

METALWORK



This cast-iron fence was produced in Glasgow at Macfarlane's 'Saracen' Foundry. Such imports were not rare in the nineteenth century but they are now becoming increasingly harder to find. The broken segment will be virtually impossible to repair.

Photograph by David Wixted

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 more information refer to the section *Further Reading*, 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.

Air pollutants, acid rain, salts and the presence of dissimilar metals accelerate the process of chemical reversion, or corrosion. In coastal environments, metals corrode rapidly under the influence of airborne salts and high humidity.

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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 right, 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 sea water, would produce a change in the position of some metals.

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,

*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 (-)*

*Table showing galvanic series for metals
in sea water*

then replacement gutters and downpipes should also be of copper. Galvanised iron or steel roofs should have galvanised gutters and downpipes. The same rule applies for water supply pipes and other plumbing.

The relative 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 large 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.

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.



This residential scale palisade style fence is made of wrought iron and cast iron components.

Photograph by David Wixted

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.



As a result of the wrought iron metal corroding, the stone fence pillar is splitting apart to the point where it is cracking and becoming virtually irreparable. Immediate action is required to remove the metal, treat it and install a new soft lead plug to accommodate expansion and any future slow corrosion.

Photograph by David Wixted

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.

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 often both 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 nineteenth century was almost all cast iron, which developed from earlier elaborately shaped wrought-iron work. Conserving cast-iron lace often requires the replacement of missing sections, or sometimes the 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.

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



This palisade fencing has encouraged the delamination of the bluestone base. The pikes of the fence rest in lead sleeves which absorb the movements of the metal. The stone delamination shows where the lead sleeves are not effective.

Photograph by David Wixted

sand-cast aluminium reproduction of the original pattern may be acceptable as a replacement.

Care of cast iron work

So 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

Steel-framed windows are commonly found in buildings of the first half of the twentieth 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 the 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.

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FURTHER READING

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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 sub-frame and removed internally. The frames can then be thoroughly cleaned of rust, coated and reglazed under ideal conditions before reinstallation 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. It is theoretically possible to have copper guttering (more noble) to a galvanised steel roof (less

noble) so 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 a 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 re-coating 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.

Paint coatings

Modern alkyd-based primers provide good protection for steel as they incorporate inhibitive (anticorrosive) 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 AS2311-1992 The Painting of Buildings provides guidance as to the best primers and top coats to use on all surfaces, including steel.

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 extremely 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.

