The Green Wire Controversy

ABYC's Electrical Standards Can Save Your Life-If You Follow Them

by Robert Loeser

Boats with AC shorepower systems continue to give their owners problems. Many of these problems-are avoidable, and some are deadly. The major problem in using power from shoreisthat theriskof lethalshockis substantially greater in and around aboat than it is in a house. Moreover, the nature of the shock hazard changes when the boat is moved from freshwater into saltwater.

An AC electrical system must be designed and installed on the boat in such a way that the crew and any nearby swimmers are protected, no matter what kind of water is underneath your hull. Any stray current in the system will always work its way back to the source of power. And when you tie into shore power, it's going to head for the AC ground that is established somewhere up on shore, possibly hundreds of feet away. The return point for shore power is a conductive rod driven into the earth. All leaking current heads for the driven rod.

When it comes to shorepower systems, it's a serious mistake to treat a boat like a floating house. The electrical standards established by the American Boat and Yacht Council (ABYC) clearly indicate that you should handle the entire boat as a grounded-type portable tool. Never ground both the hot wire and the shore-grounded neutral on the boat. The three most common errors boat owners make are: (1) connecting the grounded neutral (white wire) to the grounding wire (green wire); (2) omitting (or cutting) the green grounding wire connection to the engine; and (3) using equipment that requires both alternating and direct current, and which is not specifically designed for use in a marine environment. Making these mistakes can be very serious, if not disastrous.

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Error Number One: connecting *the grounded neutral (white wire) to the ground wire (green wire).* If the shore-grounded neutral conductor is grounded on the boat by connecting the green and white wires, underwater metallic hardware on the boat (propellers, shafts, outdrives, metallic through-hulls) becomes a current-carrying ground return path. In saltwater, when the water around the boat is a better earth ground than the long wire going ashore, current flow is established through those metallic underwater items. You could literally cut the neutral conductor going ashore and still operate all or part of the AC electrical system.

If the water is **a** better ground than that established through the marina wiring, as it is likely to be in

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saltwater, the chance for a shock is increased for anyone on the boat. If, for instance, theengine is not connected to the shore grounding (green wire) and AC leakage develops in an electrical tool or a drop light you are using, the engine will offer a ground return path. Now, if you have onehandorafooton the engine, guess who becomes part of the current-carrying path?

In saltwater, as in freshwater, you do want the green *grounding wire of the shorepower system connected to the* engine in order to bring the tool housing and engine to the same potential. Current that flows to shore through the green grounding wire cannot put anyone in danger.

Compared to saltwater, freshwater is a poor conductor; current leakage has a much more difficult time reaching the earth ground through freshwater. If the alternatine current reaches the engine "or the outdrive, a metal rudder or anything else, it will try to reach ground but will have a hard time doing so-a nasty situation for your hardware.

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In essence, the current radiates from the boat and creates a field of significant size, usually behind the boat. Anyone swimming in that field is in serious trouble. It takes a substantial voltage and current to electrocute someone, but a swimmer can easily be killed without being electrocuted. When the voltage gradient in the field behind the boat reaches just two volts per foot, the swimmer's muscles stop working, with the result that the swimmer quickly drowns.

The only effective solutionis to *make sure that anything metal below the waterlineis* connected *to thegreengrounding* wire to bleed most of the current leakage to the ground point on shore.

This brings up another question, if the AC system is connected to ground on the boat, or if there is any amount of AC leakage, will the alternating current corrode the underwater hardware? In other words, is accelerated corrosion a clue to AC leakage? The answer is no; the AC flow is dangerous, but it will not cause any significant loss of metal.

To test my theory, I conducted a series of experiments last year. The results may surprise you. In one test, I induced an alternating current flow of 0.62 amperes (620 ma) at 120 volts through seawater from a bronze through-hull fitting to a copper plate in the bottom of a test tank. After 1000 hours of continuousleakage, I could see no evidence of corrosion on either the through-hull or copper plate and, using a small scale, could detect no weight loss. When I repeated the test with direct current, using the same test set-up but with a new bronze through-hull, the results were dramatically different. In just 72 hours, the bronze fitting looked like a piece of Swiss cheese; it suffered a 30-percent metal loss. The copper plate acted as a cathode and was not damaged.

Thus, there is no major corrosion problem from AC leakage, but corrosion does occur. When a boat is wired to the shore grounding (green wire), it is automatically linked to every other nearby boat with a green grounding wire connected to the engine. This interconnection turns a marina into one giant battery. Galvanic cells are created between the boats. If the boats were constructed of the same metal, the problem would be minor; but when one boat has an aluminum or steel hull or an aluminum outdrive and others have copper ground plates or bronze shafts, for example, the anodic boats become sacrificial. The anodic boat faces continual corrosion.

There are two solutions to this problem: First, on an aluminum or steel boat (or any boat with an aluminum outdrive) you can install isolation transformers in the AC system. A transformer creates a new electrical system on the secondary side of the transformer; 120 volts enters the primary and 120 volts come out, but the secondary is no longer connected to the ground on shore. If the secondary system is grounded on the boat, that ground will not cause leaking current to flow to the shore ground. Any leakage will find its way back to the secondary wiring. When a boat uses an isolation transformer, you must stop the shore grounding (green wire) at the transformer and not connect it to the boat ground. To do otherwise would defeat the system. This method works well, but is more expensive than using an "isolator," the second acceptable solution.

The isolator is a device installed in series with the shore grounding wire. It blocks the flow of low-voltage direct current but, at the same time, will readily pass alternating current. The device prevents the boat from becoming a galvanic cell in conjunction with another boat. Because an isolator maybe called on to carry a dead short in the electrical system, and because its impedance to AC flow is a critical factor, I would certainly insist that it be "UL marine" listed. The isolator must be capable of carrying SO00 amps longs enough to trip a circuit breaker. On the other hand, the device must be able to pass low-level alternating current because problems in the water, like the one with the unsuspecting swimmer, *The only effective solution is to make sure that anything metal below the waterline is connected to the green grounding wire.. .*

are created at very low current. Of course, it must block galvanic current (DC) as well.

Error Number Two: ***omitting (or cutting) the ground wire connection to the engine.***
There is one more way to stop "interboat corrosion." Unfortunately, it's been used far too often. When accelerated corrosion was first linked to boats wired with the green wire to the engine, someone figured out that the corrosion problem could be corrected by simply cutting the green wire. At one time, in fact, cutting the green wire was actually taught as a solution in formal education programs. As far as corrosion is concerned, cutting the green wire will work, But what boatowners who cut the wire failed to realize was that in cutting the wire, the alternating current loses its return path for leakage. Anyone who went into the water when the boat was at dock could be killed. And indeed this has happened several times in recent years.

Error Number Three: ***using equipment that requires both alternating and direct current.***
In considering all of this, you should note that if alternating current leaks into the DC system at any point, the alternating current will automatically travel to the engine and the underwater hardware. This includes leakage from the DC-ungrounded conductor (positive) to the DC-grounded conductor (negative). If the leakage penetrates the ungrounded conductor of the DC system, alternating current will pass through the battery to the same ground. This is true whether the green wire is connected to the engine or not. Battery chargers, dual-voltage lights, refrigerators, and other electrical equipment where the alternating and direct currents are close together are points where this transfer can occur.

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In my opinion, AC and DC systems should be separated as much as possible. Combination AC/DC electrical panels, therefore, are a mistake. I would stick to AC equipment that has been UL-listed, or certified, for marine use. I would keep the shore power connectors in good condition. Above all, I would make sure the green grounding wire gets to the engine unless the boat has an isolation transformer.

My philosophy is simple: follow the ABYC standards and be wary of the equipment you use. You'll avoid taking part in a story with a shocking conclusion. ■

For information on obtaining a copy of ABYC's electrical standards, contact: American Boat and Yacht Council, Inc.; 405 Headquarters Drive, Suite 3; Millersville, MD 21108; telephone 301/923-3932.