Corrosion resistance
Outdoor use of aluminum enclosures

The plastic enclosures and their weather resistance are treated in the catalog N ° 3. We will deal here with the corrosion resistance of aluminum housings and accessories. The aluminum used in enclosures is available in two grades: ADC12 boxes for AC currents and 44,300 for flameproof enclosures. Both grades have good resistance to corrosion inside and outside.

Chemical composition

Material and standards	Si	Cu	Mg	Zn	Mn	Fe	Ni	Sn	Ti	Al
EN AC 44300 DIN 1706 AlSi12(Fe)	10.5-13.5	<0.10	-	<0.15	<0.55	<1	-	-	<0.15	remainder
ADC12 (JIS H5302:2000)	9.6-12.0	1.5-3.5	<0.3	<1.0	<0.5	0.6-0.9	<0.5	<0.2	-	remainder

Galvanic corrosion, also called Bimetallic Corrosion

Protective housings may be subject to a special phenomenon which reduces their lifespan, up to the perforation of the envelope or complete locking of the closing screws. This is galvanic corrosion.
Although most standards specify that appropriate safeguards must be taken to avoid galvanic corrosion on aluminum boxes, none advocates any solution or imposes materials or precise compositions of alloys.
Galvanic (Bi-Metallic) corrosion is an electrochemical phenomenon that occurs when dissimilar metals are in contact in the presence of an electrolyte (e.g. water, sea water). This will cause additional corrosion that can occur with other phenomena and uncoupled metals, and its progression is usually much faster.
A difference of potential appears between the two metals depending on both the metal and the solution. Two metals or two different alloys in contact with the same medium generally take two different potentials. If both metals are electrically connected, their difference of potential generates electrochemical reactions and an electric current flow.
The most negative metal (least noble) is positively polarized and the most positive metal is negatively biased. In the vast majority of cases, this configuration is an increase of the corrosion rate of the corrodible metal most (most negative), and a decrease in the rate of corrosion of the least corrodible metal (most positive).
Joint conditions necessary for the appearance of a galvanic corrosion couple.
Galvanic corrosion is a function of several different factors that need to be carefully evaluated when assessing the likelihood to have galvanic corrosion.
The simultaneous requirements for bi-metallic corrosion are as follows:
- An electrolyte bridging the two metals
- Electrical contact between the two metals.
- A difference in potential between the metals to enable a significant galvanic current
- A sustained cathodic reaction on the most noble of the two metals.

NB: If the metals are dry, bimetallic (galvanic) corrosion cannot occur.
Electrolyte
The conductivity of electrolyte will also affect the degree of attack.
When the conductivity of the electrolyte is low, the corrosion is localized to the contact zones between the two metals.
When the conductivity of the electrolyte increases, the corroded surface increases.
Electrical contact between metals
If the electrical contact is prevented between the two metals by interposing an insulator (aluminum oxide, phosphating, paint, oil, etc ...), the current does not run and there is no corrosion
Electrical potential difference between metals
The higher the value, the greater the electromotive force of the phenomenon. A difference of hundreds of millivolts is likely to result in galvanic corrosion, but a 200-300mV difference is unlikely to be a problem.
The galvanic corrosion potentials of various metals and alloys are listed in a table which gives the metal electrical potential values and are usually measured with respect to the Standard Calomel Electrode (S.C.E.).
"Anodic" metals such as magnesium, zinc and aluminum are more easily corroded metals than "cathodic" ones (titanium, silver, gold).
Corrosion is proportional to the potential difference between two metals.
The values to be considered are the potentials of the metals and alloys which form the couple with respect to the medium in question. These potentials are experimental values and must be distinguished from the standard potentials of thermodynamic tables. Experimental potentials are strongly influenced by parameters such as temperature, agitation and ventilation. In addition, some metals can take two different potentials when in the same environmental conditions according to whether they are active or passive (case of stainless steels in contact with sea water, for example).
These considerations show that it can be difficult to predict trends without the need for experimentation, as many parameters are likely to reverse the polarity of some galvanic couples.
Aggravation or reduction factors
- Area ratio of the two metals: the worst case is when a large cathode surface (the most positive material) is electrically connected to a small anode surface (metal most negative). The corrosion rate of the most negative metal can be multiplied by 100 or by 1000.
For instance, the assembly of a disc thermostat aluminum cup (dia 16mm) on a stainless steel tank will cause a quick corrosion of the cup if the necessary joint conditions are fulfilled.
On the other side, stainless steel screws closing an aluminum case will be much less subject to corrosion if the contact surfaces are minimized.
Resistance to corrosion of noble metals
- Regardless of its potential, the corrosion resistance of the most noble metal significantly influences the behavior of bimetallic couples. If the most noble metal corrodes, its corrosion products may, by motion, accelerate the corrosion of the most corroding metal. For instance, copper, yet considered as a noble metal and whose galvanic couple with aluminum is small, produces oxides that can corrode aluminum, which is a critical parameter in the design of earth terminals on aluminum housings that accommodate copper conductors.

If the noble metal couple is not corroding (Gold, Platinum), it will not present a risk of galvanic corrosion regardless of the metal that will be associated.
Sacrificial metal coatings
By applying to the cathode a sacrificial coating having a potential similar to or near that of the anodic member, the galvanic corrosion is reduced.
Main design rules:
- The sacrificial element should be on the anodic side and smaller.
- Be careful to use fasteners that have intact coatings.

Examples:
- Cadmium plating on steel fasteners holding 2024-T4 aluminum plates, will sacrifice the cadmium instead of corroding the Aluminum. (Potential difference 100 to 200mV)
- Zinc plating on steel fasteners will sacrifice the zinc instead of corroding the Aluminum (Potential difference 100 to 200mV).

Do not use nickel plated on steel fasteners as the potential difference (450mV) between nickel and alminum is too high and will corrode aluminum.
Note: The current trend is the search for an alternative to cadmium because of its toxicity, and its prohibition by the RoHS European Directive