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How to Stop a boat's Marine Corrosion in 3 Steps

Takeaway: *Corrosion poses a serious threat to metal boats. Learn about the 3 steps to stop corrosion: identify marine corrosion, understand the cause and eliminate the cause.*

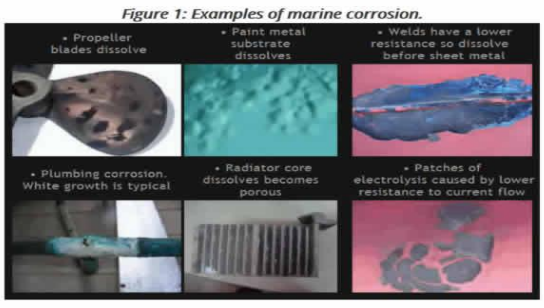
Source: Bluesky70images/Dreamstime.com

Corrosion poses a serious threat to all metal (including boats) that makes contact with the earth, whether by air, water, or land. In this article we examine the three-step process to stop a boat's marine corrosion: identify marine corrosion, understand the cause and eliminate the cause. The same process applies to all metal in all environments.

Identify Marine Corrosion

Marine corrosion may take any of several forms. Some typical examples are shown in Figure 1.

Figure 1: Examples of marine corrosion.



Understand the Cause

The Science behind Marine Corrosion

which continuously dissolves metal, is the cause of marine corrosion. This is sometimes called stray current rust." The corrosion occurs between a wet metal or a heating/cooling system and a connection with the earth that is not perfectly dry at least 97 percent of the time. Metal particles are dissolved by the electric current from the boat's batteries when electrolysis occurs.

All boat electronics (e.g., radios, sonar) must use direct current (DC) from a battery or generate their direct current from mains-shore power. The battery's direct current always flows in the same direction, carrying particles of the boat's metal with it. In contrast, shore power is alternating current (AC) that reverses direction every half cycle (e.g., a 60 Hz current reverses itself every 1/30 of a second) so dissolved particles are replaced every alternate half cycle. Therefore, alternating current cannot cause electrolysis corrosion.

The Causes of Metal Corrosion

The causes of metal corrosion are:

- Rust

Rust is of very low aggressiveness compared to electrolysis corrosion. It is only present when there is moisture in the air at 10 percent humidity or more. Rust is easily prevented by paint or plating after all electrolysis causes are eliminated. (Learn more about paints and)

- Galvanic

Compared to electrolysis corrosion, is also of very low aggressiveness. Galvanic corrosion can be eliminated by anodes but only after electrolysis is eliminated. Sacrificial anodes can then work as designed.

Galvanic corrosion is caused by the natural voltage between two different metals in a conducting medium such as standing water or atmospheric moisture. (See the article An Introduction to the Galvanic Series: Galvanic Compatibility and Corrosion for more information on two dissimilar metals.) The natural voltage never exceeds 1.2 volts and the current is in the millionths of an amp. A one-kilogram anode produces one-millionth of an amp of protective current. This can be demonstrated with two metal hulls, one inside the other and a sophisticated microamp clamp meter.

- Electrolysis

Electrolysis varies from one thousandth of an amp to several amps (up to 10 amps) of current. To counteract this would require at least 1,000 kg (2,205 lbs) of anode to have any effect on the electrolysis, and probably 10,000 kg (22,050 lbs) to stop it completely, which is likely equivalent to the weight of the entire vessel. It is much better to eliminate the electrolysis than to fight it. Having done so, then anodes can work as they are designed. Anodes are simply ineffective in the presence of electrolysis that is commonly a thousand times stronger. It is best to eliminate the largest cause of corrosion first and then the remaining sources are easier to address.

Electrolysis is more aggressive than rust or galvanic corrosion by several orders of magnitude. It is generated by all electrics and electronics that have a voltage different from the earth, and flows as a current from the installation to the earth, other vessels or installations. A boat causing electrolysis in a conductor will corrode other nearby boats. Electrolysis corrosion can only be measured as current and then eliminated.

Why Electrolysis Occurs

A battery's negative terminal is actually at -12 volts and a battery's positive terminal is at 0 volts. The earth's voltage is +1.2 volts. Any moisture is a very good conductor. Therefore, when there is a circuit from the negative to the boat's hull or engine, then negatively charged electrons are repelled from the wet metal to the earth, carrying the boat's metal with them.

All direct current battery power returns 80% or more of the current drawn through the battery's positive terminal through the battery to its negative terminal. That is why the battery's negative cable has the same copper diameter as the battery's positive cable.

For example, a starter motor on a medium-size four-cylinder diesel drawing 180 amps will return 180 x 0.80 = 144 amps to the battery via the battery's negative cable. If the metal hull or engine body is used or connected to the battery's negative terminal then a current in the range of 100 to 144 amps will flow through the hull.

Some people might blame the live well. A live well is connected to the engine or the hull either by a weld or by the water. On a fiberglass hull the live well is connected to the engine via the water. (Remember the James Bond movie where he throws a bar heater into a bath and electrocutes the person in the bath?) Fresh or salt water is only a few ohms - usually around 10 ohms per meter - so everything the water touches is connected to each other.

Some live wells are simple and are isolated from the rest of the boat, but other boats have sophisticated systems where the water in the live well is circulated and aerated, and therefore are connected electrically to the boat.

On a fiberglass boat the same current flows through the propeller, the gearbox and then the engine's cooling system. The accelerated flow rate in the cooling pump amplifies the electrolysis effect caused by the stray current.

The current flowing to the earth consists of negatively charged electrons. The earth, at 1.1 to 1.2 positive volts, attracts some of that current. Only one-thousandths of an amp is sufficient to cause enough electrolysis that you can see visible corrosion in three months.

Note: Never try to measure this with a multimeter as the battery acid may explode. In addition, any reading, if you get one, is very likely to be inaccurate. The insulation resistance must be measured with everything at full power and at an applied voltage (12 or 24 volts) without a current limit in the measuring device below 100 milliamps. The device must not have an effect on the circuit being measured. Common multimeters measure 1 volt at one-millionth of an amp and have an error probability of at least 1000:1. In addition they alter the circuit under test.

Bonding

All metals have a natural voltage. The voltage is very low but always present. The natural voltage causes galvanic corrosion. When a copper wire connects two pieces of metal the copper wire transmits the current through itself rather than through the water, thus reducing the effects of galvanic current. However the battery's positive or negative terminals must never be allowed to make contact with the bonding because the electrolysis will increase dramatically causing large and extremely expensive corrosion of the boat's metal.

Eliminate the Cause of Corrosion

Metal corrosion is caused by an electro-chemical reaction. When the electric current is eliminated then electrolysis is eliminated. This is accomplished by making all metal electrically open circuit (disconnected) in full power use, from the earth. Then no current can flow in or out so there will be no electrolysis, permanently. It requires ten cumulative days of stray current in one year to cause electrolysis corrosion that can be seen.

Glen Bishop

Owner, SeaBis System

Glen Bishop was the Surveyor for Class Society (insurance) World-wide. While surveying, he saw boats with electrolysis hull damage, most frequently around the power generation area. Two hundred boats per year were being severely damaged with a high proportion of them sinking. In 1992 over a 3-week period his vessel became porous while docked in a new mooring with a steel post between each vessel. Ten years and 220 testing vessels later he found his answer.

Glen has 53 years in marine electronics experience including nine years at sea with the last four years in submarines. As a young man he received his formal training at HMS Collingwood, Portsmouth, England. He then spent 45 years in marine electronics using MPLab, Protel, Multism, and many others constructing circuits.

Ten years ago Glen began developing an instrument that would test if electrolysis was occurring on vessels. As regular instruments were not precise enough he created a prototype and then installed on 220 vessels. The prototype was perfected and he has been clearing vessels of electrolysis ever since. His early clients were in and around Australia, and he has since expanded to a worldwide presence.

Today Glen oversees his electronic engineering company, which does research and development and manufactures special marine products.
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