ALKALINE DEGRADATION OF TIMBER HULLS
DUE TO CATHODIC PROTECTION SIDE EFFECTS

By

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Prop currently: Super Stain
Suggest: Nickel Iron Alum Bronze. or Gunmetal - (but too soft).

1. INTRODUCTION

It was common practice for many years to protect the skin fittings of timber hulled small craft by fitting a sacrificial anode cathodic protection system. This was usually accomplished by mounting a number of zinc anodes on the hull and connecting them to the skin fittings by means of internal copper straps or wires. These systems worked very well - in fact too well and over a number of years they caused extensive alkaline degradation of the hull timber, in the vicinity of the protected fittings. This deterioration of the timber was often mistaken for dry rot but was actually what could be referred to as 'galvanic rot'.

The object of this short article is to draw attention to the problem and to explain how it arises, how to identify it, how to treat it and best of all, how to prevent it.

2. A SIMPLE GALVANIC CELL

In order to explain the development of the highly alkaline conditions, which cause the deterioration of the timber, it will be necessary to have a brief look at the mechanism of a basic galvanic cell and to introduce some simple electrochemical reactions.

A galvanic cell is formed when two dissimilar metals are connected electrically in sea water. The metal with the more negative electrode potential becomes the anode and corrodes, whilst the metal with the more positive electrode potential is protected. If a zinc anode having an electrode potential of approximately -1.05V, is connected to a copper alloy skin fitting with an electrode potential of approximately -0.230V, a typical galvanic cell will be formed. The potentials quoted are all relative to a silver/silver chloride (Ag/AgCl) reference electrode in sea water. The zinc anode will then corrode and enter the water as zinc ions. Zinc ions are zinc atoms, which have given up two electrons (negative electric charges) and are left with two positive charges (Zn^{2+}). The electrons left behind on the surface of the anode flow through the electrical connection to the more positive skin fitting, due to the attraction of unlike charges. This flow of electrons constitutes an electric current and in this case is the cathodic protection current. The reaction at the anode is an oxidation reaction and can be represented as follows:-

$$Zn \;>>\; Zn^{2+} + 2e^{-}$$

Zinc atom — Zinc ion — Electrons

The copper alloy skin fitting receiving the electrons becomes a cathode and is protected from corrosion ie., it cannot enter the water as positive copper ions (Cu^{2+}). A very simple explanation of the protection mechanism is that any positive copper ions leaving the surface of the skin fitting are attracted back by the negative electrons received from the anode, thereby preventing corrosion.

The electrons on the surface of the skin fitting (the cathode) are consumed by reduction reactions and have to be constantly replaced to maintain protection. The principal cathode reaction in sea water is the reduction of oxygen and its subsequent reaction with water to form hydroxyl ions, as shown below:-

$$O_2 + 2H_2O + 4e^{-} \;>>\; 4OH^{-}$$

Oxygen — Water — Electrons — **Hydroxyl ions**

The two reactions shown above take place simultaneously to maintain the electrical neutrality of the water ie., for every $\mathbf{Zn^{2+}}$ ion given up to the water by the anode, two electrons are supplied to the skin fitting and two $\mathbf{OH^{-}}$ ions are formed on its surface and enter the water.

3. HOW THE PROBLEM ARISES

It is the formation of these $\mathbf{OH^{-}}$ ions on the protected fitting that this article is all about. Most of us are aware that caustic soda or sodium hydroxide (NaOH) is highly alkaline and is used to digest timber for paper making. When sodium hydroxide is dissolved in water it dissociates into sodium ions and hydroxyl ions as shown below:-

$$NaOH \;>>\; Na^{+} + OH^{-}$$

Sodium Hydroxide — Sodium ion — **Hydroxyl ion**

The $\mathbf{OH^{-}}$ from caustic soda is identical with the $\mathbf{OH^{-}}$ formed in the water surrounding the protected fittings and has the same destructive effect on timber. The problem begins when the water containing the OH^{-} ions is absorbed by the hull timbers and permeates through to the inside, where it evaporates. This process continues and the concentration of the OH^{-} ions increases and reacts with carbon dioxide gas from the atmosphere to form a white powdery deposit of sodium carbonate monohydrate. These highly alkaline deposits are sparingly soluble and accumulate even in moist conditions.

At this stage some deterioration of the timber has taken place and the surface can be readily broken into fibres. Although the OH^- ions are formed on the sea water side of the protected fitting, the deterioration of the timber commences on the inside, where the OH^- ions are concentrated. This is probably the reason why the problem took so long to be identified as a cathodic protection side effect. If vessels are moored for long periods, the concentration of OH^- ions can build up around protected fittings and the risk of alkaline damage is greatly increased.

4. IDENTIFYING THE PROBLEM

Positive identification of the problem can be made by rubbing the white deposits through the fingers (they produce a soapy feel), by testing with red litmus paper (which turns blue), by testing with universal pH papers (pH values of 12-14) or by pouring vinegar or 10% acetic acid on the deposits, which fizz due to the liberation of CO_2 gas.

5. HOW TO TREAT AFFECTED AREAS

Providing the problem is localised around the protected fittings, restoration work should be possible. If the alkalinity has seeped to other parts of the hull, the timber strength could be seriously reduced, making restoration work uneconomical. If restoration work is undertaken the following suggestions may be helpful:-

a. If the timber is not seriously degraded, then it should be possible to treat the area without removing the fittings. Clean away all white deposits and loose wood fibres. Using a brush, apply a 10% solution of acetic acid to the timber around the fittings and any areas, such as along joins in the timber, where white deposits are visible. Continue this treatment until all fizzing stops. Vinegar can be used for this purpose but acetic acid is more effective. Wash down well with fresh water after treatment to avoid unwanted contact with the acid. It is most likely that treatment will have to be repeated several times as the alkalinity in the wood will continue to permeate through to the inside. Please note that **eye shields**, rubber gloves and an apron should be worn when using acid solutions.

b. If the timber around protected fittings is badly affected then the fittings should be removed. The degraded sections should be cut out and any white powdery deposits washed away. Treat the area with acetic acid or vinegar to ensure that it is free from alkalinity. Replace the hull timbers as required.

6. HOW TO AVOID THE PROBLEM

Obviously the way to avoid the problem is not to use anodes to protect skin fittings. All existing anodes, including shaft anodes, should be removed. In older vessels this may present a separate problem as some fittings were previously made from brass. Generally it is cheaper to replace an occasional skin fitting than to replace timber. New skin fittings should be made from materials such as gunmetal, that do not require protection.

The most likely problem that can arise without cathodic protection is the corrosion of the propeller shaft, which may fail by crevice corrosion in the stern gland or bearing. This depends on a variety of factors, such as usage rate, water temperature, materials of the shaft and propeller, type of gland packing and the type of bearing.

Propeller shafts made from Type 316 stainless steel may give satisfactory service in the Sydney region but could fail in warmer northern waters. If the propeller shaft does fail, it is suggested that a higher duty stainless steel such as Armco Aquamet 22, be used for the replacement shaft.

7. CONCLUSIONS

If skin fittings in a timber vessel are connected to a cathodic protection system the hull will be degraded in the vicinity of the fittings. It usually takes about five years for the problem to become obvious and vessels over 10 years old may be seriously affected. It is hoped that this article will highlight the problem and allow remedial action to be taken before serious damage occurs.