

CORROSION AND ALUMINIUM ALLOYS | A PRACTICE NOTE APPROACH

The natural process of corrosion is when Nature reacts against man-made forms of material by attempting to reduce them to their natural forms - and in the case of **Aluminium**, to its natural oxide. Some materials are more corrosion resistant than others, but all materials, in time, will corrode.

Aluminium alloys used for building and engineering purposes are at least an order (a factor of ten) more resistant than zinc, but an order less resistant than stainless steels (excluding 3Cr12). Within this context the lower strength aluminium alloys are more corrosion resistant than are the higher. So the 1xxx, 3xxx, 5xxx and 6xxx series alloys may be regarded as corrosion resistant – whilst the 2xxx and 7xxx series are far less so, in relationship to other aluminium alloys.

The most important common form of climatic corrosion - WET CORROSION, is an attack on the metal by an aggressive substance generally dissolved in water. "Wet" implies the presence of moisture - thus high humidity areas are more prone to corrosion effects. High humidity areas can, for instance, include facades to buildings where free flow of air is restricted even far from the coastal areas. Continued access to oxygen is necessary to maintain corrosion properties.

EROSION / ABRASION CORROSION is a mechanical form of corrosion. Abrasive particles, high velocities or fretting remove the protective layer of aluminium oxide from the surface. This continuous exposure of a fresh active metal surface to the erosion attack leads to an accelerated metal loss. In wet conditions erosion can encourage corrosive attack.

The corrosion process is not always easily detected or apparent, but with an appreciation of both the problem and the material, corrosion may be avoided or mitigated. The severity and extent of corrosion is dependent on the concentration, presence and nature of contaminants within the aggressive solution as well as the temperature.

The concentration of the reagent is generally known, but conditions may arise where it can vary. Even in trace concentrations, contaminants can exert a marked influence, either positive or negative, on the severity of the corrosive attack.

The temperature condition is generally known. However, higher localised temperatures can occur near metal faces, for instance.

Corrosion resistance implies passivity - the state when a metal or alloy loses its chemical reactivity and behaves in an inert fashion. Passivity in aluminium results from the formation in air of a continuous film of aluminium oxide on the surface of the metal and aluminium owes its excellent corrosion resistance to the oxide film that is bonded strongly to its surface, a film that, if damaged, re-forms immediately in most environments.

Care should be taken to maintain and preserve the integrity of the passive film. The passivity pH range is between about 4,5-8,5 depending on the chemical, with a few exceptions within the range and some outside the range. An example inside the range would be pure (deoxygenated) water and outside the range fruit juices which, while acidic in nature, exert a passivating influence on aluminium. The wide use of foils as a packaging media for fruit juices attests to this.

CORROSION FORMS

- *GENERAL CORROSION*, a uniform attack over the entire surface, is the least dangerous form of corrosion because the rate is reasonably predictable and can generally be accounted for in design. However, the general corrosion alongside pitting corrosion that results from containment of deoxygenated liquids can occur at neutral pHs.
- *GALVANIC CORROSION* takes place when two different metals are sufficiently close and are immersed in the same electrolyte. The less noble active metal becomes the anode and is attacked, corroding at a higher than normal rate. Aluminium is less noble than steels and copper, but more than zinc and magnesium. Thus galvanised bolts will protect the aluminium in the first instance while, when the zinc is depleted, the carbon in the steel will attack the aluminium.

The rate at which the anodic member corrodes depends on the difference in the electrolytic potentials and to a lesser degree the physical distance between the metals. It depends on the ratio of the surface areas of active (anodic) metal to noble (cathodic) metal - e.g. Aluminium is less noble than the passive stainless steel fasteners that may be specified for joining. This is acceptable because of the much larger anodic area of aluminium compared to the relatively small cathodic area of the fastener. Similarly, brass screws are frequently used in architectural applications exposed to moisture.

Because of low nobility ranking of aluminium, galvanic corrosion needs to be carefully addressed. The principles of galvanic corrosion are important in the consideration of other forms of corrosion and should be borne in mind. If more cathodic metals, such as steel or copper alloys, are electrically coupled with aluminium, e.g. fasteners on a roof, say, galvanic attack may occur in the presence of an electrolyte. Thus, protective paint films on the cathodic metal, moisture barriers or chemical inhibition are required for optimum performance under these conditions.

- *PITTING CORROSION* is very localised. It relates to a local galvanic reaction between aluminium and its alloying elements. It results in small hollows or perforations about 0,4mm deep, there being little or no measurable general loss of metal. In stressed conditions the pits developed may lead to stress raisers and, as described below, the possibility of stress corrosion.

Pitting corrosion occurs in aluminium in both acidic and basic aqueous solutions outside the pH range of about 4 to 8,5. Within this range aluminium is passive because it is protected by its oxide film. The attack is accelerated at elevated temperatures and is more severe in stagnant (de-oxygenated) solutions.

- *In CREVICE and POULTICE (SHIELDED) CORROSION*, the metal surface suffers preferential attack in areas where it is shielded or occluded from access to oxygen - e.g. under the overlap between successive roof sheets (crevice) or behind static, moist material in corners or at the base of tanks (poultice). The surface tension of water holds water into crevices both freeing contaminants and occluding air.

One of the more important problem areas is found where sheets are stored without allowing for the free passage of air. Corrosion occurs because of the contaminants in moist air combined with surface tension effects preventing of the build up of oxide film. This is why sheets or all metals are normally stored vertically allowing for adequate air flow.

Similarly where metal, such as extruded sections, is tightly packed, good practice is to pack in an absorbing substance so that moisture in the air is absorbed into the packaging rather than acting on the metal. Where plastic is used to protect metal sections during transport, it needs to be removed as soon as possible to allow drying and the free flow of air.

ALUMINIUM



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Note that some insulating materials that are porous and absorbent may cause corrosion when wet, if they both transfer moisture and inhibit access to oxygen.

- *STRESS CORROSION CRACKING* is caused through the co-existence of three inter-related contributory factors, namely: tensile stress, higher temperatures and corrosive solutions. This applies mainly to the higher alloyed aluminium alloys containing copper, the 2xxx and 7xxx series.
- *SULPHUR REDUCING BACTERIA* can cause problems where moisture is allowed to stagnate - for instance in un-drained uprights such as could be used in a number of building operations. The corrosion appears as blistering from the inside and relates to the acidic liquid formed as bacterial effects develop.

Corrosion is a law of nature. It is here to stay. While marine atmospheres have been known about for a long period, the increased toxicity of the industrial atmosphere and of industrial processes places more emphasis on the need to understand the mechanism of corrosion inland.

Article prepared by AFSA – the Aluminium Federation of Southern Africa, phone 011 453 3339.