Making a Sacrifice

Written by Nigel Clegg

Cathodic protection seems to be something of a mystery to many readers, so this months page has been devoted to the subject.

Corrosion itself is an electrochemical process, which occurs when two or more metals of differing electrical potential are immersed in a common conductive electrolyte such as sea water. If the metals are connected together, any difference in potential will promote a flow of electricity between them through the electrolyte, forming a galvanic (or corrosive) cell. A supply of oxygen is required to complete the reaction, which involves the formation of metal oxides (such as rust) and other products which can help to accelerate the corrosion process.

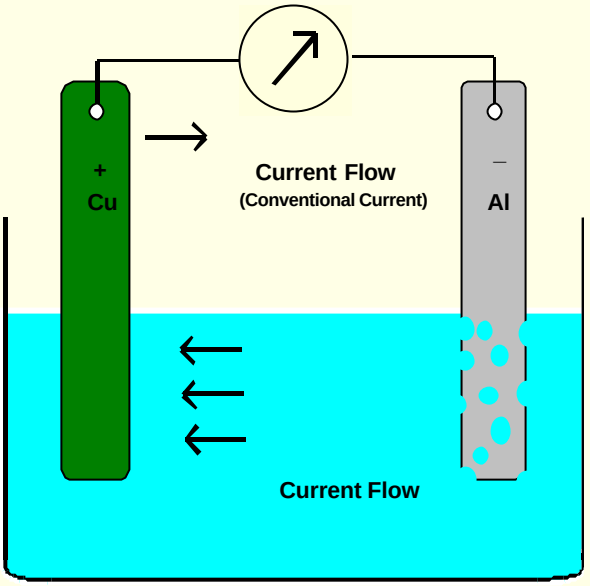
Of course we usually associate corrosion with the use of dissimilar metals such as copper and aluminium, but it can just as easily occur where metals have been heated, shaped or welded, as these process alter the crystalline structure of metals leading to localised changes in electrical potential, and may also introduce other elements such as oxygen and carbon. Similarly, bronze propellers and skin fittings can suffer rapid loss of strength and embrittlement owing to a process known as dezincification, where zinc is eroded away from the copper alloy.

When it comes to protecting metals, painting is almost always chosen as the primary means of preventing corrosion. Anticorrosive paints work by providing an insulating barrier to prevent the flow of electricity, and by excluding water and oxygen from the face of the metal. Epoxies are especially effective for this purpose, as they have excellent dielectric (or electrical insulating) properties together with excellent adhesion to most metallic substrates.

Unfortunately though, paint coatings are comparatively thin, and are prone to mechanical damage, so they must be supported by a secondary protection system which can take over if the need arises. Moreover, fittings like propellers and stern tubes are next to impossible to paint effectively, so these too must be protected by some alternative means. Cathodic protection offers a simple and very effective solution to this problem, but it must be installed correctly if it is to provide optimum benefit.

The aim of Cathodic protection is to prevent or control corrosion by reversing the flow of electricity which powers the corrosion process. On North Sea oil platforms and merchant ships this is sometimes achieved by using so called 'impressed current' protection systems, in which a carefully controlled voltage is applied between the metalwork and special platinum electrodes. But this requires a constant power source and regular supervision, so for most leisure vessels the familiar sacrificial anodes are used instead.

The Corrosion Process



A typical corrosion cell showing how the negative electrode (or anode) is eroded, while the positive electrode (or cathode) remains free from corrosion.
(Note that contrary to normal electrical engineering practice, the negative electrode in a corrosion cell is called the 'anode', probably owing to the original theory that electrons flowed from positive to negative)

Sacrificial systems work on much the same principle, except that the electricity is provided by the anodes themselves, which are chosen to ensure that they are always electrochemically negative with respect to the hull and all of it's fittings. The effect is to create an artificial corrosion cell, in which the anodes are deliberately sacrificed in order to protect the yachts hull. The amount of current which flows, and the rate at which the anodes are eroded is governed by the area of exposed metal, the conductivity of the water in which the boat is kept, and of course the type of anodes fitted.

For most sea water applications, traditional zinc anodes are sufficiently active to protect all commonly used boatbuilding metals, including steel, stainless steel, aluminium, brass and bronze. Zinc also provides limited protection in fresh water, but the reduced current flow tends to result in a thick brown crust being formed on the anodes, which quickly renders them ineffective. In mild cases this can be removed by enthusiastic

wire brushing, although replacement is often a more satisfactory solution.

To overcome this problem, magnesium anodes are usually specified for long term use in fresh water. These are marginally more expensive than zinc anodes, but they produce a slightly higher voltage which is helpful in overcoming the higher electrical resistance of fresh water, so keeping the anodes clean.

Magnesium anodes can also be used on sea going vessels, although their useful life is limited to only six or eight weeks in this medium. This shouldn't cause a problem for boats which spend only short periods at sea, but with most anodes having standard fittings, it is fairly straightforward to swap them over between tides should you be planning a longer voyage.

However, there is a commonly held belief that corrosion doesn't affect boats in fresh water, which in some respects is true. But once corrosion gains a foothold, it tends to generate by-products which accelerate the corrosion process, and may ultimately resulting in severe pitting. And of course fresh water is not always as pure as we would like it to be, especially in canals and industrial areas. With the high cost of boat repairs and underwater fittings, prevention really is better than cure!

Installing Your Anodes

Whatever type of anodes you choose, correct installation is a must if they are to work efficiently.

First of all, sacrificial anodes should always be located within line of sight of the metalwork which they are protecting. Metal which is hidden from the anodes will receive little or no protection, so you my need several anodes for complete coverage. And don't forget stern drives, bow thrusters and other expensive underwater fittings which are especially prone to damage and corrosion.

If you can, choose locations with good internal access so that fitting and wiring your anodes is as straightforward as possible. If necessary, the inside of the hull should be reinforced behind the anode in case the fastenings should be torn out by going aground, or by colliding with a submerged object.

In wooden boats, the anode fastenings must be sleeved with PVC tubing where they pass through the hull to prevent them from being corroded by acids in the timber, and to protect the timber itself from rotting. You should also keep an eye out for any white, powdery material forming inside the hull on anode fastenings. This material causes serious wood rot if it is not dealt with promptly, and should be washed off with warm water to which a small amount of vinegar has been added. And whatever the type of boat you have, anode fastenings should always be well sealed up using plenty of silicone rubber sealant to prevent leakage or corrosion.

When fitting your anodes, you may notice that they have a small 'lip' around their base. This mates with the gasket to protect the rear of the anode, and is designed to prevent any large lumps of metal from dropping off prematurely, so it is good policy to renew the gasket whenever the anodes are removed.

Once the anodes have been fitted, the job of wiring them up can begin. The voltages produced by sacrificial protection systems are very low, (typically less than one volt), so even a small resistance will significantly reduce the effectiveness of the system.

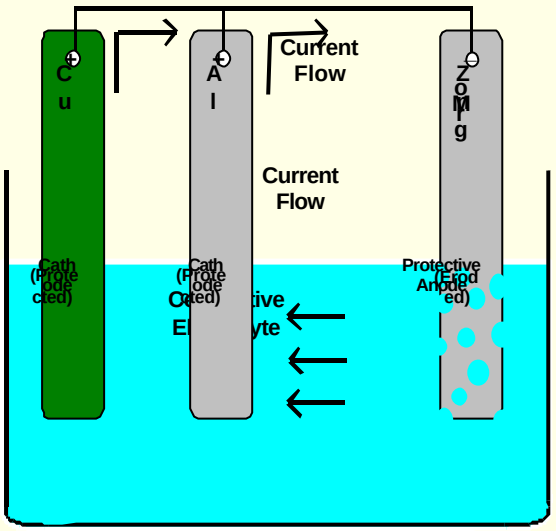
Bonding cables should be of PVC insulated stranded copper at least 4 mm^2 in cross section, with crimped terminals used wherever possible. And of course it goes without saying that connections should always be kept clean and tight.

All underwater metal fittings should be bonded together, including sterngear, rudder posts, metal keels and keel guards, and any trim tabs. However, the old practice of bonding metal skin fittings is no longer advised, because Cathodic protection does little to protect the vulnerable 'neck' of the fitting, and there is a risk that owners can be lulled into a false sense of security.

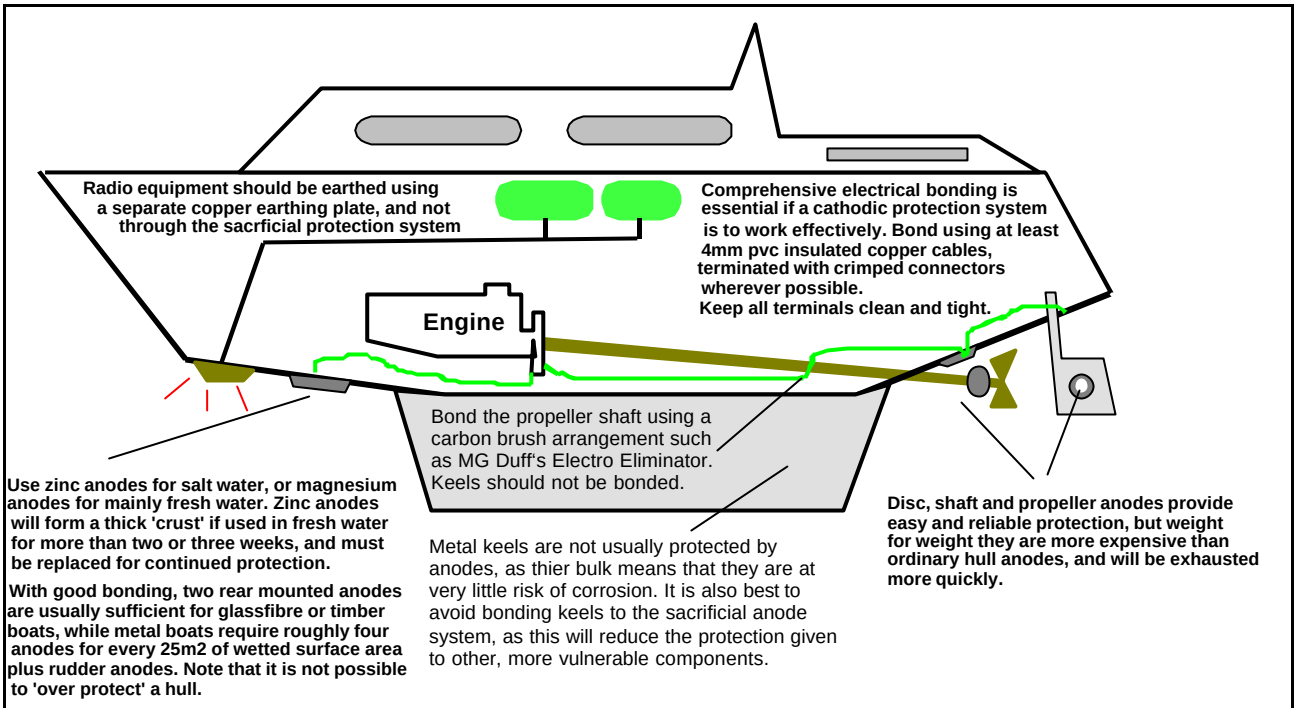
Special arrangements may be required for bonding propellers and their shafts, usually involving a carbon brush assembly like MG Duff's 'Electro Eliminator'. If necessary, flexible couplings on the shaft can be by-passed by using special braided cables, although the engine is usually better separated from propellers to avoid any problems caused by stray currents.

Alternatively, small disc or shaft anodes can be used to protect sterngear, which avoids

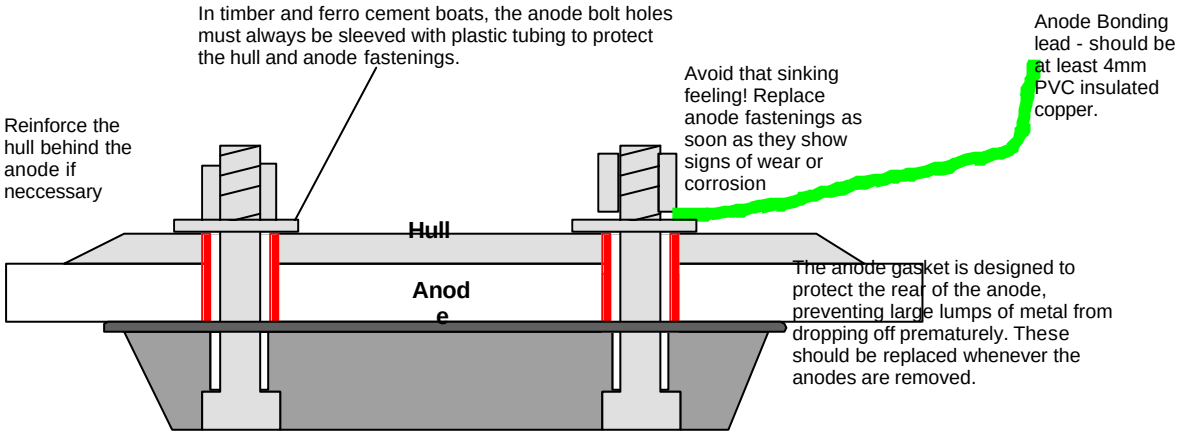
Using Sacrificial Anodes to control corrosion



This effect is put to good use in Cathodic protection systems, where an expendable zinc or magnesium anode is employed to protect other more valuable metals on the yachts bottom.



Correct installation of a Cathodic protection system. Note that all metal surfaces must be within 'line of sight' of an anode if they are to be adequately protected.



the need for bonding, although weight for weight these are rather more expensive than the larger hull anodes, and their lifespan is correspondingly shorter. Don't rely on bonding through the engine and gearbox though, as lubricating oil forms an insulating film on gears and bearings when they are turning.

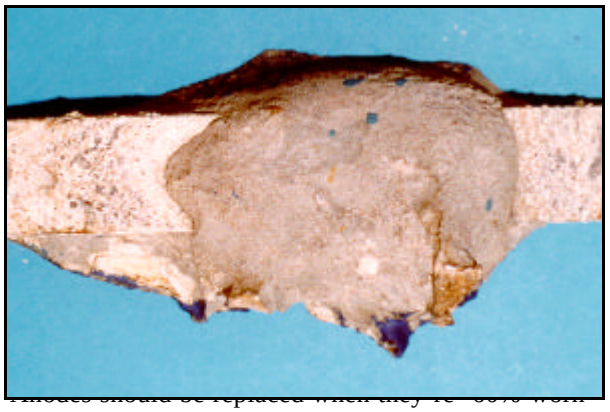
A correctly specified sacrificial protection system should have a lifespan of two or possibly three seasons, after which the anodes will be reduced to only 30 ~ 40% of their original weight. While it may be tempting to leave them on for another season, their surface area and protection afforded will be much reduced. However, if you find that your anodes are in constant need of renewal, it may be that they are working too hard and need to be supplemented, or that you have a problem with stray currents. Remember that radio equipment should be earthed using a dedicated copper earthing plate, and not via the anodes.

And while we are about it, I should also mention that many marine engines have a small 'pencil' anode fitted to protect their cooling systems from corrosion, and should be replaced annually.

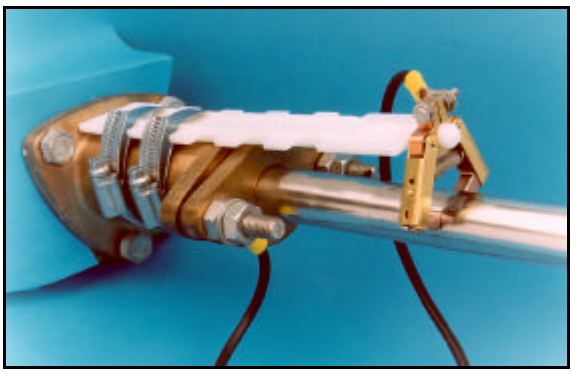
However, Cathodic protection is a complex subject, and it is simply not possible to cover every question in the space available, although a specialist firm like MG Duff should be able to answer any more tricky questions. Their technical department is at Chichester, West Sussex, where they can be contacted on 01243 533336.

If they're working properly, anodes should last for two full seasons. When lifted, they should appear clean and lightly sandblasted without any deep pitting.

Correct choice of anodes is essential if you want optimum protection for your hull. Zinc anodes are not sufficiently active for long term use in fresh water, and will quickly form a thick crust which prevents them from working properly. Magnesium anodes work well in fresh water, but have a rather limited life in the briny.



Anodes should be replaced when they're 50% worn to ensure continued protection. If your anodes look like this after a seasons use they're probably working too hard, or you may have an electrical problem. Splashing with antifoulings will also cause premature wear.



The MG Duff Electro Eliminator is a carbon brush arrangement, designed to ensure electrical continuity between your hull anodes, and propeller shaft.

Do not rely on the gearbox for continuity, as lubricating oil should form an insulating layer on moving parts. Moreover, if the oil is contaminated with water, trying to pass an electric current through the gearbox may encourage corrosion.

However, anodes will not prevent corrosion caused by poor choice of materials. This aluminium alloy drive leg and propeller was badly damaged by painting with copper based antifouling.

Anodes should always be within 'line of sight' of the metal they are protecting.

Metal that cannot be 'seen' by the anodes will receive about 75% less protection than in a 'line of sight' installation.

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