ALUMINIUM FINISHING

Introduction

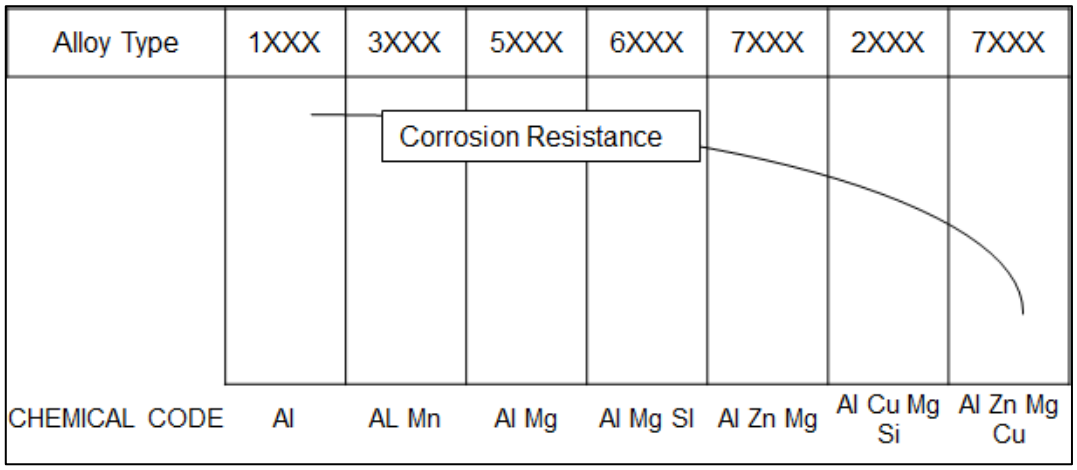
Metallic aluminium is very reactive with atmospheric oxygen and forms a surface passivation film of aluminium oxide Al_2O_3 (alumina). This protective and compact oxide film prevents further oxidation.

This natural oxide layer gives aluminium its unique corrosion resistance properties. The layer is extremely thin, (4 nm) and "self-heals" it re-oxidises if damaged or scratched. It is hard and chemically stable and will not corrode in solutions within a pH range of 4.0 to 8.5. Below a pH of 4, acid dissolution yields Al^{3+} ions and above a pH of 8.5 the alkaline dissolution leads to the formation of AlO^{2-} ions.

Aluminium Alloy Corrosion Resistance

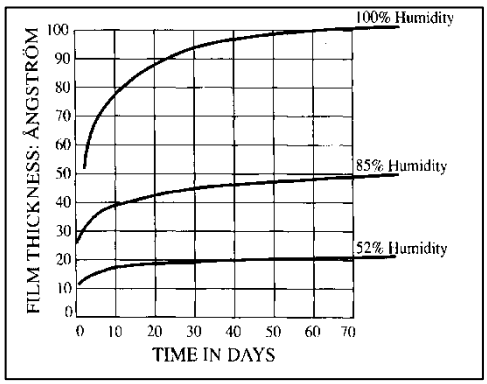
The pure aluminium 1xxx series offer the best corrosion resistance as resistance is directly related to purity.

- 1xxx series (pure) Good
- 3xxx series (Mn) Good
- 5xxx series (Mg) Good – Very good
- 6xxx series (Si/Mg) Moderate - Good
- 7xxx series (Zn/Mg) Poor - Moderate
- 2xxx series (Cu) Poor



Aluminium Oxidation in Air

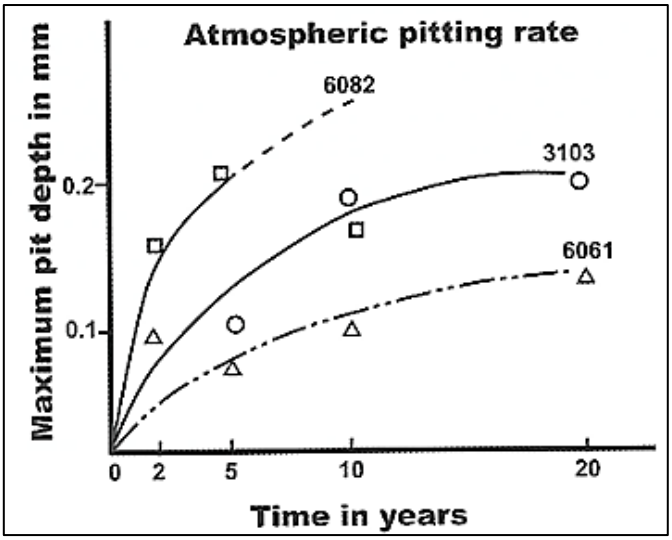
The high resistance of aluminium to corrosion begins to form immediately a newly created surface of the metal is exposed to air and the oxide film formed slowly increases in thickness until, after some days, no further oxidation takes place, unless the film is ruptured. Humidity and temperature also affect the rate of growth and thickness.



Prolonged exposure to a moist atmosphere causes slight white to grey corrosion film that is loosely adhered to the alumina surface. This is easy to rub off, leaving the alumina film behind.

Atmospheric Corrosion

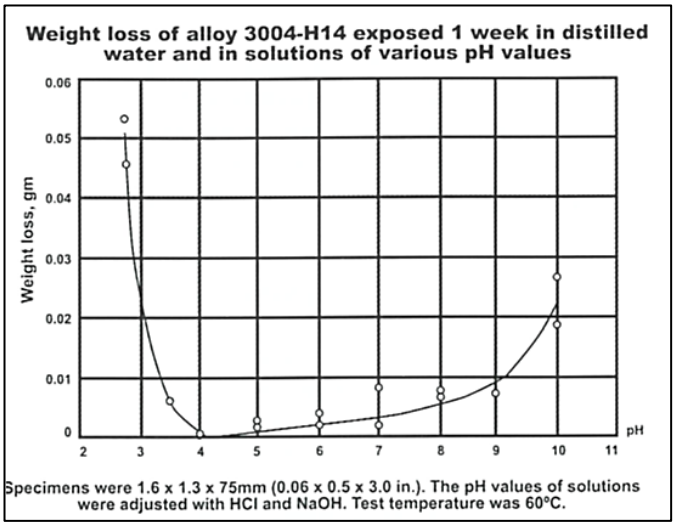
In normal rural atmospheres, and in moderately industrial atmospheres, aluminium's durability is excellent. In highly sulphurous atmospheres, minor pitting may occur.



The presence of salts (particularly chlorides) in the air reduces aluminium's durability and pitting corrosion can occur, but the maximum pit depth is generally only a fraction of the thickness of the material.

Aluminium Corrosion in Water

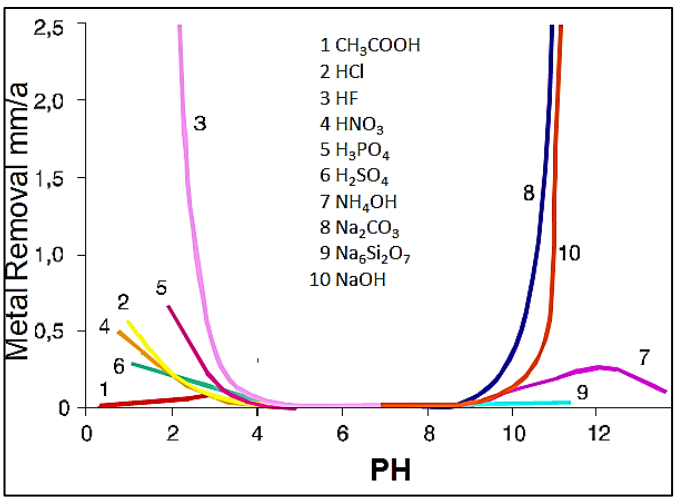
Aluminium is particularly resistant to rain and dew. Alloys are frequently found in sea water applications with 5XXX performing the best 1XXX, 3XXX & 6XXX series alloys are also used. Copper 2XXX & 7XXX are less resistant and not suitable to sea water without additional protection.



Stagnant water that is free from oxygen will prevent alumina film formation and this can result in corrosion.

Resistance to Chemicals

Thanks to the protective properties of the natural alumina layer, aluminium shows good resistance to many chemicals. Low or high pH values (less than 4 and more than 8.5) lead to the oxide layer dissolving and, consequently, rapid corrosion of the exposed aluminium. Inorganic acids and strong alkaline solutions are very corrosive. Exceptions are concentrated nitric acid and solutions of ammonia which do not attack aluminium. In moderately alkaline water solutions, corrosion can be reduced by silicate inhibitors such as found in dishwasher detergents.



Bacterial Corrosion

Due to the formation of the passive oxide film aluminium is one of the most resistant metals to attack by bacteria. However, bacterial colonies and deposits can form electrolytic concentration cells resulting in exacerbation of corrosion.

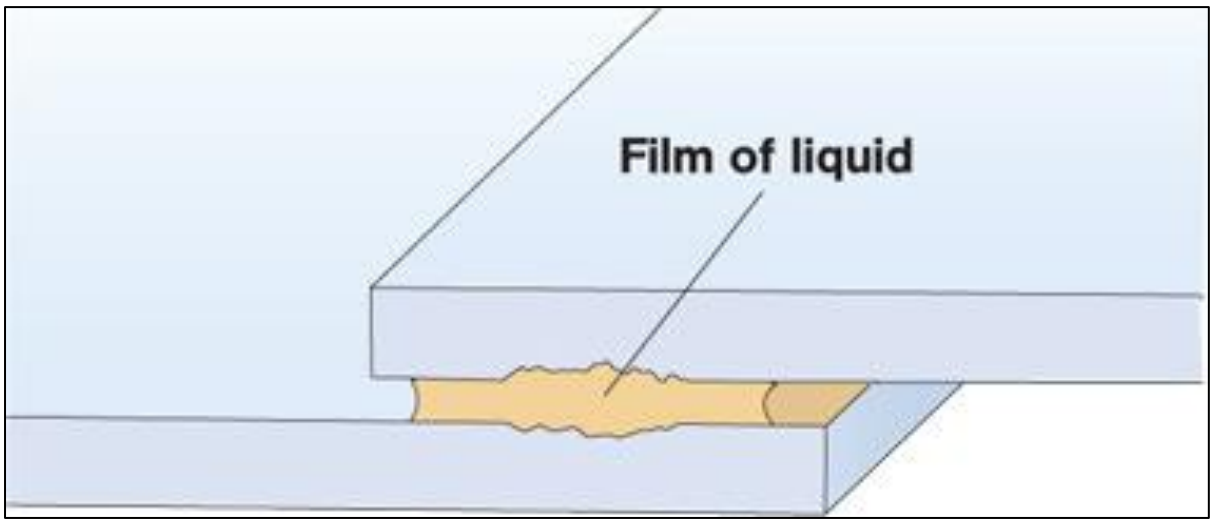
Soil Corrosion

Soil is not a uniform material as mineral composition, moisture content, pH, presence of organic materials and electrical conductivity can all vary widely from site to site.

- Aluminium's corrosion properties in soil very much depend on the soil's moisture, resistivity and pH value.
- Stray electrical currents e.g. street lighting can also affect durability.
- Corrosion is accelerated by contact with alkaline compounds such as cement, mortar and plaster.

Crevice Corrosion

Crevice corrosion occurs in narrow, liquid-filled crevices, particularly in marine atmospheres where oxygen is excluded and electrolytes become concentrated and stagnant.



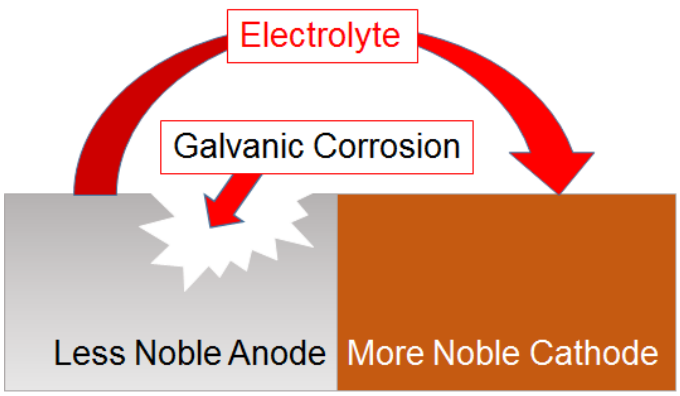
Galvanic Corrosion

Galvanic corrosion is an "electrochemical" process in which one metal corrodes preferentially when it is in contact with a different metal, when both are in an "electrolyte" and are connected both through the electrolyte and be direct metallic contact. The metals in contact act as battery and preferential corrosion is accelerated.

The least noble metal in the combination becomes the anode and corrodes whilst the most noble of the metals becomes the cathode and is protected against corrosion.

Aluminium is the least noble or anodic metal in most combinations with other metals, so is at a greater risk of galvanic corrosion.

- More Noble Cathode +Ve
  - Platinum
  - Gold
  - Carbon
  - Silver
  - Stainless steel (passive)
  - Nickel alloys (passive)
  - Copper alloys
  - Tin
  - Lead
  - Titanium
  - Cast iron
  - Steel
  - Cadmium
  - Aluminium
  - Zinc
  - Magnesium
- Less Noble Anode –Ve



Aluminium Alloy Selection for Corrosion Resistance Wrought Alloys
1XXX Commercially pure Aluminium.

Corrosion resistance of the 1XXX series is excellent, and this leads to a wide application in the packaging industry where it is used mainly in the form of thin foils. The combined corrosion resistance and ductility makes this alloy class a superb choice for cooking utensils.

2XXX Aluminium-copper.

The aluminium-copper alloys of the 2XXX series are very strong and are therefore used for structural purposes, but these alloys are prone to significant corrosion particularly in heavily polluted industrial or marine environments. Therefore, these alloys require additional barrier protection in aggressive environments.

3XXX Aluminium-manganese.

The 3XXX series alloys are most commonly used in sheet form and the control of mechanical properties is achieved by cold work and annealing. They have good corrosion resistance but in aggressive environments they may need to be lacquered or painted to provide additional protection.

5XXX Aluminium-magnesium.

The 5XXX series have better corrosion resistance than the 6XXX series. Unlike the 6XXX series, the 5XXX series can be used in marine conditions where total immersion in sea water is required. This is directly due to the higher level addition of magnesium to the alloy.

6XXX Aluminium-magnesium-silicon

The 6XXX series alloys are the most common amongst aluminium alloys and are widely used in transport, engineering and architecture. The good corrosion resistance of these alloys means that they can be used in marine and industrial environments.

7XXX Aluminium-zinc-magnesium

The 7XXX series are high strength alloys but do have reduced corrosion resistance. Hence these alloys require protection in aggressive environments and care must be taken to prevent stress corrosion cracking.

Casting Alloys
Most aluminium casting alloys are classified as having good corrosion resistance, and if used for purposes involving exposure to ambient atmospheres, they will suffer no appreciable loss of strength as a result of corrosion.

Under normal weathering conditions, superficial attack and the surface appearance of the castings are more influenced by the atmospheric conditions of the exposure site than by the differences in composition between the alloys. Weathering tests lasting more than ten years confirm that there is little difference in the resistance to atmospheric attack of the casting alloys EN 46100, EN 45200, EN 51300, EN 44100, EN 45000) and EN 46500. It is recommended that casting alloy EN 45400 be protected by painting if used under conditions involving atmospheric exposure. For more aggressive environments, e.g. marine applications or in the manufacture of food or chemicals, EN 51300, EN 44100, EN 43100, EN 47000, EN 42000) and EN 71000 will generally be found to be superior to the other casting alloys.

Further information about aluminium and aluminium alloys, their production, fabrication and end use can be obtained from:

- Website – www.alfed.org.uk
- European Aluminium Association in Brussels www.european-aluminium.eu
- International Aluminium Institute in London www.world-aluminium.org