③ A NOD TO ANODES

When it comes to sacrificial anodes, it's imperative to know their corrosion protection levels. BY STEVE D'ANTONIO

MONTHLY MAINTENANCE

A post on a sailing forum recently got my attention. A boat owner was seeking opinions because his zincs lasted only "about six months." My advice was straightforward: "While this time frame doesn't seem unusual, instead of guessing or listening to internet sages about how long zincs should last, carry out a reference electrode test; it's easy and definitive."

From here forward, I'll refer to zincs as anodes. They can be made of zinc, magnesium or aluminum. They decay in relation to the load placed on them, which is affected by many factors, including salinity, temperature, current, the amount of metal they are protecting, and the condition of the vessel's bonding system and shore-power isolation. They should be replaced when 50 percent depleted (the more anode mass, the longer the intervals between replacement). However, if they last *too* long, something is probably wrong: They might not be making good contact with the metal they are protecting, the bonding system might be in poor condition, or they might be the wrong metal for the application. Zinc, for instance, does not work well in fresh or brackish water.

The goal with sacrificial anodes is to protect other metals, including shafts, props, struts and through-hulls. This is achieved by driving the metals to be protected into a more negative voltage range, measured in one-thousandth of a volt increments known as millivolts. Each metal has its own voltage range in which it is protected, typically a minimum of -200 mV beyond the metal's resting voltage.

For instance, when measured using a silver/silver-chloride reference electrode, aluminum alloys' resting voltage is about -760. The "protected" voltage—the voltage it should register when connected to an anode—should therefore be a minimum of -950 mV. (There is some debate among experts, so you'll often find small variations shown in different literature. In my experience, -900 mV is more than adequate for commonly used marine aluminum alloys.)

It's worth noting that while most metals can't be overprotected, aluminum can; it's amphoteric, which means it corrodes in the presence of an acid or a base, so overprotecting it creates an alkaline solution around protected metals. Therefore, aluminum protection should not exceed -1100 mV.

To carry out a reference electrode test, begin by unplugging the vessel's shore-power cord. It must be *unplugged*; simply turning the power off is not acceptable. Then, using a digital multimeter that is set to read DC volts, connect the reference electrode to the negative lead, and the metal that is to be measured (through-hull, strut or the entire bonding system) to the meter's positive lead. Then, in still water, hang the reference electrode over the side (it shouldn't touch the hull), and take your reading.

If the vessel has no bonding system, then each underwater metal must be measured by making a connection from within the hull. If the vessel is bonded, only one reading need be taken to measure all bonded metals. However, prudence dictates all metals should be individually tested to ensure that the bonding system is operating properly. The propeller and shaft are a special case; even though they are connected to the engine via the running gear, the electrical contact is poor at best because the medium is filled with oil. Even common, low-cost shaft brushes can make for poor connections; the threshold for resistance between protected metal and an anode is a scant 1 ohm, so don't count on them for protection. Shafts and props should have their own anodes, and they should be measured separately or utilize a properly engineered brush system.

Repeat the testing after reconnecting the vessel's shore power. If the readings change, your galvanic isolator—the device that is supposed to isolate the bonding system from shore power and other vessels—is not working, is not wired properly or is simply not present. (There also might be an open circuit somewhere in the grounding conductor's path, which is a dangerous scenario.)

Protection ranges are as follows. Aluminum: -950 to -1100. A fiberglass vessel with common underwater metals, excluding aluminum: -750 to -1100 (a range more conservative than that dictated by ABYC Standards). A wood hull with common underwater metals other than aluminum: -550 to -600 (overprotection of wood hulls can lead to wood damage known as delignification, and some wooden-vessel owners eschew bonding systems for this reason). Steel hulls: -850 to -1100.

Finally, as far as anodes are concerned, zinc should be used in seawater only; magnesium in fresh water only; aluminum may be used effectively in seawater, fresh water or brackish water.

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While faulty shore-power wiring represents an electrocution and fire risk (left), it is for the most part not directly related to corrosion or the "hot marina" scenario. Corrosion meters or monitors use a silver/silver-chloride reference electrode to measure the voltage of underwater metals (middle). With the information, one can determine whether or not they are adequately protected. A silver/silver-chloride reference electrode is an essential component of any vessel-corrosion analysis (right). They are readily available online.