Seaguard Ltd

Corrosion Basics

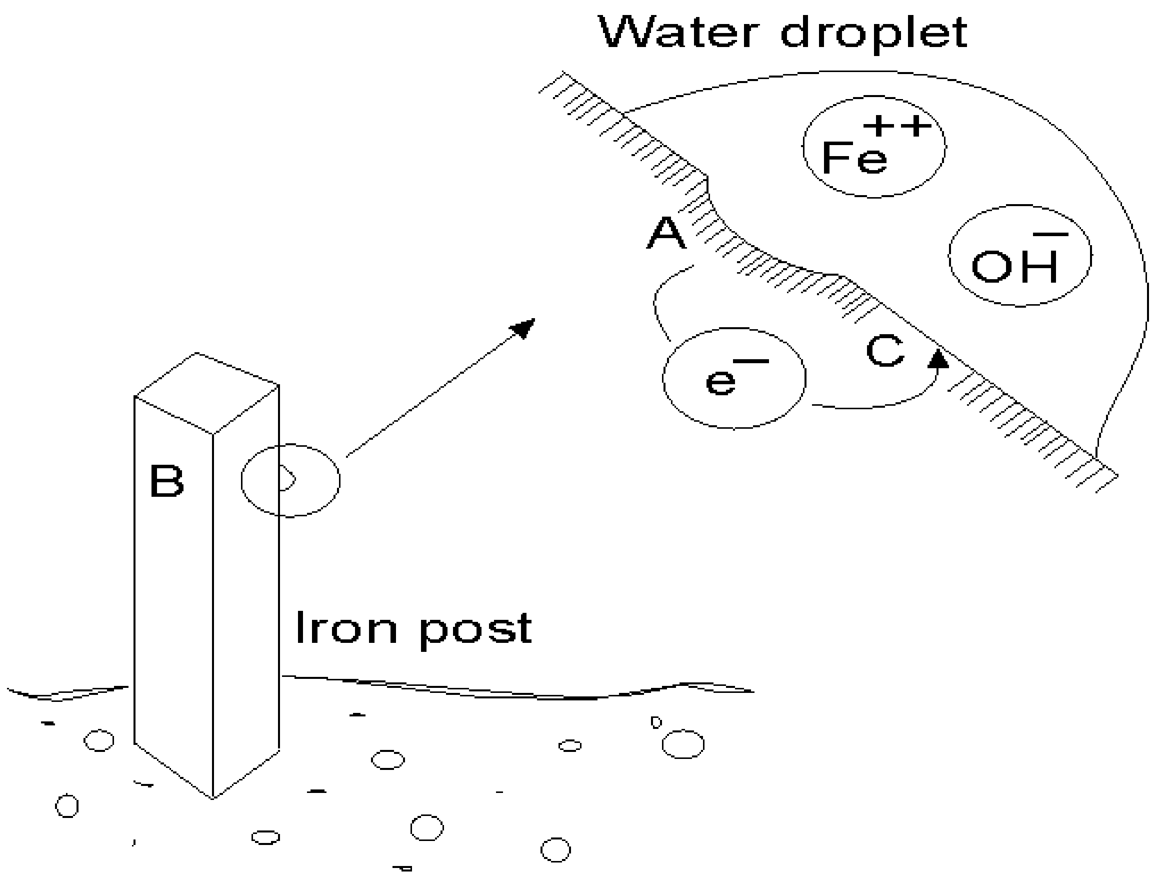
About this article

This article talks about marine corrosion, mainly in regard to small commercial and recreational craft; what causes this corrosion to take place and what reasonable steps can be instigated to prevent or minimize this corrosion. Much of what is discussed here can be applied to other structures operating in sea water.

As the title implies, this is only a quite basic introduction to what is a complex and varied subject. This article is intended only for those people who do not have a technical background in corrosion but may have to deal with its consequences. We have provided a set of references at the end of this article, which provide more in depth material.

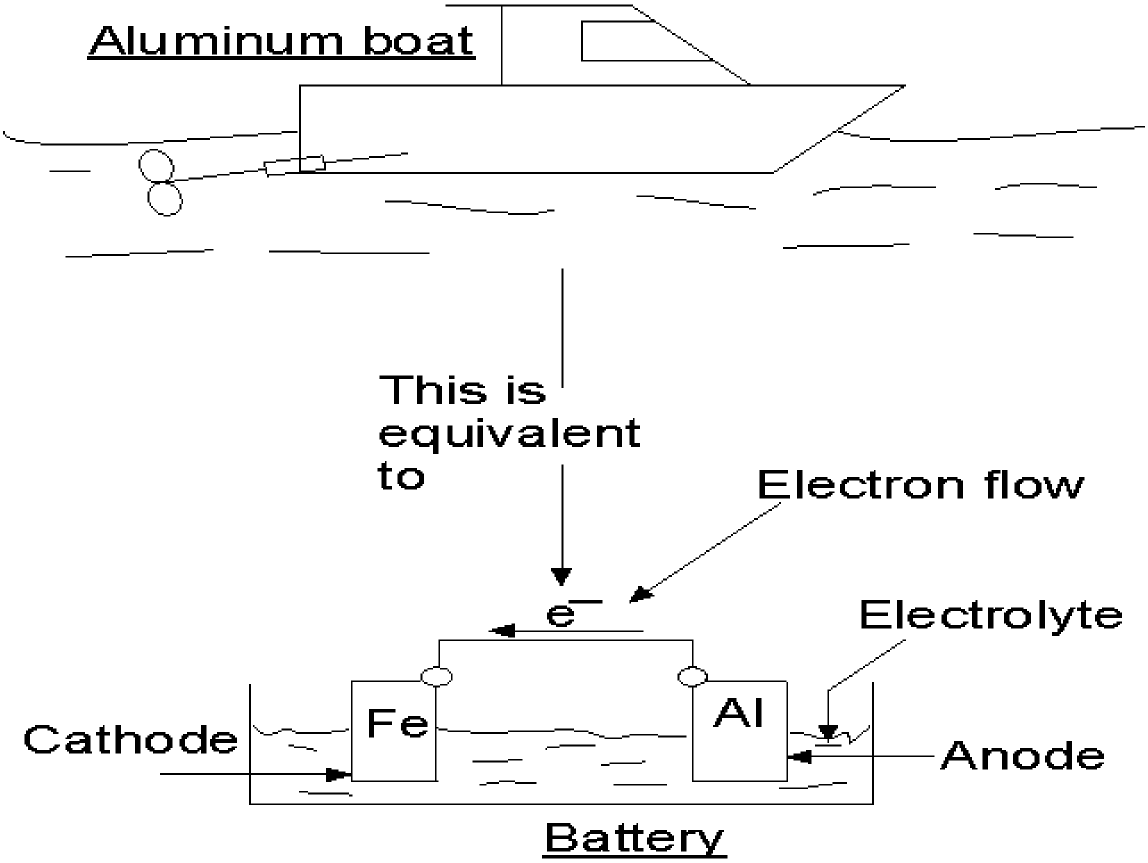
So…what is corrosion?

Corrosion is an ***electrochemical*** process involving ***metals***. That is… electricity and chemical reactions are involved and metal material is lost. A common experience for all of us are steel items rusting. For the "iron post in the ground" diagram below, area A and C are wet (it has just rained) and electrons are traveling through the metal from A to C. Area A is losing iron ***ions*** into the water. At area C, due to the presence of oxygen in the water, and a surplus of ***electrons*** in the metal, water molecules are combining with oxygen atoms and electrons to produce hydroxyl ions. Ions are positively or negatively charged atoms or molecules. Positively charged ions are attracted to negatively charged ions.



If they can travel towards one another, such as through the water (in this case termed the ***electrolyte***), they will. In the case of the steel and hydroxyl ions, they combine to form rust. The "iron post in the ground" has corrosion occurring even though it is one metal.

Corrosion can occur quite rapidly when dissimilar metals are electrically connected together. The next picture shows an aluminum hull and stainless steel propeller immersed in an electrolyte (seawater). If the propeller and hull are electrically connected, you have a battery with electrical current flowing. The corrosion associated with the connection of two dissimilar metals is called ***galvanic corrosion***. The aluminum is losing material in the form of aluminum ions. Electrons are flowing from the aluminum through the electrical connection to the stainless steel. The metal supplying the electrons is called the ***anode*** and the metal receiving them is called the ***cathode***.



For galvanic corrosion to occur, there must be an electrical circuit. This means there must be a path for the electrons to travel between the two dissimilar metals and there must be a path through the electrolyte for the ions to travel. Additionally, the chemical reaction at the cathode usually requires the presence of oxygen in the electrolyte.

The photo below shows a stainless steel bolt passing through an aluminum casting (part of an out drive). Pitting corrosion is evident on the aluminum with the stainless steel bolt in the virtually 'as new' condition.

Galvanic series

Graphite ---------------------------- +200 to +300 mV

Stainless steel (passive) --------------- 0 to –100 mV

Bronze --------------------------------------- –240 to –310 mV

Copper --------------------------------------- –300 to –570 mV

Brass --- –300 to –400 mV

Mild steel ------------------------------------ –600 to –710 mV

Aluminum ------------------------------------ –740 to –980 mV

Zinc --- -980 to –1030 mV

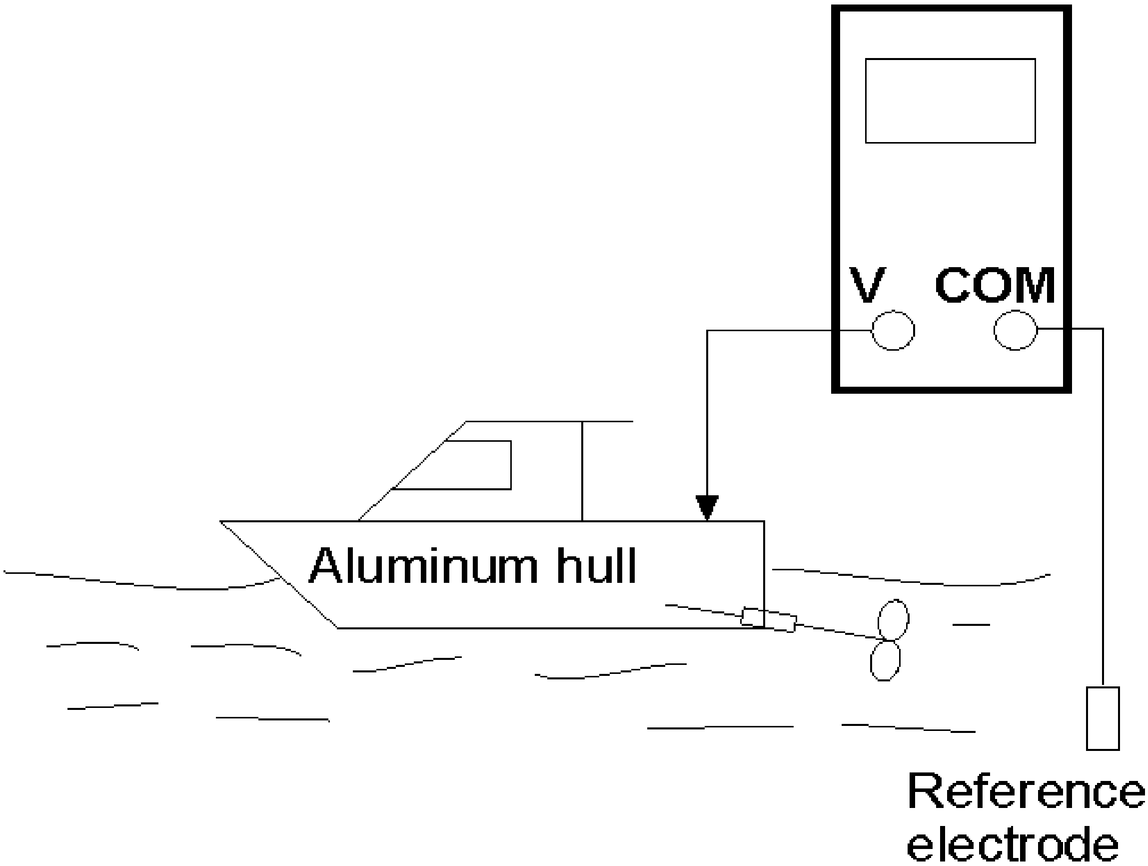
Magnesium ---------------------------------- –1500 to –1700 mV

Your boat will almost certainly have a mix of metals such as steel, aluminum, copper alloys and so on. Typical metals are listed in order of their activity in the Table above. For example, electrically connecting bronze to aluminum in a common electrolyte such as seawater will result in the aluminum being the anode and thus corroding. How do you protect an aluminum hull? Looking at the Table: zinc is more active than aluminum. Hence it is usual to fit zinc anodes on a hull to protect the aluminum. The zinc corrodes in preference to aluminum.

An example of a good zinc anode and a 'bad' zinc anode is shown adjacent in the photo. Both zincs are trying to protect the aluminum pump housing. Which zinc is working correctly? Answer: the one on the left which is corroding. It is a common fallacy that if one zinc lasts longer than another (given the same component to protect and the same size anodes) then it is a better zinc. The reverse is true. The zinc on the right in the photo either has a poor electrical contact between the zinc and the aluminum, or it has been contaminated with iron (50 parts per million is enough) during the manufacturing process.

How do you check if an anode is working? If the boat is in the water, then looking to see if the anode is corroding is one way. This is not completely fool proof as the anode may still be functioning correctly but the protection level may be insufficient to prevent corrosion.

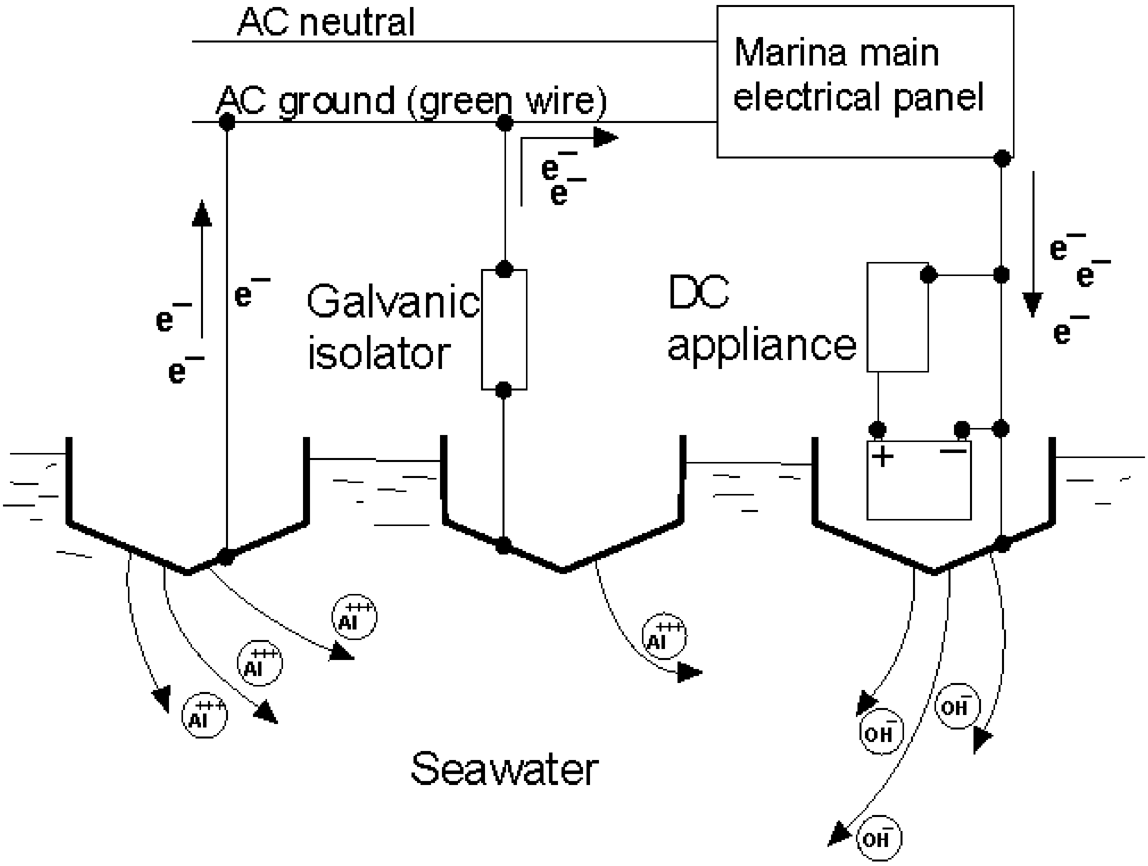
A good way to check if the protection level adequate is to use a reference electrode and a good quality multimeter set to DC volts. The reference electrode terminal is plugged into the COM plug on the multimeter. See the diagram below where an aluminum hull is fitted with zinc anodes. The out drive is also electrically connected to the hull.



Place the reference electrode (silver silver chloride) in the sea water, and connect the multimeter red lead to the hull. If the reading on the multimeter is between -850 mV and -1100 mV, then the zincs are working and your boat hull is protected. You should then repeat the test with the out drive.

Hot docks

Some marinas have a reputation as a 'hot dock'. The term arises from boats seemingly experiencing more severe corrosion when visiting a particular dock. Often the cause is small DC voltages present in the green neutral wire on the shore power point. The diagram below illustrates the problem. Three boats are connected to the shore power. One boat has a DC electrical appliance which is faulting to battery positive. This results in a positive bias on the boat neutral which attracts electrons from the other boats. Boat A experiences severe corrosion. Boat B has a galvanic isolator fitted. If the DC voltages are low (say under 1 volt) the galvanic isolator will prevent DC current from flowing and will protect Boat B.



Galvanic isolator

The galvanic isolator is a relatively simple device which generally contains a pair of diodes and a capacitor. A galvanic isolator should prevent small DC currents that may be present on the shore power neutral wire from causing corrosion on your boat. An alternative to a galvanic isolator is an isolation transformer. ABYC standards (USA) set guidelines. Not using a galvanic isolator (or isolation transformer) and connecting to shore power is a bit like playing Russian roulette. You are taking a chance and you may get away with it for now..........

Corrosion Sentry

For peace of mind and protection of your investment, we have developed an intelligent corrosion monitor. This monitor comes in three variants:

Sentry

Sentrymultizone

Sentrylog

Fitting one of these monitors to your boat is straightforward. When installed, simply press the test button. If your boat is protected, green LED's will light. The procedure is somewhat akin to checking the oil level in your car engine. Everyone does that. Why wait and find out the hard way that you have a corrosion problem?

Corrosion zones

When you are using your car radio and driving into a tunnel. The radio works only at the entrance to the tunnel. When you are around 10 tunnel diameters in distance into the tunnel the radio no longer works. An anode throws its protective current is a similar manner to the way radio waves travel. If you have an external anode on a hull and the hull contains a duct (bow thruster tunnel, waterjet intake etc.), the anode is unlikely to protect these internal surfaces. The internal surfaces form a different zone to the hull external surfaces. Another example might be ballast tanks. Each ballast tank on a vessel would be a separate corrosion zone, in this case because the electrolytes are completely separate. The **Sentry multizone** and the **Sentry log** both have the capability to simultaneously monitor three such zones.

Further reading

Everything you need to know about corrosion, Quicksilver Marine Parts and Accessories

Corrosion, Vol 1 *Metal Environment reactions*, edited by Sheir L L, Jarman R A, Burstein G T, Butterworth Heinmann, 1998

Corrosion, Vol 2, *Corrosion control*, edited by Sheir L L, Jarman R A, Burstein G T, Butterworth Heinmann, 1998

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