

Corrosion On Boats:

On boating forums I see a lot of questions and much talk concerning corrosion, particularly corrosion on metal boats. Many people raise concerns about “electrolysis”, (<http://en.wikipedia.org/wiki/Electrolysis>) which is not the correct name for this process. It is better to identify the specific type of corrosion such as **galvanic corrosion** (http://en.wikipedia.org/wiki/Galvanic_corrosion) People often confuse **stray current corrosion** with galvanic. In addition there is the ever-present ferrous metal corrosion, or simply called rust, which is also a type of electrochemical corrosion. Some metals that are commonly used in boat building, such as aluminum and stainless steel, encounter their own corrosion related problems. For the wooden boat owner and builder there is a special kind of corrosion that occurs around metal fasteners, most often screws, embedded in wood, called by some **woodburning**.

Galvanic corrosion is usually what people are talking about when they ask about electrolysis on their boat. Electrolysis is a term they most likely picked up in elementary school when they were being taught basic science, and electricity. Electrolysis is actually the opposite action to galvanic corrosion so the distinction is not trivial as some people suggest. Electrolysis is the forced introduction of a current in an electrolyte (water) to separate the components. In water this produces Hydrogen and Oxygen. Galvanic corrosion on the other hand is an electrochemical reaction that causes electrons to flow from one metal to another metal. One of the metals is the anode and the other is the cathode. If you put the two in an electrolyte that conducts current, and connect them with a wire, they act pretty much the same way a battery does. A current flows between the two metals. The atoms from one are “sacrificed” and plated onto the other metal. This happens when you have dissimilar metals such as aluminum and bronze close to each other. The aluminum disappears.

For this reason boats with aluminum hulls, stern drives and outboard engines often have a special sacrificial anode bolted to them. The anode is often made of zinc, but it can be other metals such as magnesium, which gives itself up before the aluminum does and saves the aluminum. The anode is connected to the dissimilar metals through the bonding system. Often these are generically referred to as zinc. This is not correct terminology. They should always be called anodes.

There are various methods of dealing with galvanic corrosion in addition to using anodes. The most obvious is to minimize the number of metal fittings in contact with the water, and make them all the same metal. For instance, a through hull fitting such as a water intake should be naval bronze or silicon bronze. (Just an aside, do not use brass. True brass is very subject to corrosion and will soon be gone. All the fittings used on boats that are often referred to as brass are really naval bronze or silicon bronze, or some similar alloy that is corrosion resistant.) Also some fittings today are made with very strong plastics. Plastic is, of course, non-conducting and does not corrode. However, some people are very opposed to using plastics for fittings below the waterline, due primarily to strength and fatigue issues. Also it can be difficult sometimes to get fittings that are all the same metal, or metals that are very similar in composition to each other.

All of the metal fittings below the waterline should be bonded. What is bonding? A wire is attached to all metal fittings that are in contact with the water and this wire is also attached to a common grounding point on the boat. This puts all metal fittings at the same electrical potential, zero, so no current will flow through the water from one fitting to another. Rather it will flow through the wire. But like most things having to do with the design of boats, some people believe that this actually promotes corrosion. I do not believe it does and I recommend bonding. However there are some metals that should not be bonded together, and on aluminum boats the hull should not be part of the bonding system.

Galvanic corrosion is a slow process and often takes years to manifest itself.

Stray current corrosion is similar to galvanic corrosion in that it eats away at underwater metal and fittings, but the cause is different. It is caused by electrical current in the water, introduced by a boat with a badly wired system or by bad wiring on the dock or other boats. Normally it is caused by direct current, that is, twelve-volt systems on boats. But there have been studies done that show that Alternating Current, like you have in your home and may have on your boat, can cause this too. This is usually from bad wiring on your boat or other boats around you. However, it can come from the dock system. DC current is usually very low, in the milliamps range and you may not be able to feel it tingle if you stick your hand in the water. But it is still causing the problem. AC current on the other hand can be considerable, and can kill you if you have part of your body in the water or even if you touch a metal fitting or the hull. If you suspect stray electrical currents in the water you can have an electrician detect them.

Stray current corrosion happens rapidly, sometimes overnight if there is a enough current, usually seen as massive damage to the sacrificed metal. There will be actual holes in the metal.

The best prevention is to make sure your boat is wired properly, in accordance with standards published by the American Boat and Yacht Council (ABYC) www.abycinc.org. If you have an AC system on your boat, you should have at least a galvanic isolator in the AC grounding wire (the third wire or green wire). A Galvanic Isolator stops low DC currents, less than 1.4 amps from flowing in the grounding wire, but doesn't stop AC. This green wire is there for safety and needs to be capable of conducting AC to prevent shock hazards. Never ever cut the green wire!

The best method though is to have an Isolation Transformer or Polarization Transformer in the shore connection. This will effectively isolate your boat's system from the shore side system. It should also be wired according to ABYC standards. In Europe and much of the rest of the world you should follow ISO standards. They are very similar to ABYC standards used in the USA and Canada.

Ordinary electrochemical corrosion, rust or oxidation, is also a problem for most ferrous metals, such as steel. These metals must be cleaned before painting to remove any

corrosion or contaminants and then painted with a special primer that treats the metal. Then paint over with marine paints. If done correctly this treatment will last several years or more with occasional touch up of rust spots. But on a regular basis the metal must be cleaned by grinding or sandblasting, re-primed and re-painted. If done as regular maintenance steel boats can last many years. It is not unusual to see steel boats that are fifty or more years old.

Some metals have their own built in protection. They form an oxide on the surface that excludes contaminants and prevents corrosion. Marine grade aluminum is one of these. By marine grade I mean 5000 or 6000 series aluminum alloys, such as 5052 or 5058. Aluminum forms an oxide on the surface. The aluminum will not corrode unless the oxide is damaged or washed away. Often aluminum hulls, tanks and other boat parts are not painted because there is no necessity to paint them for protection. However, if a builder or owner decides to paint aluminum then a special process called etching is required to remove the oxide, because the paint will not adhere well to the metal.

Aluminum and stainless steel should never be installed where they will always be wet. Fuel tanks are often mounted on flat surfaces where moisture will collect under the tank. These tanks will corrode very rapidly. Any metal tank should be mounted above a surface so air can circulate around all sides of the tank. Metal tanks should never be encased in foam for the same reason. For more on Aluminum see, **Aluminum Tanks and Boats: to Paint or Not to Paint** <http://newboatbuilders.com/docs/aluminum.pdf>.

This is also true of marine grade stainless steels. All stainless steels are not created equal. Some are more corrosion resistant than others, but contrary to popular belief, stainless steel will corrode. The secret is to keep it dry. Stainless steels are prone to **crevice corrosion**. Moisture gets into microscopic hairline cracks or pits, where oxygen is excluded, and corrosion sets in. Often these cracks are in welds. However, if kept dry and checked regularly, stainless steel can last for a lifetime. So stainless is best used where it is exposed to the air and has little exposure to moisture. Also stainless, like aluminum, needs to be marine grade, usually 300 series such as 316L. It is also a common belief that stainless steel is non-magnetic. This is not true of all stainless steels. Be sure you have the correct grade of stainless. Marine grade stainless is non-magnetic.

Wood boats suffer from a special kind of corrosion called **woodburning** around metal fasteners. This type of corrosion is caused primarily by leaks and oxygen starvation around the fastener, and *over protecting* the boat with anodes. Yes, you can put too many anodes on the boat. The fasteners in wood boats are generally metal screws but boat nails, rivets, and bolts also suffer from this. In many old boats the screws are galvanized. At the point where the screw meets the wood and oxygen is excluded, sodium hydroxide forms, that eats away at the metal and destroys the wood immediately around the fastener. Sometimes this can be spotted in bare wood by a dark ring around the fastener. But more often than not you cannot see any sign of this type of corrosion. Marine surveyors will often remove fasteners at random looking for this type of corrosion. Any that are corroded must be replaced. But, you cannot put a new fastener back in the same

hole. The hole must be reamed out and plugged to get rid of the rot. Then a new hole must be drilled for the new fastener.

Another way to detect this is to spray white vinegar on the area around the fastener. If it foams sodium hydroxide is present. If the fastener is fairly new and there has not been much damage to the wood you can stop the process by spraying vinegar on it twice a day. Do this for several days until it no longer foams. But you also need to correct the cause.

Another variation on woodburning corrosion occurs in boats with wood hulls and metal interior structure. This used to be called composite construction, but today that term usually refers to fiberglass boats. Where the metal meets the wood, the metal will corrode. During yard periods when a boat is out of the water, a few planks should be pulled and the interior checked for this condition. If not, the framing and bulkheads can deteriorate until the hull fails.

The message for boat builders is; build the boat right. Pick the right materials. Install them correctly. Install electrical systems correctly. Do not overprotect. Follow ABYC standards. If you are not sure consult an ABYC certified corrosion technician.

References: There are thousands of resources available on the Internet. Here are a few.

Yacht Corrosion Wiki:

http://www.cruiserlog.com/wiki/index.php?title=Yacht_Corrosion

To Bond Or Not to Bond:

<http://www.cruiserlog.com/forums/index.php?showtopic=10402>

Types of Marine Corrosion: Don Casey BoatUS.

<http://www.boatus.com/boattech/MarineCorrosion.htm>

Corrosion: David Pascoe: <http://www.yachtsurvey.com/corrosion.htm>

Stray Current Corrosion by EduCell

http://m.educell.com/cell/div_guide.jsp?guideId=2132&orgId=47&dId=85&catId=Cat_178&subNm=Marine%20Corrosion&catNm=Engine%20Shop

Corrosion Prevention for Metal Boats: Michael Kasten

<http://www.kastenmarine.com/corrosion.htm>

Fastener Corrosion: Sea Magazine

http://www.seamagazine.com/hob/DM_article.asp?id=4045

Corrosion Protect For Metal Fittings <http://www.practical-sailor.com/marine/corrosionprotection.pdf>

Electro Guard <http://www.boatcorrosion.com/aboutcorrosion.html>

Books: Both are available from Amazon through my bookstore

<http://newboatbuilders.com/pages/bookstore.html>

Metal Corrosion in Boats: Nigel Warren

The Boat Owners Guide to Corrosion: Everett Collier

Published Standards:

ABYC A-28 Galvanic Isolators
ABYC E-2 Cathodic Protection
ABYC E-11 AC and DC Electrical Systems on Boats

Courses:

ABYC. Marine Corrosion Certification (<http://www.abycinc.org/calendar/index.cfm>)