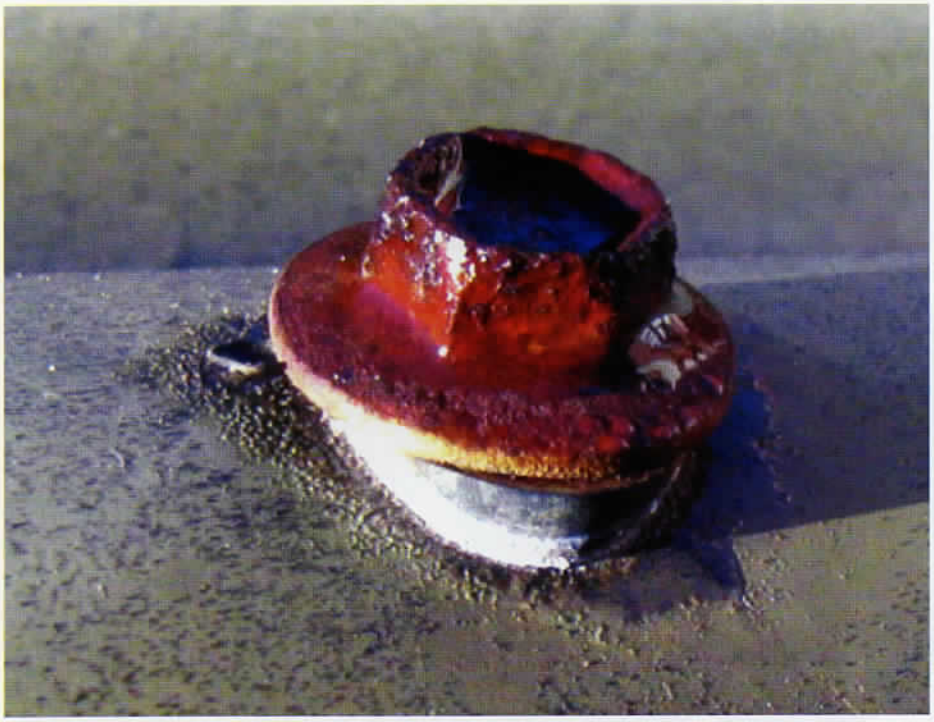
# Metal Compatibility and Corrosion



*This close-up photo of a self drilling fastener used on a Colorbond™ roof shows the corrosion of the roof sheeting caused by the use of rubber washers containing graphite. Graphite is extremely cathodic to most metals. Non-graphite washers should be used for this application.*

## INTRODUCTION

Inquiries are regularly received at the Corrosion Management office regarding the use of different metals in contact. The metals most commonly used for construction; steel, aluminium, stainless steel, galvanized steel, zinc-aluminium alloy coated steel (Zincalume™) brass, copper, bronze and cast iron, each has its own place in the electrochemical series.

Corrosion Management has published information in the past with tables of electrical potential (see CM November 2003). However, the presentation of the information in this form is relatively complex, so in this issue, it has been simplified to into a more practical form.

## CORROSION DRIVERS

Corrosion only occurs when an electric current flows between areas of different electrical potential, and the rate of corrosion will be determined by the magnitude of the current and the availability of an electrolyte to conduct in.

In the absence of either moisture, dissolved salts (ions) and an electrical potential between two points, corrosion will not occur.

For some metals, pure water (condensation, rain) has a low corrosion impact. On other metals, particularly zinc before it has time to form its stable oxide film, pure water is very corrosive and gives rise to the `white rust' that appears on zinc (galvanized) coatings from time to time.

Surfaces that are wet for long periods of time (shaded or sheltered areas) will suffer higher corrosion stress than upward-facing, exposed surfaces. This is frequently manifested with metal roofs, particularly in coastal locations, where the underside of the roof has long periods of chloride-contaminated wetness.

## METAL-TO-METAL CONTACT

The most common metal-to-metal connection arises from fasteners. Bolts, self-drilling screws and blind rivets are the most commonly used methods of connecting building products.

For exterior applications, bolts and self-drilling screws are usually manufactured from mild steel and coated by electroplating, galvanizing or proprietary processes to provide acceptable durability.

Blind rivets are usually a steel-aluminium combination, with the main section of the rivet being aluminium. For heavy duty applications, other materials such as monel metal may be used for these rivets.

These fasteners are used to connect cladding to buildings. Metal cladding is either pre-coated sheet such as BlueScope Colorbond™ or zinc-aluminium or galvanized sheet. Aluminium sheet is also used for cladding.

Fastener durability is always an issue with designers and the use of stainless steel fasteners is an apparent solution. Most commercial grades of stainless steel (the 300 and 400 grades) are mildly cathodic to mild steel (hydrogen half-cell potential approx. 0.25 volts) and significantly more cathodic to zinc and aluminium (hydrogen half-cell potential approx. 0.5 volts).

Where the anode is large (the cladding) and the cathode is small (the fastener), the metal-to-metal corrosion stress is relatively low. In dry environments, the performance of the assembly may be acceptable, and in very aggressive environments where the overall performance of the cladding determines the life of the installation, stainless fasteners may provide a solution.

BlueScope Steel will not warrant its Colorbond™ roofing or cladding if used with stainless steel fasteners.

Serious corrosion failure can occur if large cathodes are exposed to small anodes. The use of stainless steel screen mesh on mild steel painted or galvanized frames is an example, particularly in water screening operations.

Some spectacular architectural failures have occurred through the connection of stainless steel cladding to mild steel structural elements in coastal areas where airborne chlorides can penetrate the building envelope.

While it is not commonly encountered in Australia, copper cladding used for roofing – usually on public or heritage buildings can cause serious corrosion with both galvanized steel, mild steel and Zincalume™ rainwater products. The small amounts of copper residues carried by the rainwater can corrode zinc-based coatings very quickly.

*Any construction project involves a number of different materials including uncoated, painted and galvanized steel, aluminium, aluminium-zinc alloy coated steel and copper-chrome-arsenic treated timber and copper, brass or lead in lesser applications. The compatibility of these materials in contact will influence their durability.*

Lead flashing should never be used in contact with aluminium or aluminium alloy products, and while it was used traditionally to flash galvanized iron roofs, lead is significantly cathodic to zinc, with a half-cell potential difference of 0.8 volts.

A moderating factor with galvanized sheet produced in earlier times is that the galvanizing alloy used had a relatively high (1.5%) lead content. Most galvanized products now use high-grade zinc (99.5+ purity).

One commonly experienced disaster with lead occurs with aluminium boats. Lead sinkers left on the bottom of an aluminium boat hull for long enough in the same place can cause perforation of the hull. This can occur to a lesser extent with brass fittings left in prolonged contact with the aluminium in marine conditions.

The most cathodic of materials is graphite. While not a metal, its metal-like properties of being a good conductor of electricity, and its use in the manufacture of rubber gaskets and washers has resulted in its being responsible for accelerated corrosion of metal roofing and cladding.

The hydrogen half-cell potential of graphite is +0.6 volts – giving it a potential of 1.2 volts to zinc and aluminium, which is why the standard dry-cell battery uses zinc and graphite to generate its current.

Graphite containing washers used on self-drilling fasteners will cause localised corrosion of galvanized or Zincalume™ coated cladding. Colorbond™ coated sheeting will usually start to blister around the washer if graphite-bearing rubber washers are used.

Fastener manufacturers with Australian Standard compliant products have adopted non-graphite (usually gray neoprene) washers that will alleviate this problem. The presence of soot on metal roofing from heaters is also a source of graphite-based corrosion.

In certain environmental condition, sometimes associated with poor ventilation or stagnation in water, some cathodic metals can become much more cathodic – up to 0.2 volts, which will accelerate their attack on anodic materials to which they are connected.

The metal-to-metal reaction is not all bad news. The electrochemical relationship between zinc and steel is a significant benefit in using these materials in combination. Mild steel has a half-cell potential of around 0.3 volts with respect to zinc.

This allows pre-galvanized products such as sheet, wire and tube to be processed after galvanizing without requiring repair of the cut edges where the steel is exposed. The relatively thin sections used with these types of products ensure that a relatively large area of zinc protects a relatively small area of steel.

It is for a similar reason that decorative chrome plating suffers rapid deterioration if any holidays occur in the coating. Decorative chrome plating is done by applying a copper base coat, usually followed by a nickel undercoat topped by the chrome plating on the surface.

This combination guarantees the rapid corrosion of the steel substrate, as each of these materials is significantly cathodic to steel.

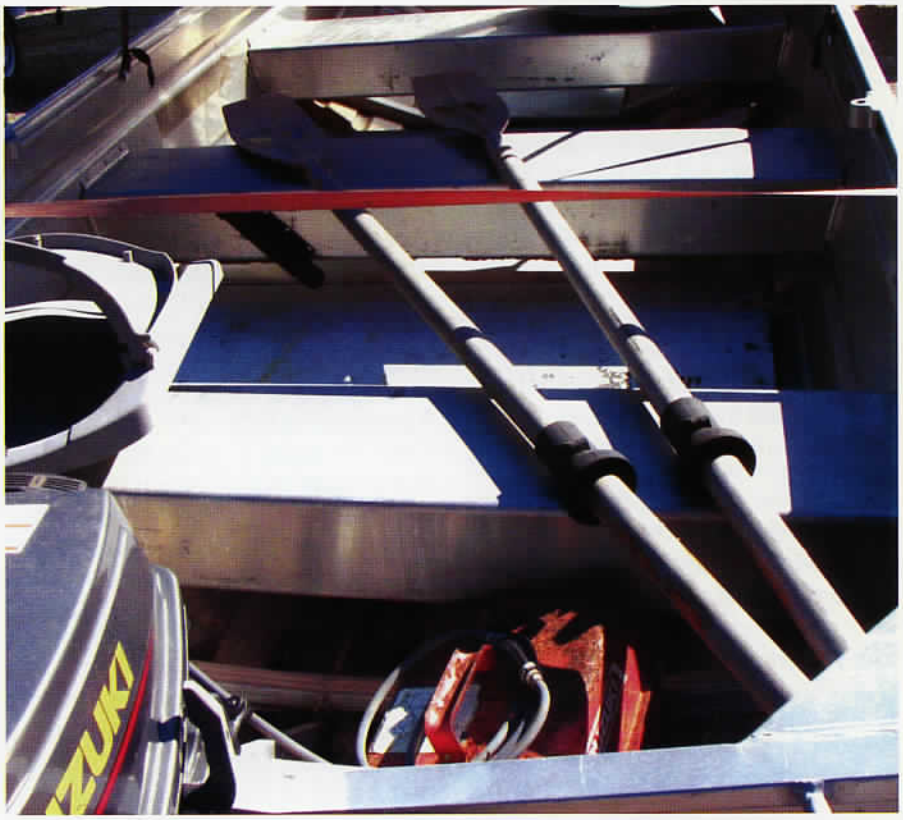
## SUMMARY

Manufacturers of metal building products can provide compatibility information with respect to approved types of fastening and fixing arrangement.

Zinc and aluminium products can be used in contact without any problems. Stainless steel can be used in contact with less noble metals, but careful assessment of the operating environment should be done.

The low current voltages associated with bimetallic corrosion make it relatively easy to electrically insulate incompatible metals. This can provide a solution where stainless steel components need to be connected to mild steel structures.

*Outboard motors commonly use magnesium anodes to prevent corrosion of the aluminium motor housing. The use of stainless steel propellers and components can cause corrosion problems if not accommodated in the design of the motor.*




*Unpainted aluminium boats are susceptible to intermetallic corrosion if lead sinkers or brass fittings are left in contact with the hull in the presence of salt water, and can result in perforation of the hull.*

# CORROSION MANAGEMENT

CORROSION MANAGEMENT is published for those interested in the specification, application and performance of protective coating systems.

## CONTENTS



*COVER: Tempus Two Winery at Pokolbin, NSW is the Hunter Valley is an outstanding example of the use of galvanized steel as an architectural self-finish.*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*Tempus Two Winery*

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