</td>
</tr>
<tr>
<td>Bronze Composition M (86% Cu, 3% Zn, 6.5% Sn, 1.5% Pb)</td>
<td>-240 to -310</td>
</tr>
<tr>
<td>13% Chromium Stainless Steel, Type 410 (passive)</td>
<td>-280 to -350</td>
</tr>
<tr>
<td>Copper Nickel (80% Cu, 10% Ni)</td>
<td>-210 to -280</td>
</tr>
<tr>
<td>Copper Nickel (75% Cu, 20% Ni, 5% Zn)</td>
<td>-170 to -250</td>
</tr>
<tr>
<td>Lead</td>
<td>-190 to -250</td>
</tr>
<tr>
<td>Copper Nickel (70% Cu, 30% Ni)</td>
<td>-180 to -230</td>
</tr>
<tr>
<td>Inconel (78% Ni, 13.5% Cr, 6% Fe) (passive)</td>
<td>-140 to -170</td>
</tr>
<tr>
<td>Nickel 200</td>
<td>-100 to -200</td>
</tr>
<tr>
<td>Ti-8 Stainless Steel, Type 304 (passive)</td>
<td>-50 to -100</td>
</tr>
<tr>
<td>Monel 400, K-500 (76% Ni, 30% Cu)</td>
<td>-40 to -140</td>
</tr>
<tr>
<td>Stainless Steel Propeler Shaft (ASTM 630:#17 &amp; ASTM 566:#18)</td>
<td>-30 to -130</td>
</tr>
<tr>
<td>Ti-8 Stainless Steel, Type 316 (passive) (3% Mo)</td>
<td>0.0 to -100</td>
</tr>
<tr>
<td>Titanium</td>
<td>-50 to +60</td>
</tr>
<tr>
<td>Hastelloy C</td>
<td>-30 to +80</td>
</tr>
<tr>
<td>Stainless Steel Shuttling (Bar) (UNS 20910)</td>
<td>-250 to +60</td>
</tr>
<tr>
<td>Platinum</td>
<td>+190 to +250</td>
</tr>
<tr>
<td>Graphite</td>
<td>+200 to +300</td>
</tr>
</tbody>
</table>

*The range shown does not include sacrificial aluminum anodes. Aluminum alloy sacrificial anodes are available that have a maximum corrosion potential of -1100 mV.*
boat from an underwater metal fitting, which can be several orders of magnitude higher than the "natural" voltage levels shown in Table 1. The result is a very rapid reaction that can cause profound metal damage in a matter of days or even hours.

- Crevice corrosion is an all too common type of corrosion that affects stainless steel. Simply put, stainless steel is not particularly stainless unless it is exposed to oxygen. Only in the presence of oxygen does an oxide coating form on the surface of the metal; it's this coating that mitigates rust or corrosion. In situations where stainless steel gets deprived of oxygen but moisture is still present, crevice corrosion will occur. This can happen, for example, when a chainplate starts to leak, introducing water into the space where the chainplate passes through the deck—an area where there is very little oxygen.

PROTECTING YOUR BOAT FROM GALVANIC CORROSION

Protecting the metals you don’t want to corrode means turning them into the cathode of the corrosion “battery.” We can do that by providing a sacrificial anode that is less noble (lower on the galvanic table) than the rest of the metals on the boat. This would all be relatively straightforward if we had only one metal to protect. But most boats have a variety of metals, many of them under the waterline, each with its own voltage. Aluminum alloys fall at the least noble end of the spectrum while stainless steel falls at the most noble end. To make it easier to turn all of these disparate metals into a single cathode, American Boat & Yacht Council (ABYC) Standard E-2 recommends tying underwater metals together using an 8 AWG green insulated wire in a process known as bonding.

Bonding allows all of the dissimilar metals to achieve an equalized potential (voltage). By connecting all of the bonded metals to an adequately sized anode or anodes that have a voltage potential of at least -200 mV relative to the corrosion potential of the least noble metal being protected, we create a cathodic protection system. This is what the anodes on your boat do – give up their lives for the good of their more noble metal mates.

Bonding can be controversial. Why? One reason is that a DC fault into the bonding system could lead to electrolytic corrosion. Theory says that if there were a DC fault into the bonding system, it would migrate equally throughout the bonding system due to its designed low electrical resistance. This would cause voltage potentials at all points within the system to equalize, which means no current could flow. If there is no current flow, then there can be no corrosion. Sound theory. But many bonding systems in the real world are a corroded mess. My contention is that things may not be quite as "equal" as theory would wish, so voltage potentials could vary, and electrolytic corrosion could occur.

Note that it certainly is possible to protect a boat without bonding the metals together. But this method runs the risk of some other metal than the one you intended acting as the sacrificial anode – a thru-hull made of a lower-quality bronze alloy, for example. It's all great fodder for an interesting debate about bonding versus no bonding. I've owned boats that were bonded and boats that were not. I've never had a problem in either case because I kept track of my sacrificial anodes and conducted periodic inspections of my boat’s underbody.

Sometimes sacrificial anodes can’t get the job done. This could be because the differences between the voltages of the anode and cathode (the metals to be protected) are too close or because the area to be protected is large relative to the boat. In these cases, impressed current systems measure potentials in real time via a sensor, and a non-sacrificial anode emits adequate current from the boat’s battery to protect the metals connected to the system. Aluminum sterndrives are a good example. In the early years after they were introduced, many had serious corrosion issues. Today, to supplement the protection from sacrificial anodes, the Mercury Marine sterndrives are protected by the Mercathode systems and Volvo uses the Active Corrosion Protection (ACP) system.

LEVELS OF PROTECTION

It used to be the case that most boats were made out of fiberglass, and most underwater metals were bronze except for the prop shaft, which was marine-grade stainless. In that world, zinc was the perfect anode material. How do I know that? If you look at Table 2 below, you’ll see that to protect a fiberglass boat, the anode needs a voltage of between -550 and -1,100 mV. If you compare that to Table 1, you’ll see that zinc has a reference voltage of -980 to -1,030 mV, right within the specified range. At -240 to -310 mV, all bronze alloys are significantly above zinc on the cathodic scale, and shaft-grade stainless is even more noble, at -30 to 130 mV. So zinc will offer plenty of protection. In fact, until just a few years ago, sacrificial anodes were called “zincs,” and many boaters still use that term. But our world has gotten a lot more complicated.

Zinc anodes have actually begun to fall out of favor in recent years. Zinc works just fine in a true saltwater situation. But as water becomes more brackish to fresh, zinc becomes less effective. In fresh water, it actually
forms an oxide on its surface that stops it from working as a sacrificial anode. The two other anode materials that have come to the fore in recent years are magnesium and aluminum.

Magnesium is the most expensive anode material but also the least noble metal on the list, so it runs out of electrons quickly; in fresh water it lasts only about a third as long as zinc. It can also overprotect other metals that are chemically active, like aluminum, creating too much current, especially in such chemically active water as polluted fresh water or saltwater. The reaction between the aluminum and the magnesium can even result in an alkaline solution that will start eating away at the aluminum. Magnesium should be used only in clean fresh water, never in brackish, polluted, or saltwater.

Aluminum anodes, on the other hand, will work nicely in both salt and brackish water. That’s because the alloy used in anodes includes iridium and other metals that interfere with the oxidation of the aluminum. This is important because many people who keep their boats in the water in coastal communities are often migrating from pure saltwater into brackish and even fresh water on a daily basis. The aluminum alloy in high quality anodes will protect aluminum hulls and sterndrives, so follow your manufacturer’s recommendation when replacing anodes.

So once you decide what anode material will work best with your hull material and boating environment, how do you know how many anodes you need? And how do you determine if your boat’s cathodic protection system is in order?

If you own a good multimeter or Digital Volt Ohm Meter (DVOM), then you already have one of the key pieces of equipment you’ll need. You’ll also need the silver-chloride reference electrode mentioned earlier. You really can’t measure your boat’s hull potential accurately without one, at least not using the potential values used throughout ABYC’s E-2 standard. BoatZincs.com is a good source for a reference cell. The cell costs about $125 and includes a publication that explains how to hook it up to perform tests and what to expect in your readings. I think this is money well spent.

Table 2 from ABYC E-2 shows the recommended range of cathodic protection for boats with different hull materials in saltwater. Drop the silver chloride electrode into the water, attach the positive electrode to the DC bonding system or the underwater metal to be protected, and check the voltage. If the reading is higher (less negative) than shown in Table 2, then you need more anodes. Once the maximum negative voltage potential for the anode material in use is reached as shown in Table 1, adding more anodes will increase anode life but will not have any impact on voltage.

**IF PROTECTION FAILS**

In spite of your best efforts, sooner or later you may be the victim of underwater metal corrosion that is caused by something other than your boat or the level of cathodic protection you have provided. This is where the experts on every dock weigh in with not-so-expert advice that is sure to drive you crazy!

Of course, the obvious question is how do you know if you even have a problem? Without the proper measurement equipment, the only way to judge is visual. Keep in mind that if things were done correctly before a spring launch, you should expect to get a full season’s use from your sacrificial anodes. If you suddenly start running through anodes every four weeks, don’t jump to conclusions. The appendix of ABYC E-2 includes a list of things that can alter anode consumption rate.

If environmental conditions haven’t changed, start looking for signs of galvanic corrosion. The first sign is paint blistering (starting on sharp edges) below the waterline, and a white powdery substance forming on the exposed metal areas. As the corrosion continues, the exposed metal will become deeply pitted.

Before it gets to that point, you need a genuine expert with the proper training and some specialized tools to make sure you get a solid diagnosis of the problem(s) that may be causing either accelerated anode consumption or serious corrosion. The ABYC has a list of certified corrosion specialists that is searchable by state at its website. This should be your first stop in my opinion. Go to www.abyccinc.org and use the “Certified Tech Search” button on the home page.
MOST PEOPLE ARE familiar with the Where’s Waldo? books, where the reader scours the pages to find a distinctively dressed cartoon character. Well, here’s the marine version. No, you’re not looking for Waldo in a Captain’s hat, but the photo above contains 11 technical faults. Your job is to locate as many as possible. The problems fall into two main areas: Electrical and fuel/ventilation. All of the faults are based on standards developed and maintained by the American Boat & Yacht Council (ABYC). Boats should be built – and maintained – to these standards. Additionally, the ABYC standards are relied upon by surveyors during pre-purchase and condition-and-valuation surveys.

The picture was taken in the engine room of a twin gasoline-powered boat during a pre-purchase survey. Hopefully, this was not your boat!

Where’s Waldo?

Can you find the problems in this photo?

By Brian Goodwin

Photos: James McCrory, McCrory & Associates
1. IMPROPER CONDUCTORS.
Conductors (wires) are the distribution network of the electrical system. They are subject to a harsh environments, temperature, vibration and humidity. As a result they should be designed appropriately. Such residential conductors as Romex™ have a solid core that will break over time due to vibration. Additionally, welding cable is often wrongly used for battery cable. The jacket and insulation are not rated for the marine environment and will break down over time. The correct conductors should meet the requirement of UL 1426 Boat Cable or SAE J378 and J1127 or J1128.

2. CONDUCTOR PROTECTION.
The main culprit here is chafing of the conductors passing through a bulkhead. Over time, the chafing on the bulkhead will cause exposure of the copper and a bad situation. Chafe protection can be accomplished with loom, conduit, or overlapping electrical tape.

3. CONDUCTOR SUPPORT.
Conductors must be secured every 18 inches. This could be accomplished with smooth-edged metal clips or straps, metal clips with insulators, or plastic straps. Keep in mind that plastic straps can’t be used in areas—over engines, say, or over shafts or other machinery—where failure would cause a hazard. Additionally, the insulation should not be damaged by the support during installation.

4. NO BATTERY TRAYS OR BOXES.
These batteries are certainly not in battery boxes, and further investigation—not evident from the photo—showed that they are not in battery trays either. The intent of the tray or box is to contain any accidentally spilled battery electrolyte and protect the surrounding area.

5. SPRING CLIPS MUST NOT BE USED.
While spring clips may be a quick solution for a dead battery, they are not an appropriate method to connect to battery terminals. In this example, the temporary battery charger has migrated into a permanent installation. Also the spring clips are continuously energized by the battery and not protected by the terminal covers. A proper connection should be made with ring terminals on the studs or battery terminals on the posts.
6. IMPROPERLY SECURED BATTERIES. Batteries contain a chemical cocktail and have a tremendous amount of energy. In this case a bungee cord is simply not up to the task. Batteries should be secured with hold-downs or straps so they will move less than one inch.

7. NO WING NUTS ON 6 AWG OR LARGER CONDUCTORS. Wing nuts are quick and easy to use, but they are not suitable for making high current connections because there is a limit as to how far the human hand can torque them down. In this case, the main DC negative conductor is connected to the battery by a wing nut.

8. METAL TOO CLOSE TO BATTERY. Metallic components in the fuel system within 12 inches of a battery terminal need to be protected with an insulating barrier. This is to prevent incidental contact from tools during battery installation and removal.

FUEL AND VENTILATION

1. BULKHEAD PENETRATIONS. Bulkhead penetrations need to be sealed to prevent the migration of any fumes between the engine room and the inhabited spaces, cabins, staterooms, etc. This is particularly important to contain carbon monoxide, a lethal, colorless and odorless gas that is a by-product of combustion.

2. FUEL FILTER FIRE TEST. The fuel filter needs to pass the 2.5-minute fire test. In this instance, the plastic bowl at the bottom of the filter would melt before 2.5 minutes in a fire. The installation of a metal bowl under the filter provides the additional protection required.

3. CONTINUOUS ENERGY FLOW. This remote fuel pump is connected to the battery and continuously energized even when the ignition is off. The fuel pump should be energized only when the engine is running.

So how many did you find? Would you buy this boat? The next time work is done on your boat, ask the technician if he's certified by ABYC and the work will be done to ABYC standards. As electrical issues – followed by fuel issues – are the leading causes of fire on board, the safety of your crew and boat may just depend on it.

Brian Goodwin is the Technical Director for the American Boat and Yacht Council.
Isolation Transformers

Clean, safe shorepower can be yours

By Charles Fort

If you could put a single device on your boat that would make your boat shockproof for swimmers, prevent galvanic corrosion, stop the worry about reversed shorepower polarity, and give you clean AC power for sensitive electronics, would you want one? If you answered yes, read on.

Isolation transformers are a way to achieve all of those goals. Without getting too technical, think about an isolation transformer as your own private onboard power source that uses your boat’s shorepower connection. Confusing? Not really. An isolation transformer takes your marina’s often wild and unpredictable 120VAC shorepower and converts it to pure clean power. And by creating an onboard power source, it greatly enhances the safety of those on your boat or swimming nearby.

THE GREEN GROUND SAFETY WIRE

Most of us know how important the green ground shorepower wire is. It carries fault current (electricity that’s going somewhere it’s not supposed to, like when shorepower shorts against a metal case onboard) back to shore where it can’t hurt anyone.

But marina shorepower systems may be less than reliable. Due to long-term corrosion or improper installation, the ground wires are sometimes not properly connected, meaning you (and nearby swimmers) are not protected from a fault if the AC shorepower shorts into the DC system. This could happen because of a problem in any AC/DC appliance, such as a battery charger. If that happens, any fault current is going to follow a path all through the boat’s DC ground and bonding system, which is connected to the engine and underwater fittings, such as thru-hulls and prop shafts. Because leaking current always searches for a way back to its source (in this case, the marina’s shorepower system ashore), leaking current will exit the boat and head toward shore. If a swimmer passes through the current, they will be electrocuted and may be killed. This is called Electric Shock Drowning (ESD), and every year several people are killed this way.

The beauty of an isolation transformer is that because it’s taken over duties as the boat’s power source, any leaking current will simply return to the transformer on the boat, protecting everyone in the water. A great side benefit is that the transformer automatically corrects polarity problems from the shorepower. Reversed polarity can be dangerous because AC appliances that should be off when their power switch is turned off will still have current flowing into them. Even worse, when polarity is reversed on some household appliances, such as refrigerators, the metal case may be energized with 120VAC. Anyone who comes into contact with that refrigerator and a ground could be electrocuted. Need more convincing? Isolation transformers also prevent galvanic corrosion that can occur between boats in a marina that share a common ground through the AC shorepower. This connection can cause neighboring boats to damage or destroy each other’s less noble underwater fittings, like aluminum outdrives. And finally, isolation transformers supply clean power to such sensitive AC electronics as computers and plasma TVs.

So all of this goodness must come with a price, right? Sure, you don’t get something for nothing, and in this case you pay two ways: Cost and weight. Transformers are filled with copper wire and by their nature are heavy. A typical transformer for a 30-amp shorepower system weighs about 60 to 70 pounds and must be installed within 10 feet of the shorepower inlet. Small boats may not tolerate the extra weight well. Costs range from about $600 on up, plus installation, though the peace of mind may be well worth the price.

POLARITY TRANSFORMERS

Polarity transformers are a slightly different type of device. Some experts feel these are even safer than isolation transformers because they retain the green shore power ground wire. They do everything a regular isolation transformer does but require the addition of a galvanic isolator to prevent boat-to-boat galvanic corrosion, increasing the cost somewhat. Either of these systems will vastly increase electrical safety of those onboard and in the water, as well as provide clean proper-polarity power.

Photo: Charles Industries

For more on Electric Shock Drowning, go to www.BoatUS.com/Seaworthy/esd
Power Line Hazards

Make sure you know how tall your mast is before you go under powerlines

By Charles Fort

Earlier this year, we wrote about lightning (see Striking Lightning Facts, January 2015), your odds of being struck and what kind of damage an errant lightning strike can do. But there’s another source of lethal electricity that can destroy a boat and cause serious injuries and even death – power lines. Last year, a 43-foot sailboat hit a power line in Florida after leaving the Intracoastal Waterway, and the boat caught fire. Fortunately, no one was injured.

High-voltage power lines can carry hundreds of thousands of volts across rivers and bays, and there are plenty of them on the ICW. Power lines that cross navigable waterways are marked on charts with their clearance listed as the height of Mean High Water (MHW), which is an average of several years of high tides. If the power lines are near a bridge, their lowest clearances are required to be higher than the bridge. But the clearances are accurate only in the marked channels – outside of that, the lines may be much lower. Be certain of your mast height (also called air draft) and the power line clearance before you go under them. Don’t forget to add the height of your mast-mounted VHF antenna – usually an additional 36 inches. Keep in mind that if you have safely gone under a power line in the past, it’s no guarantee that it’s still safe; the water level may rise from tides, flooding or controlled damming, or the line may expand and sag from heat. Also, look out for downed or sagging lines following storms or high winds. Keep in mind that if the tip of the mast or antenna should come close to high voltage lines, the electrical current may be strong enough to bridge the gap and flow to the boat.

According to the U.S. Coast Guard, should your boat come in contact with a power line, don’t jump into the water. The electrical charge may pass through your boat and electrify the surrounding water. The safest approach is to stay in the boat and avoid touching anything metal. Leave the boat only after it has moved away from the line.

It’s not just on the water where power lines can be dangerous. BoatUS claim files show that other boats have hit power lines while at launch ramps. A few years ago a Seaworthy editor was pulling his 22-foot sailboat out of a boat ramp at a small lake in Washington state after a sail with his family. He brought the boat to the staging area to lower the mast and prep the boat for the road when he was startled to hear what sounded like angry bees near the top of his mast. The sound turned out not to be angry bees, but an angry high-voltage line that was not far from the top of the boat’s aluminum mast. The boat was quickly moved away from the power line and the mast lowered. If anyone had been touching the mast and the electricity jumped from the line, they could have been electrocuted. The small-boat ramp was not designed with sailboats in mind; a boat with even a slightly taller mast could have created a disaster.

Look up and carefully scan the area for power lines before raising your mast – and don’t forget to check again as you bring the boat out of the water. Older launch ramps are more likely to have low power lines that can snag an unwary sailor.
WAKEBOARD TOWERS AND TUBES

Wakeboard towers make it easier for boarders to get more air and do cooler tricks. A tower enables a towrope to be connected to a higher point than a ski pylon that’s attached down low to the stern of the boat. But towers are made for skiing and wakeboarding and typically not designed for the much greater forces that can occur while pulling inflatable tubes. If a tube gets stuffed in a wave or wake, it puts tremendous strain on the tower, which could fracture or even break it. BoatU.S. Marine Insurance has several claims from breaking towers, including one in which a man was seriously injured when a piece of the broken tower hit him in the face.

Most manufacturers specify exactly what the tower can safely tow, and many prohibit towing tubes. Even so, it’s best to instruct passengers to keep forward of the tower and out of the potential path of a failed part. The force on the towrope can turn a broken part into a missile. Strong attachment points such as cleats and pylons on the stern should be used for tubes. Wakeboard boat owners should check over the tower carefully a few times per season, looking for cracks, especially at the welds. Any damage should be addressed before the tower is used again.

KEEPING YOUR COOL

One measure of your engine’s health is its temperature. When engines run hot, it’s a sign that should never be ignored. While sudden changes in temperature that lead to an alarm are most often caused by a blocked sea strainer or damaged impeller, a gradual increase in operating temperature on an inboard or I/O engine is more likely due to buildup of scale in the raw-water cooling system. To transfer engine heat from antifreeze in the fresh-water cooling side of the system, seawater or lake water in the raw-water system passes through heat-exchanger tubes or plates immersed in the antifreeze. Those heat-exchanger tubes and the hoses leading to them can get clogged with deposits from saltwater.

Most engine manufacturers recommend having the heat exchanger cleaned and pressure-tested by a radiator shop every three to five years. If you’re operating in warm southern waters, inspecting the heat exchanger on an annual basis and pulling the end fittings off to make sure the tubes are not clogged with silt or debris will help you spot problems early. Finally, flushing the raw-water system annually with a product designed to reduce scale can greatly increase the life of your engine.

WEATHERWISE

This is the time of year when thunderstorm season begins in earnest. If you’re out skiing or tubing when the sky darkens, you may well decide to run back to a dock and tie your boat up until the storm passes. But if you leave your boat this way, with the stern to the waves, it may look like this when you get back. It’s always preferable to return the boat to its regular trailer or slip before a storm if at all possible. But doing so is not always practical and, if that means getting caught out on the water in strong winds and lightning, it also may not be safe.

So if you need to leave your boat for a few hours or overnight on a dock like this, tie it up bow to the waves. If the boat has a cover, put that on to limit the amount of rainwater that gets into the boat. If it has a bilge pump, check that it is working. If you do all this even when the sky is not threatening, then that sudden thunderstorm will be far less likely to ruin your summer fun.
**MANIFOLD LIFE**

Exhaust manifolds are large double-walled metal castings—pipes within pipes—that carry hot exhaust gases away from the engine block on inboard engines. This arrangement allows hot exhaust gases in the internal pipe to be surrounded by an external water-filled pipe, called a water-jacket, which remains cool. Without the cooling effect of the water, the exhaust gas would overheat the manifold and risers and burn through the exhaust hose in short order.

If there is a breach in the inner casting and water finds its way into the gas portion, it can seep into the cylinders when the engine is at rest. This condition could either seize the pistons with rust or create a “hydro-lock” condition, which results in the premature death of your engine. Manifolds live in a harsh environment and have a limited lifespan. The way you use your boat will be a factor in their longevity, as will the type of water it’s used on. Saltwater boats are going to see a shorter manifold life when compared to their freshwater counterparts.

How long do they last? Most experts suggest that a manifold will have a life expectancy of six to eight years. However, heavy use in saltwater can see this drop to as low as three years. One sign of a potential problem is rust streaks on the outside of the manifold. A mechanic can remove the manifolds and pressure test them. If you have an infrared thermometer, you can use it to see if they overheat under load—a sign of clogging that eventually leads to failure. Have your manifolds inspected once or even twice a year if they are aging; there is usually little warning before they fail. Unfortunately, this kind of loss is usually the result of long-term corrosion, which is not covered by insurance.

**NAVIGATION LIGHTS**

A couple of years ago, a *Seaworthy* editor was watching a spectacular Fourth of July fireworks show in Washington, D.C. from a hillside overlooking the Potomac River. When the show was over, hundreds of boats that were in the river for the show began to leave. From shore, the boats were seen mostly as red, green, and white lights jockeying for the best route home in the dark, with, not surprisingly, more than a few close calls noted. What was a surprise though, is that the editor counted a half dozen boats with the red and green navigation lights reversed. When things are dicey in the dark, the last thing you want to do is confuse your fellow boaters. Make sure your navigation lights work—and that they are showing the proper colors. Turn them on in the dark, and verify from a distance that they are bright and correct. A previous owner could have reversed them inadvertently when replacing them. Even if the manufacturer put them in wrong, you’re still responsible for making sure they are correct.
It’s the time of year when everyone at BoatUS is trying to read the tea leaves to figure out what kind of hurricane season lies ahead. Colorado State University (CSU) releases an annual forecast of tropical storm activity, and they are predicting seven named storms compared to 12 in an average season. Most other forecasters agree, citing lower than average temperatures in the Atlantic and a still-developing El Niño event in the western Pacific, both of which are believed to decrease hurricane activity. That should be good news.

But as we discussed in the January 2014 Small Stuff, some statisticians have argued that forecasters would have been more accurate in their pre-season forecasts over the past several decades if they had simply predicted the historical average every year.

Without forecasts we can believe in, we tend to fall back on gut feel and superstition. And from any perspective, we’ve had an uncanny run of luck. The “hurricane drought,” as the long period since we have had a “major” hurricane (Category 3 or higher) make landfall in the continental United States has come to be called, is just shy of 10 years old.

There have been hurricanes in that period – 59 to be precise – but only a few have actually made landfall and those that have were all Category 2 or less when they came ashore.

Just how unusual is this? NASA researchers ran 1,000 computer simulations of the period from 1950 to 2012 to simulate 63,000 separate Atlantic hurricane seasons. They found that a nine-year period without a major landfall is likely to occur once every 177 years on average. They didn’t calculate how often a 10-year streak would happen, but you can be sure it would be rare indeed. Sounds like too much to hope for …

If you’re looking for signs that our luck may have run out, how about Tropical Storm Ana, the first tropical cyclone of the season that made landfall on South Carolina on Mother’s Day, more than two weeks before the official opening of the 2015 hurricane season. But there have been 21 pre-season tropical storms in the past century, and those seasons ended up being almost evenly divided between active and not. Ah, but there’s been one other pre-season tropical cyclone named Ana. That one opened the 2003 hurricane season and ushered in three of the most destructive hurricane seasons in history, including the one-two-three punch of Charley-Francis-Jeanne that slammed into Florida in just over a month in 2004, and Hurricanes Wilma and Katrina in 2005.

If the hurricane drought has left you with a case of hurricane amnesia, download our Boater’s Guide to Preparing for Hurricanes, sign up for hurricane alerts to come right to your inbox, and browse the many articles on hurricane preparation at www.BoatUS.com/hurricanes/

Tropical storm Ana churns off the South Carolina coast on May 8 this year.
Most marine surveyors will tell you that one of the best parts of their jobs is the varied work – no two days are ever the same. Bill Gates (no, not that Bill Gates), a longtime surveyor and BoatUS Cat Team member, was near Albany, New York, on his way back from an assignment when he came upon a traffic jam. Being from New York City, Bill has seen plenty of traffic jams in his life, but this one was... well... different. Stampeding across local roads on their way to the New York State Thruway was a herd of bison that had escaped from a farm. Bison are no-nonsense bulldozers on legs and had apparently decided that a mere fence was not going to keep them penned in. The bison, which are about as big and heavy as a car, proceeded to bust through the fence, ford a river and a major highway, and then stampede through a public park, pursued by police.

Bill was slightly delayed, but made his next appointment. The bison did not fare so well, regretfully. They are, according to the farmer who lost them, “Not herdable.”

So you know how it is. You’re living on your boat in a marina in South Carolina, and you get a hankering for some wide open seas and some fishing, so you slip the docklines and head off. And that’s the last anyone sees of you for 66 days.

At least, that’s what happened to Louis Jordan. He had been living in a marina aboard his sailboat, Angel, when he decided to head for the Gulf Stream, “where a lot of fish are.” He left the marina on January 23 after telling his family he was “going into the open water to sail and do some fishing.” Describing himself as “an inexperienced sailor,” Jordan found himself in a storm that dismasted his boat, and broke his shoulder.

Jordan’s father, Frank, notified the Coast Guard in Miami on January 29 that he hadn’t seen or heard from his son in a week. One week later, Jordan was still missing. Alerts were issued from New Jersey to Miami to be on the lookout for Jordan and his sailboat. On February 8, a search was begun but was abandoned after 10 days when no sign of Jordan or the Angel had been found. Despite reports from other sailors claiming to have seen Jordan’s sailboat, none of the sightings was confirmed, and the case was suspended. Jordan hadn’t filed a float plan so there was no way to narrow down his whereabouts.

It turns out that Jordan spent more than two months living on rainwater, fish he netted from around the boat, and some food he had stored for his voyage.

On April 2, the Coast Guard’s Fifth District Command Center in Portsmouth, Virginia, received notification from a German container ship saying they had spotted a man and a sailboat some 200 miles east of Cape Hatteras.

The crew of the German ship, the Houston Express, took Jordan aboard. A Coast Guard MH-60 Jayhawk helicopter crew launched from Air Station Elizabeth City, in North Carolina, and hoisted Jordan from the deck of the ship before flying him to Sentara Norfolk General, where he was recovering from a shoulder injury and dehydration. Next time Jordan has a hankering to go fishing, we’re betting he’ll file a float plan.

What could possibly go wrong?

Here’s our newest photo to challenge you to find out what could possibly go wrong. It’s obviously a bilge area, and it has at least four safety-related issues. See if you can find them. They may be American Boat & Yacht Council (ABYC) standards violations, USCG violations, or just things that make you say, “Really?”

We’ll post the answer in the next issue, along with a new challenge. For those who can’t possibly wait for the next issue, we’ll also post the answer on the Seaworthy magazine website.
The Afterdeck: Slow And Steady

No one knows quite how long ago man first balanced on a log, discovered he could float ... and then realized he was really far away from shore ... and found out he couldn’t swim. But the evidence suggests it was a very, very long time ago. The oldest boat ever recovered was a “logboat” that is believed to have been carved around 10,000 years ago somewhere in what is now the Netherlands. Long before that, our ancestors colonized places that scientists assure us could only have been reached by floating there on something – Australia 40,000 years ago, Crete 130,000 years ago, and the Indonesian Island of Flores where ancient artifacts have been found that date back 800,000 to 900,000 years.

We can be pretty sure that once ancient humans figured out how to craft vessels that could be more or less depended upon to stay afloat, we wanted to do more than drift with wind and current. Dugout canoes gave way to more sophisticated boats with rudders, oars, and sails. By 2500 BC, the Egyptian pharaoh Khufu (better known as Cheops to the Western world) was buried with a ceremonial “barge” 20 feet wide and 143 feet long.

But oars and sails could take us only so far. The great European voyages of exploration were done aboard ships that averaged about 4 knots, the pace of a very brisk walk or very slow jog. No surprise that when steam technology came to ships in the late 1800s, sail all but disappeared in a few short decades. Today we have boats breaking speed records over 200 mph, and recreational power boats with three or four engines regularly buzz around at highway speed.

No question: Fast is fun. But when it comes to safety, returning to our seagoing roots and slowing it down to walking pace is definitely better. Our brains are better able to keep up with the pace they’ve been used to for most of our evolutionary development. Our reflexes don’t react soon enough after driving cars on roads where things like friction work differently than on the water. With no brake pedal to stomp on and inertia working against us, boats tend to be objects in motion that stay in motion – until they encounter an object not in motion. That’s when photos like this show up in our claim files.

So, please, take it slow this upcoming 4th of July weekend. Give your lizard brain every possible chance to do the right thing. Sure, open up the throttle when you’ve got miles of water around you. But when you’re maneuvering after the fireworks, a walking pace is best. And when you’re heading in to the dock in a crowded marina, you’re going too fast if you’re not bored. Far better to get there slowly than not to get there at all.