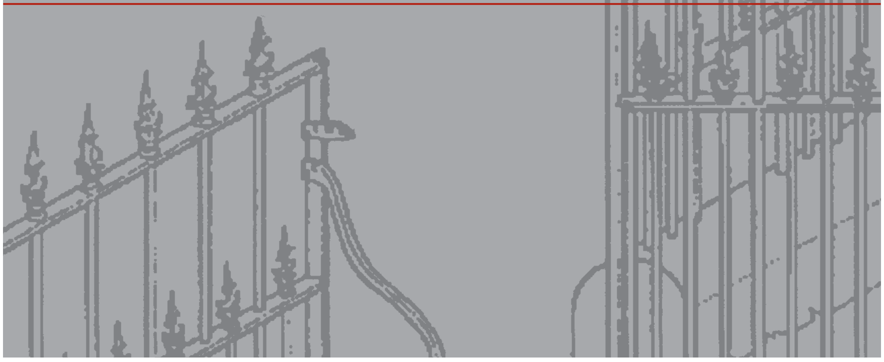
The maintenance series



Information sheet

3.1

NSW Heritage Office

Metalwork

Table showing galvanic series for metals in seawater

More noble (cathodic) protected end (+)

Gold
•
Silver
•
Stainless steel
•
Nickel
•
Bronze
•
Copper
•
Brass
•
Tin
•
Lead
•
Iron + Carbon steel
•
Aluminium alloys (high strength) Cadmium
•
Aluminium (commercially pure) Zinc
•
Magnesium alloys

Less noble (anodic) corroded end (–)

Introduction

This information sheet deals with the care and conservation of metals used in building, including cast and wrought iron as fencing and decorative panels, steel-framed windows and roof plumbing. For further information refer to the references at the end of the sheet, and to the separate information sheets on *Corrugated Roofing*, and *Slating, Tiling and Roof Plumbing*.

Corrosion of metals

Most metals slowly oxidise when exposed to atmospheric conditions, changing to another form such as the mineral ore from which they were produced. Rusting iron and steel produce reddish iron oxide. Some metals such as gold and certain stainless steels are more resistant than others to this process (or more noble) and remain largely unaffected. The process of chemical reversion, or corrosion, is accelerated by air pollutants, acid rain, salts and the presence of dissimilar metals. In coastal environments metals corrode rapidly under the influence of airborne salts and high humidity.

Galvanic corrosion

Galvanic corrosion occurs between dissimilar metals. If two such metals are in electrical contact in an electrolyte (or conducting solution) such as water, one of the metals will corrode at a faster rate than it would normally, and at the same time the other metal will be protected from corrosion. A less noble metal in the **galvanic series**, shown here, will corrode preferentially and protect a more noble metal (one higher in the series). This is the principle behind the galvanising (or zinc coating) of steel: the zinc corrodes preferentially and protects the steel.

The relative position of metals on the galvanic series is not the same under all conditions. Heat, or an electrolyte other than seawater, would produce a change in the position of some metals.

Galvanic corrosion of original corrugated metal sheeting.

Photograph by Bruce Edgar.

The further apart two metals are on the series, the greater will be the galvanic reaction. Combining two distant metals in a damp environment will lead to rapid corrosion of the less noble metal. This is why metals such as zinc (or galvanised steel) and copper should never be used together. Lead flashings and cappings, traditionally used in conjunction with galvanised steel roofs, can cause corrosion if the roofing is replaced with modern steel sheeting coated with a zinc–aluminium alloy.

Even if the two metals are not touching, corrosion can still occur. Water can provide an electrical bridge, or carry in solution a small amount of the nobler metal to the other, where it precipitates or plates out and causes corrosion. Thus, water running off a copper roof into galvanised gutters will lead to rapid corrosion of the zinc galvanising and then the steel of the gutters.

It is good conservation practice to minimise the number of metals used externally. If copper is used for the roofs, then replacement gutters and downpipes should also be of copper. Galvanised iron or steel roofs should have galvanised gutters and downpipes. The same rules apply for water supply pipes and other plumbing.

The relevant area of the two metals affects galvanic corrosion. A small scratch or hole in the zinc coating on a galvanised steel sheet will heal as the ‘throwing power’ of the zinc is sufficient to protect the adjacent steel. Equally, when a galvanised sheet or length of galvanised wire is cut, the exposed steel is protected by the much larger surface area of the zinc coating. But if zinc is lost over a larger area (more than a few square centimetres) then the remaining zinc will not be able to protect the bare steel, which will consequently corrode (rust).

Crevice corrosion

Unlike galvanic corrosion, crevice corrosion requires only one metal and water to be present. This type of corrosion results from different oxygen concentrations within water lying in a crevice, hence its formal name of *oxygen concentration cell corrosion*. The water exposed to the air is richer in oxygen than the water deep in the crevice. The metal adjacent to the oxygen-rich water acts as a cathode or more noble metal, while the same metal deep in the crevice acts as an anode, or less noble metal, and so corrodes.

It is good conservation practice to minimise the number of metals used externally. If copper is used for the roofs, then replacement gutters and downpipes should also be of copper.

The danger with crevice corrosion is that it always occurs deep inside the crevice, where it may not be seen. A common example of crevice corrosion is the thinning or necking of bolts or rods which pass through wood or metal sections. Keeping these areas dry is thus important for good maintenance.

Deformation or stress corrosion

A third form of corrosion results from the cold working of metals. The deformed zones, such as a bend in a pipe, behave like less noble metals compared with the undeformed parts, and so corrode more rapidly. The head and point of a nail (which have been stressed during manufacture) will corrode faster than the shank.

Ornate palisade fence, Centennial Park reservoir, Sydney.

Photograph by David McBeath.

Palisade fences

Palisade fences typically have a low stone or rendered brick plinth surmounted by a palisade of wrought iron or mild steel shafts. The shafts penetrate flat wrought iron or mild steel rails and carry ornamental spearheads or tops of cast iron. The iron palisade is supported along its length by posts of cast or wrought iron or masonry.

A common conservation measure needed for palisade fences is to replace stays that may have been misguidedly removed to allow easier access for lawnmowers and the like. The stays are needed to brace the fence and ensure its lateral stability.

Corrosion in palisade fences

Crevice corrosion can occur where the shafts penetrate the rails, and also between the spearheads and the top rail. Careful filling and painting of these areas is required to eliminate crevices where corrosion may occur.

The traditional practice was to set the iron shafts in a leaded joint by pouring molten lead into an oversize hole around the base of the shaft and tamping it down as it cooled. The lead insulates the iron from damp stone and, because it is soft, allows a certain amount of movement due to thermal expansion and contraction of the iron.

The problem with such fixings is that repeated thermal cycling creates a very small gap between the iron and the lead, allowing water entry and consequent crevice corrosion. Severe corrosion of the iron can result in rupturing of the masonry base as the rusted metal expands.

Iron Palisade Fence Construction

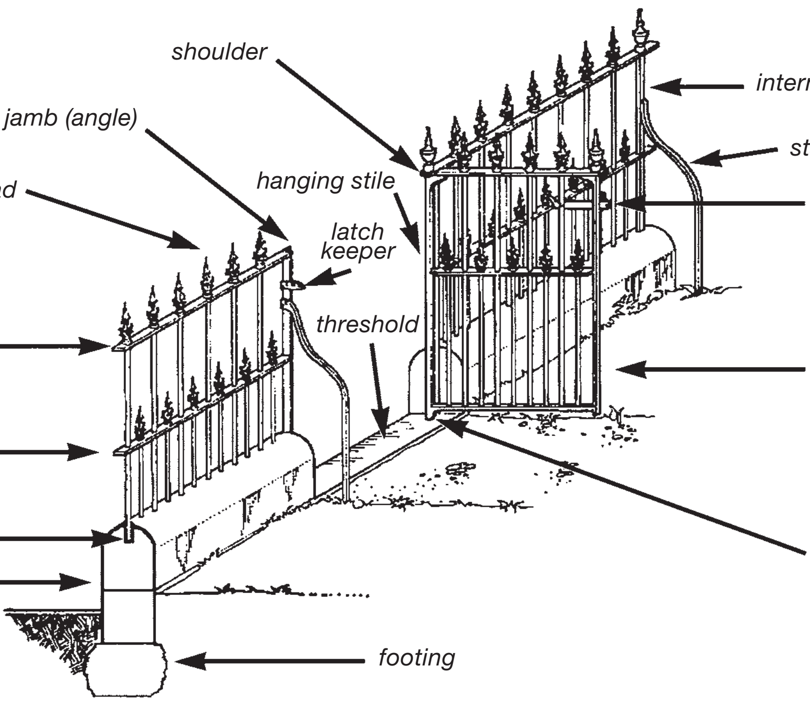


Illustration from Ian Stapleton, How to Restore the Old Aussie House*, Flannel Flower Press, 1991*

Remnants of cast iron lacework can be used to identify original patterns.

Photograph by Bruce Edgar.

In order of increasing intervention, conservation approaches to corroded palisade shafts include:

- removing the shafts, treating them for rust, and replacing them according to traditional practice with molten lead;
- removing the shafts, treating them for rust, and replacing them with a modern packing such as expansive tape;
- cutting off the corroded base and welding on a new base of mild steel, galvanising the whole shaft, and resetting it in lead;
- cutting off the corroded base and welding on a new base of stainless steel, which is then set in lead or in expansive tape. If lead is used it will be the less noble metal and will therefore corrode;
- cutting off the corroded base to a stump and fastening a new base of stainless steel tubing over the stump using epoxy adhesives. The outside diameter of the tubing must match that of the shaft. The tubing can then be set in lead or in expansive tape;
- replacing the entire palisade in new galvanised steel painted an appropriate colour.

The chosen method will depend on the significance of the fence and its current condition. A common, but visually unacceptable, approach is to introduce a new bottom rail to which the shafts are fixed, thus avoiding the need for joints into the stonework. Cutting off the corroded bases of all shafts and refixing the whole palisade at a lower height is usually also practically and aesthetically unacceptable due to unavoidable changes in height across gates and at posts.

Decorative ironwork

Decorative ironwork, such as iron lace of the 19th century, was almost all cast iron, which developed from earlier, elaborately shaped wrought iron work. Conserving cast iron lace often requires replacement of missing sections, or sometimes complete reconstruction of a verandah long since removed. The original pattern of the cast iron may be found by careful searching of the site for remnants of the original material, examining early photographs, or inspecting adjacent identical buildings, such as in a terrace. Spacings of columns, uprights and rails can often be determined by looking for evidence of fixings in floors, pavements or walls.

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Foundries can reproduce ironwork using existing pieces as patterns, although care is required because slight shrinkage occurs when the iron cools. A better result may be obtained by producing a new pattern for the casting.

Cast aluminium sections are widely available today. Depending on the significance of the ironwork, an accurate sand-cast aluminium reproduction of the original pattern may be acceptable as a replacement.

Care of cast iron work

As long as it is clean and dry, good-quality cast iron corrodes very slowly, leaving a thin surface film of rust. There are many cases where doing very little, except the occasional brush clean, is an appropriate conservation approach. This applies particularly to situations such as cast iron grave surrounds in cemeteries located in dry inland areas.

The thin application of fish-oil-based coatings is an appropriate treatment, but requires regular reapplication to maintain a cared-for look. The next level of care is painting, which is dealt with below.

Cast iron is a very brittle material, and any high impact or stress may cause it to fracture. It therefore needs careful handling and protection from damage if heavy building work is being done nearby.

Steel-framed windows

It is good conservation practice to repair and retain existing building elements where possible, rather than replacing them with new materials.

Steel-framed windows are commonly found in buildings of the first half of the 20th century. Rusting of the steel frames, which were seldom galvanised, is a concern for both the window and the surrounding wall. When iron and steel corrode the volume of the rust produced is much greater than the original volume of the uncorroded metal. The expansive forces produced by corrosion of steel fixings buried in masonry (or tightly fitted into a limited space, as in the case of a window) can cause damaging spalling or bursting of the surrounding brick, stone, terracotta or concrete.

The ready availability of extruded aluminium alloy frames might seem an attractive alternative to rusting steel, but is generally inadvisable. Considerable damage can result from attempts to remove steel sub-frames embedded in masonry. Attaching alloy frames to steel sub-frames invites galvanic corrosion, which cannot always be prevented by isolators between the two metals.

In addition to the physical problems, aluminium window sections are usually bigger than steel, and result in an unacceptable change in appearance. Moreover, while steel windows can be maintained for a long time, once an aluminium window deteriorates it requires complete replacement.

Repairs to steel windows

It is good conservation practice to repair and retain existing building elements where possible, rather than replacing them with new materials. When replacement is required, the new materials should generally match the old – steel for steel in this case.

Well-made steel-framed windows are constructed so that the frame can be unscrewed from a subframe and removed internally. The frames can then be thoroughly cleaned of rust, coated and reglazed under ideal conditions before reinstatement in the building. Because such windows can be removed and installed from the inside, no scaffolding is necessary and the work can be staged progressively to suit a minimal budget. Hot-dip galvanising of steel frames is strongly recommended, in addition to other protective measures dealt with below.

Gutters and downpipes

Materials

From the discussion of galvanic corrosion, it is clear that gutters, rainwater heads and downpipes ideally should all be made of the same metal, and this should in turn be the same as the metal roof covering.

Loose fixings.
Photograph by Warwick Connor.

It is theoretically possible to have copper guttering (more noble) to a galvanised steel roof (less noble) as long as the two metals are not in direct contact. However, such a combination is risky, as a wet leaf or twig jammed between gutter and roofing can make electrical contact between the two metals and lead to corrosion of the steel.

Protecting iron and steel

Surface preparation

Good surface preparation is critical to the successful protection of ungalvanised iron and steelwork. A range of techniques is available, including wire brushing, grit blasting, acid pickling, solvent and flame cleaning. When carefully controlled and not overdone, wet grit blasting is a good technique for removing heavy build-up of old paint or rust layers. The surface is left clean and slightly roughened, which provides a good key for paint adhesion.

Any rust left after wire brushing can be chemically pretreated prior to painting. Most pretreatment solutions must be thoroughly flushed with clean water to remove excess residue.

In many cases full stripping is not necessary. Provided the old paint is sound, and not so thick as to obscure the detail of the cast iron, it is better to paint over it, preserving the record of previous finishes.

Irrespective of which cleaning technique is used, bare metal should be primed immediately. Ten minutes exposure is a maximum to aim for in aggressive environments such as those on the coast. Cleaning, drying and recoating need to be carefully coordinated as a continuous operation.

Caution: Lead-based paints

It is very likely that paint from before 1970 contains lead, either in the primer (red and/or white lead) or as coloured pigment in the finishing coats. Because of the toxicity of lead, the removal of these paints must be undertaken with extreme care. Use methods that minimise the generation of dust or fumes. The poultice method of chemical stripping is worth considering.

Information on lead removal is available from the Australian Paint Manufacturers Federation or the Lead Reference Centre at The Environment Protection Authority, www.epa.nsw.gov.au.

Paint coatings

Modern alkyd-based primers provide good protection for steel, as they incorporate inhibitive (anti-corrosive) pigments such as zinc phosphate. Given correct surface preparation and adequate priming, the best intermediate and top coats are:

- alkyd gloss enamel
- exterior quality acrylic latex
- alkyd micaceous iron oxide paint.

The Australian Standard AS2311-1922 *The Painting of Buildings* provides guidance as to the best primers and top coats to use on all surfaces, including steel.

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Two finishing coats are essential over primed steel, with a total film thickness of 105-150 microns. Micaceous iron oxide paints are only available in a limited range of colours, but they are very durable. They have a characteristic speckled appearance which may not be appropriate for some applications. The Sydney Harbour Bridge is an example of their use.

Paint coatings should be inspected annually, looking for signs of chalking, cracking and other defects such as rust. Maintenance repainting should be undertaken before the commencement of significant coating failure.

FURTHER READING

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