Modern Lightning Protection on Recreational Watercraft

While you can’t prevent a strike, there’s a lot you can do to mitigate – or even prevent – damage

By James Coté

The recent advances in electrical and electronic systems have revolutionized recreational boating. Vessel operations have been simplified and the boating experience enhanced due to the integration of electronics into almost every onboard system, from navigation and communications to propulsion and maneuvering. Complex engine electronics known by various names including Engine Control Unit (ECU) and Engine Control Module (ECM) have increased performance and reduced emissions on modern engines. However, these advances have come at a cost. Many 21st-century boaters depend on electronic systems to navigate and maneuver their boats, and many modern engines will not function if their electronics are compromised. That makes modern mariners and their boats vulnerable to a lightning strike that damages these now mission-critical systems, potentially leaving the boat dead in the water without navigation or communications equipment.

Continued on page 4
Long-Term Corrosion Inhibitor is specifically formulated to prevent rust and corrosion. I’d give that a try. Lastly, ensure that those hose clamps are of good-quality stainless steel. Many are not, and they’ll degrade prematurely in a wet environment.

Roger J. Nolfe
Ticonderoga, NY

WATER HEATER ALERT
On page 13 of the latest Seaworthy you pass off water heater maintenance with a shrug, “… after all, there are no moving parts.” Wrong! You go heavy on the closed valve on the pressure-relief line, but totally ignore the pressure-relief valve itself: a moving part. That item should be cycled at least annually to assure it is functional and not jammed with scale. Then there is the gas valve: also a functioning, moving part. Or if the heater is electrical, there is a switch and its associated heavy wiring. So, please go back and give the water heater its due. There are a lot of moving parts, wiring, and piping associated with a water heater that need to be tended to.

Richard Siorek
Sterling Heights, Michigan

MATERIALS MISTAKES
The very first sentence of “Fire Away” in the October issue of Seaworthy seemed to contradict my long-understood concept of combustion: i.e., that there are three necessities: fuel, ignition, and oxygen. Somehow, the last of these was left out of the article. Perhaps it was obvious that oxygen (in air) is around and in boats, but it is required for combustion. As an aside, spontaneous combustion can occur without an obvious source of ignition; I once had such an experience. I sat on a fuel-soaked timber while working on the bottom of my boat, went home, took off my stained pants, showered and returned to see my pants smoldering on the floor. After taking them outdoors, they burned!

Peter Loysen
Silver Spring, Maryland

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You are, of course, correct that oxygen is needed for combustion, and that many fire-suppression systems work by depriving the fire of oxygen. As you surmised, we focused on the ignition source and the fuel source as being the two ingredients that are normally missing, while oxygen is, except in very rare cases, not the inhibiting factor on a boat.

We do sometimes see cases of spontaneous combustion on boats. In that case, we could argue that the ignition source was the heat required to bring the combustible material to ignition temperature. Without that, spontaneous combustion would not occur, no matter how much fuel and oxygen you have.

On page 5 in the 2nd to last paragraph of “DC Electrical Fires” it is stated, “… batteries were hooked up in parallel instead of in series.” If you are dealing with 12V batteries and you hook them in parallel you will remain at 12VDC, but you will have as much amperage that both batteries can produce. This is perfectly fine with the exception of isolation charging. If you hook two or more 12V batteries in series you will create 24+ volts! Doing so will cause smoke to escape from your electronics and could start a fire.

Paul & Karl Schueztow
Vermilion, OH.

Several readers caught our mistake.
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LUBRICANTS ROUNDUP
I always enjoy your articles, and you always have good new information. Question about lubricants to slow down rust: I have hose clamps in the bilge which look to have a light rust buildup that I wanted to treat. I understand that some treatments could hurt the rubber hoses that they are holding. Comments about where you should not use these lubricants?

Joel Matthews
Osterville, Massachusetts

John Tiger writes: You can simply use good ol’ WD-40 to protect these clamps and slow down rust. According to their website, WD-40 is designed for use on rubber surfaces so it will not harm or degrade your rubber hoses. Furthermore, WD-40 now has “WD-40 Specialist” products available, designed for specific functions, one of which, called

Long-Term Corrosion Inhibitor, is specifically formulated to prevent rust and corrosion. I’d give that a try. Lastly, ensure that those hose clamps are of good-quality stainless steel. Many are not, and they’ll degrade prematurely in a wet environment.

The author recommends Never Seez for wheel lug nuts and other similar fasteners. While anti-seize compounds are great, some fasteners are required to be torqued to a specification dry. I learned this the hard way after snapping several lug bolts on a vehicle and discovering that the manufacturer specified the torque for the lug nuts dry. I thought I had bad lug bolts, but the anti-seize compound made the reading on the torque wrench much lower than it actually was. Moral of the story is to check the manufacturer’s specifications and realize that you may be applying a lot more torque to a fastener using anti-seize compounds.

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We enjoy the timely articles in every issue of Seaworthy. We usually read the whole publication the same day that we receive it. Regarding the article in the October issue, “Watch Your Wake!,” we would like to share something that seems to work for us. Instead of yelling over the VHF at the bozo who passes too close and too fast, we calmly say something like this: “Securite, Securite, Securite. This is Dharma. This is a warning to all vessels transiting between Dodd Narrows and Nanaimo. The 45-foot Bayliner Rocket Ship is traveling northbound at a high rate of speed creating a very dangerous wake as it passes close by other vessels. Vessels between Dodd Narrows and Nanaimo should be on the lookout for the substantial wake that Rocket Ship is creating.” If we can’t read the name we just give a good description. In our experience, the vessel usually slows down.

Gary and Patty Ritzman
Mercer Island, Washington

To the gentleman who wrote the wake article, a big thank you. I built a 28-foot trawler tug that is quick to roll. The summers here in Puget Sound, Washington, are busy with boats of all descriptions; the worst are those with huge stern wakes. They seem to go from point A to point B with no regard for who or what is around them. I may make copies of your article to hand to them if I see them in the same harbor.

Richard Hanenburg
Puyallup, Washington

MORE MARINE CORROSION 101
I enjoyed your excellent article on corrosion by Ed Sherman in the July issue. The availability and use of aluminum for cathodic protection has been very slow in coming. We live on our boat for four or five months in the upper Chesapeake Bay (very low salinity) and the rest of the time on the East Coast and in tropical Atlantic waters. While in the Chesapeake, I have noticed a hard coating buildup on my zinc fish, and I am considering shifting to an aluminum fish. In addition to the fish, I currently have zinc anodes on my rudder strut and propeller shaft as well as in my engine and generator. Would using an aluminum fish concurrently with my installed zincs anodes have a detrimental effect on the boat’s cathodic protection, or would the zinc just try to protect the aluminum fish? Should all anodes be changed when moving from saltwater to fresh/brackish water for an extended period of time?

Harry Keith
Marathon, Florida

Ed Sherman responds: Based on what you have told me, you will be best off using the aluminum anodes exclusively, though it is a bit of a challenge in some cases to find aluminum anodes for specific purposes. But it should be your goal to switch to aluminum for everything as you can. You won’t harm your cathodic protection system per se by having a blend of zinc and aluminum anodes. But you will be “confusing the system,” for lack of a better phrase. Why? Because the effective potentials of the materials are different, and therefore they will sacrifice at different rates. The zinc, in fact, may simply coat over in the brackish/freshwater environment. Once they pacify, their ability to even function as a sacrificial anode is typically gone without roughing up the surface to get new zinc exposed. Aluminum functions well in both brackish and saltwater.

Van E. Moore
Gibsonville, North Carolina

Raul Chacón responds: The short answer is that yes, a lawsuit can be filed, but the difficulty may lie in identifying the culprit. With that many boaters, a potential defense could be that it was not their wake, but that of someone else. Wakes may also be amplified when in synch with other wakes, thus the possibility for multiple parties at fault. Hopefully, a friendly discussion with the operator can preclude the need for legal action.
Unfortunately, sensitive electronics on boats have become increasingly vulnerable to lightning strikes, yet lightning-protection systems have not kept pace. It’s not that there haven’t been significant advances in lightning science since Benjamin Franklin developed his theories on how to protect barns and livestock. The National Fire Protection Association, Underwriters Laboratories, and industries which are significantly at risk from lightning, such as telecommunications, wind generation, aviation, and fuel, have achieved consensus on the science of lightning protection and have embraced new protocols and practices. But the recreational boating industry has been slow to adapt those changes to the marine environment. There are at least three reasons for that.

First, corrosion and motion on board boats, as well as limitations with respect to weight, space, and geometry, make lightning protection more challenging than in shore-side installations. Second, the mandate of the standards body for the industry, the American Boat & Yacht Council (ABYC), focuses on protecting life; protecting equipment has been a lower priority. Third, there has been strong disagreement between professionals about the best way to mitigate damage in a lightning strike and precious little data to support one point of view over another. The sometimes-raucous debate surrounding certain unproven lightning-protection devices and such theories as “fuzzy” lightning dissipation terminals and early-streamer emission terminals, as well as unorthodox placement of grounding terminals (a.k.a. grounding plates), have sharply divided the recreational boating technical community, all of which makes consensus on lightning protection difficult, if not impossible.

This lack of guidance is frustrating for those with boats at risk. While a runabout in Portland, Oregon, or a daysailer in Portland, Maine, may have little risk of lightning damage, larger vessels (particularly sailboats) in such lightning-prone areas as the Chesapeake Bay or Florida absolutely should be protected using the best technology available. Any marine-insurance adjuster can attest that the potential for loss on these vessels can be great. The National Fire Protection Association made some fundamental changes to the watercraft chapter of NFPA 780: Standard for the Installation of Lightning Protection Systems in 2008 that incorporate the thinking that has become accepted in other industries. While the recommendations in NFPA 780 have yet to be embraced by the recreational boating industry as a whole, understanding what it says — and why — may assist you in developing a lightning-protection plan for your boat.

**LIGHTNING 101**

The simplest way to think of a lightning strike would be as a short circuit between the cloud and the earth. The earth and an active thundercloud have either a positive or a negative polarity with respect to each other, just like battery connections that can arc if they are not separated by a long enough air gap. Whether the positive charge is in the cloud or on the water may have great importance to a physicist, but matters little to the cow in the barn or the VHF radio antenna on the mast.

The important point is that the earth (or in our case, the water) contains an unlimited supply of positive and negative charges; it is the thundercloud that induces the charge concentration in the water. For example, if a large concentration of negative charge coalesces in a storm cloud over the ocean, a large concentration of positive charge is drawn to the very top surface of the water directly beneath it. (Opposites attract.) Since air is a good insulator, no electricity will flow between the cloud and the water unless the airborne charge loses altitude, moves close enough to the surface of the water, and the lightning jumps the gap. If an electrically conductive material, such as an aluminum tuna tower or mast, stainless steel rigging, or a long vertical copper wire, comes between the cloud and the water, then the gap that must be jumped becomes shorter. The boat short circuits the voltage, much like a wrench across battery terminals.

Because boats are built from electrically conductive components installed between the water and the areas aloft (masts, rigging, antennas, towers, support structures, electrical wiring), a lightning strike is inevitable if an active thundercloud containing electrical charges passes overhead at a low enough altitude. How much damage the lightning strike does to the boat depends upon how easily the electrical energy from the strike can find its way through the boat to ground. There will be a lot less damage if the discharge is contained in a well-designed lightning-protection system than if it takes a detour through the ship’s wiring and sensitive electronics on its way out of the boat.

This is a basic concept that surprises many boaters: A lightning-protection system is not designed to prevent a lightning strike, but rather to provide a safe discharge path for the lightning. This is the only viable solution for lightning protection (short of going back to wooden ships, kerosene lamps, and sextants). The technology to prevent lightning strikes does not yet exist.

Still, there are devices out there claiming to do just that. Lightning dissipaters (LDs) look like metal bottle brushes
or frayed paint brushes and are installed on the top of the mast. The hypothesis is that the numerous conductive points on the LDs safely dissipate accumulated charges so the lightning strike will not occur. As far as I am aware, not a single independent testing laboratory has confirmed the effectiveness of lightning dissipaters as lightning preventers.

Early-streamer emission (ESE) terminals have also gained traction in some circles. Fancy lightning rods often shaped like a torpedo that usually come with electronic circuitry, these are supposed to attract lightning better than a standard lightning rod, (also called an air terminal) to ensure that the lightning strikes the grounding path rather than what is being protected. Once again, I am not aware of any independent studies validating the effectiveness of these devices.

Lightning-protection systems actually function by acting as the "best" short circuit between the cloud and the water, one designed to lead the lightning harmlessly to ground. The system accomplishes this in two ways: by attracting lightning away from more destructive pathways between cloud and ground, and by sending the charge around, instead of through, what it is protecting.

The first concept has traditionally been known as the “cone of protection” or the area protected by an air terminal from a strike. Traditionally, the cone of protection has been thought to include a circle centered on the base of the air terminal whose radius equals the height of the terminal and to extend from the top of the air terminal to the ground at a 45 degree angle. In fact, the length of the final jump that lightning takes before striking the air terminal is about 30 meters. Recent research suggests that the actual area protected can be defined by an imaginary sphere with this radius that is “rolled” up to the air terminal. All objects inside the imaginary sphere will not be protected by the air terminal, which means the area protected often differs in size and shape from the cone of protection model.

Modern lightning protection for airports and power plants use the rolling sphere method and place air terminals so that the areas of protection overlap and include any sensitive equipment that would be damaged by a strike.

The second concept will be familiar to many as the Faraday cage. As early as 1836, Michael Faraday discovered that objects surrounded by metal were protected from lightning (explaining why we are safe from lightning while in our cars). Many old-school sailors have used Faraday’s discovery to good purpose when they placed sensitive electronics in the oven during a lightning storm (with the oven off, of course.) This practice can be significantly updated by placing sensitive electronics in the microwave oven!

21ST CENTURY LIGHTNING PROTECTION

Benjamin Franklin pioneered lightning protection in 1749 with the invention of the lightning rod, and, when it comes to recreational boats, until recently, little has changed. Under his model, the lightning is attracted to the lightning rod, which then passes the lightning current harmlessly to a submerged metal plate (grounding terminal) via special wires (down conductors) that are installed specifically for this purpose. Side flash conductors connect any large metal structures to the grounding plate to prevent secondary flashes from these metal structures.

NFPA 780 draws much from the old-school system while incorporating improvements based on the modern understanding of lightning protection. While solutions will vary depending on the boat, let’s talk about the basics.

Air terminals (lightning rod or Franklin rod) should be installed at the highest points of masts, towers, etc. On a sailboat a single air terminal could be bolted to the mast; on a sportfish it could be bolted to the tower and made to look like an antenna. This should be higher than anything you are trying to protect from a lightning strike, such as a VHF antenna.

A heavy electrical conductor should be connected from each air terminal directly down to a grounding point on the hull. In the case of a sailboat’s mast, aluminum is a good conductor, so no separate wiring run needs to be installed. (Note that the wiring inside of the mast will be protected due to the Faraday effect.) An aluminum tower will work the same way on a sportfish so long as the legs are connected to an adequate grounding plate. Where no aluminum structure exists to act as a down conductor, a 4 AWG wire or larger should be run from the air terminal to the grounding plate in as straight a run as possible and well separated from other wiring.

The grounding point should be a corrosion-resistant
metal plate installed on the exterior of the hull below the waterline. The plate should be at least one square foot in size and at least 3/16 of an inch thick. Research shows that most of the electrical discharge occurs along the edges, so a long, narrow plate, especially one with grooves cut in it, will be most effective at dispersing the charge. A new major point of contention is where to install the grounding plate, or plates. Some research indicates that a location at or near the waterline is by far the most effective solution. On a sailboat, the lead keel can be used as the grounding plate if the keel is not fiberglass-encapsulated or covered in fairing. If the mast is solidly keel stepped, there would be no need for a separate conductor from the mast to the keel. Metal rudders or propeller struts are also acceptable as grounding plates.

PROTECTING ELECTRONICS
Surge-protective devices (SPD) or transient voltage surge suppressors (TVSS) should be installed on all equipment that’s mission critical, expensive, difficult and/or prone to lightning damage. Examples include the ECU/ECM, alarm systems, chartplotters, and instruments.

TVSSs are the most exciting development in the field of lightning protection. These semiconductor devices provide protection by suppressing lightning-related voltage spikes. They are widely used in the telecommunications, wind generation, and avionics industries.

TVSSs are connected across the input terminals supplying voltage to a piece of equipment; they can be thought of as fuses that react to voltage instead of current. The TVSS is an open circuit as long as the supply voltage feeding the equipment is in the normal range. However, if a lightning strike causes a momentary voltage spike and puts, say 1,000 volts on a 120-volt device, the TVSS will “clamp” or short circuit 880 volts and convert it to heat. The excessive heat could, and probably would, damage the TVSS; but destroying a $250 surge arrester to protect a $5,000 engine controller is good engineering.

Voltage surge protection would be prudent for engine controls, navigation systems, steering systems, and shorepower systems. TVSSs come in many voltage ratings, energy ratings, response times, and so on. Some are designed to protect whole distribution systems, while others are suitable for individual equipment protection only. A well-designed system includes cascaded protection, with extra protection on mission-critical and lightning-prone equipment, such as main engines and shorepower systems. The key to a reliable and cost-effective system is to ensure that appropriately rated devices are specified and properly installed. The best TVSS in the world will be ineffective if it is not connected properly.

Despite the best technology, there can still be challenges with an NFPA 780-based system, particularly when the system is improperly or only partially installed. For example, if the air terminal is installed lower than an adjacent antenna, it will not protect the antenna; in that case, the antenna cable carries the lightning current. Also, if the down conductor is connected to the bonding system rather than directly to a dedicated grounding terminal (ground plate), the lightning strike can energize the entire bonding system before discharging into the water. Another common mistake is to secure the lightning down conductor to other wiring. The high current from a strike through the down conductor can result in voltage surges in these adjacent wires, leading to additional damage in equipment that would otherwise be completely unaffected by the lightning strike.

IN CONCLUSION
The recent revolution in marine electronics demands an evolution of our thinking on marine lightning-protection; equipment protection should be an important aspect of any modern lightning protection system. The knowledge and resources to safely transform this change in thinking into reality are readily available, both from the NFPA and industries also at risk from lightning. However, there are unique challenges on pleasure craft that are not addressed by others. These must be solved by sharing the experiences of lightning-protection systems and their effectiveness across the industry.

James Coté is an electrical engineer, ABYC Master Technician, Fire Investigator and Marine Investigator. He operates a marine electric and corrosion control consulting firm located in Florida. For more information, go to: www.cotemarine.net
Inspecting Your Sailboat Rigging

Here’s how to go over your rig with a fine tooth comb

By Dylan Bailey

If there’s one thing production sailboats have in common, it’s that nearly all of them use stainless-steel standing rigging, whether wire or rod. There are likely also stainless steel fittings, chainplates and turnbuckles. Stainless steel is a great material for rigging but has its Achilles heel: corrosion. Stainless steel in a saltwater environment will eventually suffer from some form of corrosion, whether it’s stress-crack corrosion, fatigue cracking or crevice corrosion. Sailboat rigging in freshwater may also suffer from stress and fatigue cracking (see sidebar). What might appear to be a small crack or area of pitting will degrade the fitting by eating away at the metal. Any cracks or corrosion will weaken the fitting, and the failure of a single fitting can bring down a rig.

The mast should be tuned annually (the stays tensioned properly to ensure the mast is in column or aligned without any bends) and any time the mast is put back into the boat after it has been unstepped. A quick inspection of the rig for obvious issues (bad fittings, frayed wires, etc.) should be done whenever the mast is tuned. When should you begin inspecting the rigging more than casually? It is not easy to set a timeline: boats in the cool north that are only used part of the year will not have the same potential for corrosion as boats used in the warm, humid south. My recommendation is that any standing rigging more than 10 years old should be carefully inspected annually and before any long offshore passage. For boats that are used year-round, I would recommend inspecting the rigging at five to seven years. Because of the higher stress on their rigging, multi-hulls should be inspected at five years.

So, let’s get to it. For our rigging inspection we will need the following tools: a bosun’s chair or climbing harness, a Scotch-Brite pad, a magnifying glass, and a camera with a macro setting. The macro setting will allow you to take close-up photos that can be enlarged on your tablet or computer after your inspection. When taking your photos, make sure you know where on the rig they are located. Taking a quick note along with the photo will help clear up any confusion later.

1 Start by taking a look at the overall rig. Sight up the rig from deck level. How is the geometry? All stays and shrouds should be run without any bends and at even angles. Are there hard spots or kinks where a stay has an awkward bend? Standing in front of the mast, sight up from the base. Is the mast in column (straight)? There should be no bends in the mast side-to-side or facing forward. Walk around to all of the shrouds and stays and give them a pull. They all should feel roughly at the same tension. To be accurate, you would want to use a tension gauge. But when I first start inspecting a rig, I’m mostly trying to get a feel if anything appears to be dramatically out of tune.

2 Next we want to pick a place on deck to start inspecting all of the deck fittings and wire; this can be bow, stern, or midship. If the mast is deck-stepped, start at the base, looking for corrosion on the step and cracks in the base of the mast. Then working clockwise to make sure you don’t miss anything, inspect all fittings...
from eye level to deck level including swages/mechanical fittings, turnbuckles, chainplates, and toggles. Start with the wire at eye level, and scan downward, checking for rust and broken strands. For rod rigging, we’re looking for cracks or corrosion. Take a good look for corrosion where the wire enters the swage or mechanical fitting. Next check the t-bolts, tangs, turnbuckles, and pins. Clean any rust off with the Scotch-Brite pad. This is important: anything more than light rust staining could be an indication of crevice corrosion, which weakens the metal. You may not be able to remove all of the rust, but you do need to see the underlying metal. Use your magnifying glass to look for cracks and pitting on the fitting. The turnbuckles should be straight without any bend to them. Inspect the condition of the threads of the stud. Ensure the turnbuckles have locking pins. Photograph the fittings, especially where you think you have sighted a crack or pitting. Get up close with the camera on the macro setting and make sure that the area of concern is in focus; this is important later for when you enlarge the photo.

Pay close attention to the chainplates. Inspect the caulking where it enters the deck; it should not be cracked or peeling. Look for cracks in the chainplates on the edges and especially around the pinholes. For external chainplates, inspect along the edges for cracks and rust blooms. A small amount of rust may be OK; it might just be staining, though it should still be investigated. But significant rust is a sign that there may be crevice corrosion, which is a reason to pull and inspect the chainplates. Unfortunately, the area that is probably affected the most is buried and not visible unless the chainplate is removed. Stainless-steel corrosion happens much faster when there is no oxygen present – like where the chainplates pass through the deck, which is why we’ll inspect them belowdecks as well.

Now we’re going to inspect all attachments to the mast and boom that are on deck and at eye level. Inspect the gooseneck fitting for the mast and the vang attachment for corrosion or cracks. Any attachment points on the boom for running rigging also need to be inspected. Again, take close-up photos if you find any problems. Check all blocks to make sure they turn freely. All shackles should be secured with seizing wire. The winches need to turn freely and stop when the direction is reversed. Do the line stoppers stop the line? Give the line a good tug with the line stopper closed. There should be no movement. Inspect each piece of the running rigging for wear. What is the condition of the halyard and the safety line (a second halyard) you will use for going aloft? Don’t take chances here.

Before going up, let’s go inside the boat to inspect the condition of the mast step if it’s belowdecks. Mast steps here are often in a damp environment, and a lot of mast steps are made from non-stainless steel on older boats, which can rust. Some boats have an aluminum mast step. If the step or base of the mast is corroding, it will have
white powder on it. Remove the powder and look for pitting underneath. If you find pitting here, or on any other aluminum fitting, such as the mast or boom, have a rigger follow up with a professional inspection.

6 EVEN IF THE mast is deck stepped, we will still want to go below to take a look at the chainplates. Are there signs of water intrusion on the bulkheads? You might have to remove some cover panels to gain access to the chainplates. Are there signs of rust? Clean any rust with your nylon pad. Use a flashlight and your magnifying glass to inspect the chainplate carefully. Pay close attention to the edges of the chainplate for rust and cracks. Cracks and corrosion can develop behind the chainplate and where it passes through the deck. Again, these are areas that are deprived of oxygen where crevice corrosion will develop. Chainplates don't last forever, and if you want to be absolutely sure you can count on them, I'd recommend replacing them after 20 years of service or if there are any signs of crevice corrosion, which can happen in less than 15 years in harsh environments.

7 NOW THAT WE have inspected everything at deck level and below, and you found no deficiencies that would keep you from going up the mast, then it is time to do so. If you are not comfortable, then I recommend having a professional rigger conduct the aloft part of the inspection. Never do this by yourself, even if you have a hoist that allows you to do so. Have someone there to assist you and to manage your safety line. For the aloft portion of the inspection, work your way up from the bottom, rather than starting at the top. This way, if you are at the spreaders and find a cracked swage fitting, you can make the decision to stop. This part of the inspection will be conducted in the same manner as the lower fittings and chainplates, this time also paying close attention to where fasteners are installed into the mast. On an unpainted aluminum mast, we are looking for the white powder and pitting which are signs of corrosion and can lead to hairline cracks. Again, if you clean the powder away and find pitting, you'll need to have a professional rigger take a look. On a wooden mast, you're looking for soft wood and discoloration where the fastener goes into the wood. For carbon fiber you're looking for cracks. Inspect the spreader ends and tips for wear and the condition of the boots.

8 THOUGHT YOU WERE finished? Not yet. Now go find somewhere comfortable and view all of your photos on a tablet or computer. Enlarge them to help find any cracks or pitting. This is why you took your photos in order and made notes about what was what. Discuss any of your findings that concern you with a professional rigger. Save all of your photos in a file so you can compare them the next time you do the inspection.

Now that you've done a bottom-to-top rig inspection, you can feel more comfortable the next time the wind pipes up. At the beginning of each season, take an hour or so to re-inspect the rig, focusing on the areas you might have noted to keep an eye on.

Dylan Bailey is a marine surveyor with more than 30 years in the marine industry.

STAINLESS STEEL FAILURES

Stainless-steel rigging under heavy stress can have stress cracking or fractures that will often be identified by hairline cracks. These cracks will lead to stress-crack corrosion and crevice corrosion in the saltwater environment. Crevice corrosion can also develop in areas of pitting when the stainless steel is devoid of oxygen. This is the most common form of corrosion on a stainless-steel chainplate. This chainplate was cut in half to demonstrate how far the pitting went into the metal.

Painting chainplates is a bad idea because it hides corrosion. Once rust is visible through the paint, the corrosion is severe, and the chainplate will need to be replaced.

Broken wire at swage fitting on a catamaran mast head.

Dylan Bailey is a marine surveyor with more than 30 years in the marine industry.
Fires on boats tend to occur most frequently around the engine, whether the engine is an inboard or an outboard. That's because the engine is the place where fuel, in the form of gasoline or diesel, and an ignition source, in the form of heat or spark, are most likely to come together. On an inboard, that means fire most commonly originates in the boat's engine room (“Fire Away,” October 2015). On an outboard, fire often start under the outboard cowl. That difference is significant. It means that an engine fire on an outboard-powered boat is far more likely to be noticed earlier, is far more contained, and is far easier to control than on an inboard. Fires also start in the DC electrical system, including the battery and wiring, though it's usually easier to get quick access to those areas than it is on an inboard-powered boat. Here are five most common causes of fire on outboard boats and recommendations on how to avoid them.

1. **Regulator meltdown.** Twenty-nine percent of fires on outboard boats start somewhere in the engine electrical system (Figure 1). The vast majority of those start due to a failure in the voltage regulator or the electrical connections to it. This eventually causes heat or a spark that ignites the fuel or even the fumes under the cowl. The good news is that the incidence of fires associated with voltage regulators is almost nonexistent on engines less than 10 years old. We begin to see these fires as the engines age beyond 10 years, and the incidence increases dramatically after 15 years. While the overall incidence is still relatively low, voltage regulators on many engines are not that expensive or difficult to replace. If it's easy to replace on
your engine, a new voltage regulator may well save you a 
call to TowBoatUS and a long, boring ride home at the end 
of a tow line.

2 \textbf{BATTERY SWITCHEROO.}\ As is the case with in-
board boats, the second biggest source of DC elec-
trical fires is in the battery wiring. Half of those are 
operator error – reconnecting the batteries wrong in the 
spring. That might mean crossing positive and negative, 
shorting out the posts with a metal tool, or reconnecting 
in series when they should have been in parallel. If you’re 
disconnecting your batteries for any reason, photograph the 
configuration with your phone first, label the battery cables, 
and mark the positive post with red fingernail polish.

3 \textbf{MISSED CONNECTIONS.}\ Before you reconnect 
those batteries this spring, take the time to inspect 
battery connectors for pitting or rust, and to make 
sure the battery connectors are the appropriate size for 
the posts. Loose connections, chafed battery cables, and 
shorted switches all cause a few fires from time to time, and 
preventing them is simply a matter of regular inspections 
and conscientious maintenance. Battery connections should 
be inspected and tightened at least twice each season.

4 \textbf{LEAKY LINES.}\ Eleven percent 
of outboard 
fires are caused by 
some sort of a fuel 
leak. Most often hose 
clamps loosen due to 
gine vibration until 
fuel begins to seep 
out from around fit-
tings. This is usually 
not hard to spot if you 
take off the cowl. Look 
for shiny fuel lines, 
and sniff around for 
the telltale odor of raw 
gasoline. Tighten any 
loose hose clamps, or 
replace them if they are the small clip-type that are easily 
damaged. Rubbing the hoses with a cloth and smelling it 
will alert you if the hoses are becoming permeable and need 
to be replaced.

5 \textbf{CHARGE IT RIGHT.}\ While most outboard boats 
don’t have an AC electrical system, most do get 
hooked up to AC at some point to charge the batter-
ies. Fires result from using non-marine chargers that lack 
the proper settings to keep marine batteries at a proper 
float rate without overcharging them. Automotive char-
gers should never be used on boats. Not only do they lack 
sophisticated float settings, but many are not ignition pro-
tected. If the charger is in an enclosed area and fuel fumes 
accumulate, a fire or explosion can be the result.

Finally, be aware of where you leave your boat when stor-
ing it. The few total losses for outboards from fire in the 
BoatUS Marine Insurance files almost all resulted from 
storing the boat near something that burned, most often a 
barn or a garage.
KEEP YOUR SCUPPERS CLEAR THIS WINTER

Winter in most parts of the country means freezing temperatures, which means ice. Expanding ice can sink a boat in several obvious ways, such as cracking a strainer or thru-hull fitting. But it can also block a cockpit scupper, allowing the weight of subsequent snow and rain to push the stern of the boat down enough to cause water to backflow through fittings or exhaust openings. When enough water backflows, the boat can sink. Even if your boat is stored ashore, clogged scuppers can cause damage when accumulating water finds its way into the interior.

The best way to keep scuppers ice-free in the winter is to make sure they’re clear of debris so water drains quickly without freezing. And the best way to do that is to visit your boat often to check them. Even if you cleaned the drains last autumn, you’re liable to find that leaves and other debris have mysteriously found their way back aboard. Installing a $2 mesh designed to fit into a roof’s downspout can help keep your scuppers flowing between visits. You can make your own or buy one like the Expanded Leaf Strainer shown here. It’s made by Amerimax and is available at home supply stores like Lowes and online at Amazon.com.

BATTERIES AND COLD WEATHER

For those of you in California, Florida, and the Gulf States (lucky readers in Hawaii can pretty much ignore this), chances are that even if temperatures don’t go below freezing, it can still get cold enough to affect your battery’s performance. The last thing you need if you’re heading out into chillier waters is a dead battery and no way to get home. To start with, flooded-cell batteries will lose up to five percent of their charge each month in cool weather, so if the boat is sitting and the batteries are not on a charger, you’re already at a disadvantage. Even more importantly, batteries lose up to 35 percent of their capacity when temperatures fall near freezing, so older batteries that do fine in warm weather may not be able to generate enough amps to turn the engine over in cold weather. In addition, the engine oil is more viscous, so it takes more energy to crank the engine in the first place. If you’re uncertain of how much capacity your battery still has, take it to an auto parts store, and have it load tested. Keep each cell filled with distilled water (for wet cells only; AGM and gel batteries are sealed), and clean and tighten the lug connections to deliver as much electricity as possible to the starter.

SHOREPOWER FAIL

If you leave your boat in the water this year, chances are you’ll be plugging into shorepower. But before you do, inspect the connection to your boat. A recent Seaworthy study found that 17 percent of boat fires were attributed to the AC system, and the shorepower system was responsible for many of those. Shorepower inlets are exposed to water, and the connections are subject to vibration and corrosion. A particularly vulnerable link is the terminals at the back of the boat’s shore-power inlet where the boat’s wiring is connected. Those terminals are also usually surrounded by combustible material. An overload in the shorepower system can easily overheat these wires and cause a fire. This winter, inspect your shorepower inlet. If you see discolored contacts, stop using the cord immediately and fix or replace it. It’s very possible that the inlet wiring inside the boat is damaged, so inspect that as well. Be careful not to overload your shorepower system with high-amperage appliances. (This is yet another reason to never use a heater to winterize.) Check along the cord, too, and look for gouges and crushed spots that can create heat.
WIRE NUT FAIL
We’ve said many times in these pages that crimping is the proper way to make wire connections. Crimping mechanically grips the wire strands so they won’t easily come out, and the sealed type protects the connection from corrosion, which can lead to heat or failure of the circuit. Wire nuts – the kind used in cars and around the house – should never be used on boats. While they’re easier to use (crimp connections require an inexpensive crimp tool), they simply don’t hold well. Wire nuts are designed to be used with solid wire, not the stranded kind used in boats. For a wire nut to tighten correctly, it must cut threads into solid wire. Wire nuts can’t tighten stranded wire adequately, and the nuts may actually cut some of the strands, leaving you with less wire and more resistance (heat). Finally, they are difficult to seal against water and corrosives. The bilge pump (left) was rendered useless when the installer used household wire nuts and the connection simply came apart. The bundle (at right) has many broken strands, and the wires are corroded.

WINTER FUEL SYSTEM CHECK
The Seaworthy editors spent a great deal of time in the claim files in the past few months looking for the causes of fire aboard boats of different types. Not too surprisingly, gasoline plays a role in many of those fires, if not in how they start, then in providing the fuel to keep the fire going. Deteriorated hoses, corroded hose clamps, loose fittings, and leaking fuel filters can all contribute to a fire. So if you have a gasoline engine on your boat, whether an inboard or an outboard, take the time this winter to get up close and personal with your fuel system and make sure everything is in good working order. This is a good time of year to get down in the engine compartment and simply sniff. If you smell gasoline when the boat has not been used for a few weeks or more, you definitely have a sneak leak. You need to track down where that smell is coming from. Start with the deck fills, if you can get to them, and trace as much of the fuel system as possible. Pay particular attention to the fuel filters, fuel pump, and fuel hoses. Old fuel hoses can become porous, allowing fumes to seep out that can be dangerous when the engine is operating. Wiping each fitting with a clean rag and smelling it will help you locate a porous hose or a small weep that might otherwise miss detection. Fix it and go into next season confident that gasoline is going to be where it should be – and not where it shouldn’t.
S
O, YOU’RE SAILING along off-
shore and suddenly you come
across this. Your first thought
is what the heck is it? Offshore water
slide? Drone landing pad? Super-secret
NSA spy project? If you said giant
ocean vacuum cleaner, you’re actually
pretty close. While not yet operational
(or even built) the Ocean Cleanup Ar-
ray is designed to funnel wind–and
plastic enter the ocean each year and
tend to accumulate where the currents
converge. Plastic, the company says,
kills hundreds of thousands of birds
and mammals every year and dam-
ages shipping and tourist beaches. The
idea is the brainchild of Boyan Slat, the
20-year old founder and CEO of The
Ocean Cleanup: (Note; some Seawor-
thy editors have foulies older than he
is.) Slat hopes to install the first system
near a small island in South Korea this
year. Eventually, the plan is to build a
60-mile-long system to clean up about
half the Great Pacific Garbage Patch,
between Hawaii and California.
www.theoceancleanup.com

M
ARINE SURVEYOR
Daniel Rutherford sent us
this picture of a not-so-
clever way to defeat an engine cutoff
switch (also
known as the
kill switch). The
idea behind the
switch, of course,
is that if the
operator, who
is attached by a
lanyard to the
switch, goes overboard, the lanyard
will pull out the switch and instantly
stop the engine. If you suddenly find
yourself in the water, the last thing
you want–especially if you’re alone on
your boat–is to see your boat continue
on (or, worse, circle back.) PWCs and
most outboard engines now have cutoff
switches, and many new inboard
and sterndrive boats do as well. De-
feating the switch is like keeping a
life jacket on the seat next to you
– it’s not going to help you if you go
overboard. “I guess as you are being
thrown out of the boat you are sup-
posed to reach down and grab the
vise-grips to activate the switch,”
said Rutherford. “Yikes!”
on the Hudson River, wanted to tell us about an incident that happened just as the cold weather hit the area last fall. A 30-foot powerboat with a couple on board, said Bill, went ashore at full speed, just across from his marina. Initially, it was thought the operator had a heart attack. Rescuers found the couple unconscious but alive on the boat after the incident. It turned out that the couple had put up the boat’s canvas as shelter from the cold and rain, but an exhaust leak filled the cockpit with poisonous carbon monoxide (CO), incapacitating them. Fortunately, the couple has recovered. As bad as the accident was, imagine, Bill said, if the boat had struck other boats in the water, or hadn’t run aground right away – the couple could have been killed by the CO. Seaworthy has often discussed the importance of a CO alarm below. But if your boat has canvas that can trap leaking exhaust, you should consider adding an alarm in a sheltered place in the cockpit as well.

If you read the news, it seems like there’s a frantic race on to develop driverless cars. Fortunately, boaters can escape such things on the water. Can’t we? Actually, according to the UK’s Nautical Institute, if you don’t want to share space with an automated vessel, you’re too late. Small autonomous vessels are already a reality for both subsea and surface work. But the move seems to be for larger and larger unmanned vessels, which will eventually impact recreational boats. Fortunately, the Institute says, it’s going to be a long time before merchant ships ply the waters unmanned, though more and more systems are being automated.

Admiralty lawyers will tell you that maritime law has its quirks. Established well over 200 years ago, before diesel engines, automobiles (and smartphones), the laws are mostly used for commercial shipping – but not always. Last year at a repair yard in Massachusetts, the owners of an old 41-foot wooden fishing boat disappeared after leaving it for repairs. The yard sued the owners for the work done and storage fees, but then did something a lot of people didn’t know could be done: they arrested the boat. Admiralty law allows a boat to be arrested for money owed because in Admiralty law, boats can be held responsible for debts – just like people. While this was a fishing boat, recreational boats can also be arrested for unpaid debts. While not common, a repair yard could arrest a boat during a dispute for payment. The BoatUS Consumer Protection department says that to avoid this outcome, it’s best to always pay your repair bill first, then dispute any charges or quality of work. That way you won’t have to worry that the US Marshals might knock on your door, looking for your outlaw boat.

While it may seem like your editors are obsessed with smartphones, we’re not really. Most of us here remember when phones had dials, and can remember (wistfully at times) when leaving the house meant leaving the phone. But the devices just do so darn much, and it seems like there’s always some new revolutionary must-have app. We can navigate with them, call for help with them, take videos, and now, maybe someday prevent seasickness. A new study in the journal Neurology showed that stimulating the scalp in specific areas with very low voltages tended to prevent motion sickness. The study postulates that smartphones could easily be adapted to this kind of treatment. Because 3 in 10 of us suffer from motion sickness, and 6 in 10 of us have smartphones, the odds may be in our favor.

Speaking of plastic trash, last summer, Captain Kevin Bell of Potomac Marine TowboatUS, was returning back to his base in Neabsco Creek, Virginia, when he saw an osprey hanging upside down on a channel marker. The bird was obviously in distress, and after getting close to the bird he could see why: one of its legs was tangled in fishing line. It wasn’t able to free itself, and had likely broken a wing as well. Bell contacted Virginia Fish and Wildlife, but they told him that they had nobody in the area to help. With a friend’s assistance, Bell brought the osprey back to Hampton’s Landing Marina. They contacted the Raptor Conservancy of Virginia, whose staff agreed to care for the bird. Sadly, the bird didn’t pull through. Captain Bell said this is the second time an osprey has died on the same marker from fishing-line entanglement. To find out more about fishing line recycling, visit: www.boatus.org/monofilament/
The Afterdeck: Avoiding the Winter Blues

You don’t want to be the owner of this boat. Think about it for a moment. You would have awakened to a lovely blanket of new snow, pristine white and sparkling, and a text from work that your office was closed for the day. You’d probably lounge around with your coffee, checking out your favorite sites on the Internet, and get caught up with your spouse. Then the phone rings and someone from your marina says, “Sorry to tell you this, but…”

Suddenly you’re having a bad day. While the guy from the marina drones on about salvaging the boat, you’re trying you’re trying to get your mind around the image of your baby under the icy cold water. When he asks who’s going to pay, the clenched feeling in your stomach almost disappears. You’ve got this. Juggling the phone with one hand and rifling through the contents of a file drawer with the other, you pull out your insurance policy. Then you notice the date in the upper right hand corner. October 15, 2015. Could it be? There must be another policy in the drawer. You can remember renewing … can’t you? But when you think about it, you actually can’t remember writing out the check and putting it into an envelope. You can’t remember calling BoatU.S. with your credit card information.

All those times you emptied your mailbox in the fall flash before your eyes. Those catalogs and circulars, those newspapers and envelopes you threw away without even looking at them… Could your renewal have been among them? Yeah, it could have been. Uh oh. Bad feeling. It almost certainly was. Renewing your insurance just slipped your mind.

Oh boy, now the dollars signs start dancing in front of your eyes. Thousands in salvage charges. The cost of leaning up a fuel spill. The damage to the boat. You bought insurance to protect you from these problems. Your day just went from bad to worse.

This didn’t have to happen. You could have signed up for automatic renewal, and your credit card would have been charged when your insurance premium came due. No lost envelopes, no missed payments, and no chance of not being covered on a bad day.

So be glad that you’re not the owner of this boat, and sign up for automatic renewal. Just give us a call at 800-283-2883, or go to our online service center at www.boatus.com/insurance/pay. Together we can make sure a bad day doesn’t get even worse.
Electrical Do-It-Yourself Uh-ohs

These common electrical mistakes can be more than a mere nuisance

By Frank Lanier

There’s no shortage of people who can do a good job slapping on a coat of paint or tune up an engine, but based upon marine surveyor Frank Lanier’s experience inspecting boats, the pool of qualified folks with the skill level to make electrical repairs and installations gets a lot smaller. Hopefully, you won’t find any of these cringe-worthy mistakes on your boat.

Jethro’s Sure-Fire Patented E-Lectrical Connection.

Boaters are a creative lot when it comes to solving problems afloat. Not only is the homegrown junction splice used in the positive battery conductor non-standard, it also leaves an energized bolt to arc and spark while bouncing around the engine compartment – a real fire hazard.

Bonding System

Here we have a hose clamp being used to secure a bonding wire to a seacock, an installation that is as ineffective as it is unorthodox. While the pros and cons of having a bonding system installed are often debated, one thing is certain - if one is installed, all connections must be tight and corrosion free for the system to work properly. One that’s improperly installed or maintained will provide the worst of both “to bond” and “not to bond” worlds and your thru-hulls won’t be protected.

Sterndrive Corrosion

Here’s proof that sterndrive owners are caring, giving folks. If your marina neighbors have grounding, bonding, or other such wiring issues, your aluminum drive will give of itself, acting like a huge sacrificial anode to protect their below the waterline metals. As aluminum is low on the galvanic corrosion / noble metal pecking order (making it more susceptible), always ensure your sterndrive’s sacrificial anodes and/or corrosion suppression systems are present and operational.

Wiring Gone Awry

The only thing worse than dealing with an electrical issue is having to wade through a jumble of loose, unorganized wiring before even beginning the troubleshooting process. Unsupported wires and cables can bounce around while underway, causing plenty of electrical issues, ranging from broken connectors or wires (such as the brown wire shown in the center of the left photo) to gremlin-like intermittent problems that seem to magically appear and disappear with no rhyme or reason. Worse, they can chafe and cause a fire.

Battery Basics

Industry standards call for batteries to be installed in liquid tight, acid-proof boxes or trays, be properly secured (movement no greater than one inch in any direction), and have all exposed positive terminals covered to prevent accidental shorting. All good recommendations, but sadly none of them are met in this particular installation. Another recommendation is that no battery cables and conductors are...
AWG and larger be connected to the battery with wing nuts. They’re difficult to properly torque and may work loose due to vessel movement (use marine grade nyloc nuts instead). Keep in mind that a battery is a really just box of electricity and if it gets loose, sparks can fly and ignite something flammable nearby.

**HOMEMADE AC POWER CORD ADAPTOR**

Need AC power aboard but don’t want to fuss with those frilly, unnecessary add-ons like plugs, breaker panels, and permanent wiring? Simply take a 30 to 15 amp adaptor, cut the end from a three plug extension cord, then tape the wires to the prongs at the 15 amp end (no need for that fancy, electrical grade tape either). Waaalllah - problem solved. Not. This is a fire and/or electric shock just waiting to happen.

**AC PLUG INSTALLATION**

While common sense dictates that (unlike in this photo) an AC plug has to be mounted, many DIYers don’t know that residential style solid copper wiring (aka ROMEX) is not recommended for use on board vessels. Solid wire is susceptible to breakage due to vibration - the reason marine grade wire is constructed of multi-stranded copper wire.

**CROWDED BATTERY TERMINAL POST**

How many wires can you connect to one battery post? More than you should, as this photo aptly illustrates. ABYC recommends that no more than four conductors be secured to any one terminal stud. Too many connections create the potential for heat or worse, arcing, that could start a fire. A better option here would be to relocate these connections to an appropriately protected fuse or breaker panel.

**BATTERY SWITCHES (THE FINE PRINT)**

Yes, we all know that battery switches need to be mounted - but does that mean the structure the switch is mounted on has to be mounted as well? Isn’t the intent of the requirement still met regardless? This is obviously the type of philosophical question this boat owner felt should be left up to someone else. The wires from the switch to the battery are guaranteed to come loose eventually, with the potential for sparks and a fire.

**FUSE PROTECTION**

DC-powered equipment installations always require fuse or breaker protection. In some cases it’s acceptable to power equipment via a connection directly to the battery, but always ensure a properly sized inline fuse is part of the installation. Without a fuse, the wire carrying current to the device can ignite if there is a short in the device.