CTB - 1
Technical Bulletin

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Corrosion

Introduction

Whilst architects, roofers, plumbers and builders may not need to fully understand the chemistry and mechanics of metallic corrosion, there should be an awareness of the many materials' design, specification and installation combinations that have a potential to cause unsatisfactory material performance.

The most common factor leading to eventual material replacement is time. This statement recognises that all materials eventually suffer from some form of deterioration. While premature replacement of brittle building materials can be initiated by impact damage, and timber may rot or suffer from termite attack, the most common reason for failure of metal products is corrosion.

Definition

Corrosion may be defined as the destruction or deterioration of a material because of electrochemical reactions with its environment. For steel, it is often the case of the iron endeavouring to return to the original hydrated iron oxide or iron oxide state. Although other metals form various oxides when corrosion occurs, 'rusting' is a term reserved for the corrosion of iron and steel.

All environments are corrosive to some degree. The rate of corrosion is generally governed by the available moisture within a specific environment. Sources of corrosive species, such as marine influences and acid rain derived from industrial contamination, can cause an otherwise benign environment to become highly corrosive. This will only serve to expedite degradation of the material, leading to premature failure.

BlueScope has endeavoured to take advantage of the natural galvanic protection associated with preferential corrosion of active metal alloys in contact with less active metals, specifically steel. To achieve this effect, metallic coatings are applied to steel substrates for the purpose of increasing the corrosion resistance of the steel product. Some examples of applications for which metallic coatings are commonly applied to steel, for the prime purpose of providing corrosion protection, are as follows:

1. Hot-dipped aluminium/zinc/magnesium coatings (e.g. ZINCALUME® steel) used for roofing, walling, rainwater goods, and numerous other fabricated articles for interior/exterior use.
2. Hot-dipped zinc coatings (zinc-coated steel) used for structural purlin fabrication, fence posts, concrete decking, and numerous other articles for interior/exterior use within the building industry.

There are two different types of metallic coatings: 'active' (or sacrificial) coatings and 'noble' (or cathodic) coatings. The terms active and noble indicate whether the metallic coatings are active (will corrode) or noble (will not corrode) relative to steel. Aluminium/zinc/magnesium and zinc coatings are active coatings.

At defective areas in an active metal coating, such that the steel substrate is exposed, the metal coating will corrode preferentially and sacrifice itself to protect the steel substrate. By contrast, a defect in a noble metal coating will cause the steel substrate to corrode to protect the metal coating.

Noble metal coatings therefore must contain minimal porosity which may indicate a thick coating requirement or carefully controlled process parameters.

Two important qualities of an active metal coating are:

a. essential corrosion resistance.
b. ability to corrode in a controlled manner to sacrificially protect the steel base.

(Sacrificial protection is also commonly referred to as galvanic protection. Refer Corrosion Technical Bulletin CTB-2 Galvanic protection.)

When a metal is placed in a corrosive environment, cathodic and anodic areas are established on the surface. These areas form localised corrosion cells and are usually microscopic in size. Chemically active sites such as surface defects, cracks in surface films, or grain (spangle) boundaries are where anodic corrosion reactions are initiated.

Metal dissolution (or corrosion) is expected to occur at these sites according to the following anodic reaction:

$M \Rightarrow M^{X+} + Xe^-$

(M = Metal Ion, X = an integer ≥1)

When considering the surfaces of bare metals, cathodes are typically found at sites of lesser chemical activity such as within grain interiors. For corrosion to occur, the electrons made available from dissolution at the anodic sites must be consumed at the adjacent cathodic sites. Concerning corrosion of active metals, the two main reactions at the cathodic sites are:

- Reduction of hydrogen ions to produce hydrogen gas, which will predominate in acidic environments:

  $2H^+ + 2e^- \Rightarrow H_2$

- Or, in near neutral environments dissolved oxygen is reduced to form hydroxide ions and hydrogen gas by the following reaction:

  $2H_2O + 2e^- \Rightarrow H_2 + 2OH^-$
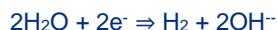
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Corrosion Technical Bulletin CTB-2 Galvanic protection