
**Guidelines for the selection of coating
types, tests and methods of assessing
the performance of coated aluminium
in architectural applications**

*Lignes directrices pour la sélection des types de revêtements, essais et
méthodes d'évaluation des performances de l'aluminium revêtu dans
les applications architecturales*

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

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Guidelines for the selection of coating types, tests and methods of assessing the performance of coated aluminium in architectural applications

1 Scope

This document establishes a system to select coating types for architectural applications depending on environment. It gives guidelines for the selection of tests and methods of measuring performance in terms that are of direct interest to the building designer.

This document is applicable to organic and anodic oxidation (AAO) coatings on aluminium, including those produced from liquid and powder paints, and combined coatings of organic and anodic oxidation coatings. It is designed to be applicable to novel coatings developed in the future.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 7583, *Anodizing of aluminium and its alloys — Terms and definitions*

3 Terms and definitions

ISO/TS 16688:2017

For the purposes of this document, the terms and definitions given in ISO 7583 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1

abrasive wear

wear process of a material caused by cutting or scratching actions of hard bodies or hard particles

[SOURCE: ISO 4378-2:2017, 3.3.1.2]

3.2

adhesive wear

wear process due to adhesion and extraction of material out of the body surface

[SOURCE: ISO 4378-2:2017, 3.3.1.3]

3.3

accelerated test

test undertaken under conditions designed to speed material deterioration

[SOURCE: ISO 23936-2:2011, 3.1.1]

3.4

architectural applications

external and internal building applications for coated aluminium products where both appearance and long life are important

3.5

coating

covering on a substrate, which has protective, decorative or specific technical properties

3.6

coil coating

coating process whereby the coating material is applied continuously to a coil of metal which may be rewound after the film has dried

[SOURCE: ISO 4618:2014, 2.56]

3.7

designer

person or organization responsible for stating the form and specification of a building or parts of a building

3.8

durability

ability of a coating to withstand fabrication and installation procedures and a service environment without excessive degradation of the decorative and other specific properties of the finish

3.9

inorganic coating

coating (3.5) of a coated product consisting primarily of inorganic, non-metallic material

3.10

organic coating

coating (3.5) of a coated product consisting primarily of organic material

3.11

paint

liquid or powder containing pigments, which, when applied to a substrate, forms a film having protective, decorative or specific technical properties

[SOURCE: ISO 4618:2014, 2.184, modified — The definition has been changed so that it is restricted to liquid and powder coating materials and not to opaque films.]

3.12

simulation

use of a similar or equivalent system to imitate a real system so that it behaves like or appears to be the real system

[SOURCE: ISO 16781:2013, 2.9]

3.13

sol-gel processing

conversion of a chemical solution or colloidal suspension (sol) to an integrated network (gel) which can then be further densified

[SOURCE: ISO/TS 80004-8:2013, 6.4.5]

3.14

time-of-wetness

period during which a surface is covered by adsorptive and/or liquid films of aqueous solution

[SOURCE: ISO 9223:2012, 3.5, modified — The definition has been generalized so as not to be specific to metals and corrosion.]

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3.15**underfilm corrosion**

corrosion of a metal surface taking place beneath a coating

EXAMPLE Filiform corrosion and the corrosion that can occur beneath blistering.

3.16**visible defect**

unacceptable physical imperfection or flaw in the surface coating detracting from the specified reference material or from the product's functions

[SOURCE: ISO 16348:2003, 2.4]

4 General**4.1 Selection of methods to protect metals against corrosion**

ISO 11303:2002 gives guidelines for the selection of methods of protection against the atmospheric corrosion of metals and alloys. It is applicable for technical equipment and products made of structural metals, including aluminium alloys, and used under atmospheric conditions. It identifies the main considerations in the decision-making process:

- the structural metal;
- the design of the structural element;
- the active agent, e.g. chloride ions;
- the condition of action, e.g. ambient temperature.

It uses the atmospheric corrosion classification of ISO 9223:2012. The principal factor in the selection process is the service life of the component or product, which is derived in relation to its most important functional property, e.g. colour.

This document is concerned with aluminium alloys as the structural metal, although it gives no guidance on alloy selection. The design of the structural element is also outside its scope. It is concerned with the selection of coatings depending on the active agents and conditions of action in atmospheric environments with regard to functional properties. However, it includes no quantitative information that relates the quality degree of the coating to service life. ISO 15686-1 gives general principles of service life planning.

4.2 System for selecting coating types for architectural applications

With reference to the guidelines of ISO 11303:2002, the following steps can be followed to select a coating type for a specific architectural application.

- Identify active agents and conditions of activity of the environment.
- Rate the intensity of the agents. [Clause 5](#) provides guidance for the main agents: acidic pollution, UV (ultra-violet) radiation and chloride deposition.
- Weigh the contributions of the agents according to the conditions of activity, e.g. time-of-wetness, ambient temperature, wet/dry cycling frequency, the frequency of cleaning or washing by rain.
- Using the information of [Clause 7](#), select the coating types most likely to be suitable. Refer to the specifications for coated aluminium listed in [Clause 6](#) for more information on specific coatings.
- Eliminate any coatings on the basis of other factors such as requirements for the design of the structural elements including colour and reflectivity, and costs.

- Undertake comparative tests to identify the coatings most suitable for the service environment. Tests and methods of measuring performance are described in [Clauses 8](#) and [10](#), while the applicability of tests for different environments is covered in [Clause 9](#).

5 Types of environment

A main function of the coating is to preserve the original appearance of the coated product. Thus, the coating should not degrade so that it becomes unsightly. An example is the effect of UV radiation on organic coatings and dyed AAO coatings, which can cause a change in appearance. Furthermore, the coating should prevent the corrosion of the aluminium substrate. Thus, degradation of the coating, even if it is not noticeable, can be the precursor to aluminium corrosion which can affect the appearance of the product. Note that EN 1999-1-1:2007+A1, Eurocode 9, gives basic design rules to avoid loss of load-bearing capacity due to corrosion for buildings and structures made of wrought aluminium alloys.

ISO 9223:2012 gives six classes of outdoor and indoor environments based on corrosivity alone. ISO 12944-2:1998 includes the same categories but adds further examples. [Table 1](#) gives those categories and includes descriptions from both those standards.

The corrosivity categories of ISO 9223:2012 are defined by the first-year corrosion effects on standard specimens of uncoated aluminium, carbon steel, zinc and copper, which are assessed in terms of the most significant atmospheric agents influencing the corrosion of the metals and alloys. The agents considered were the time-of-wetness, and sulfur dioxide (SO₂) and chloride pollution levels. The standard includes data defining different levels of exposure to these agents. The levels of time-of-wetness extend from not more than 10 hours per year to more than 5 500 hours per year. The levels of SO₂ deposition rate extend from not more than 4 mg/(m²·d) to more than 200 mg/(m²·d). The levels of chloride deposition rate extend from not more than 3 mg/(m²·d) to more than 300 mg/(m²·d). ISO 9223:2012 also includes data for other important pollutants although they are not used as classification criteria.

ISO 12944-2:1998 is concerned with painted steel structures.

For the purposes of this document, the categorization of ISO 9223:2012 has certain deficiencies as follows.

- It is based on the corrosion of uncoated metals.
- It does not fully differentiate the effect of chloride ions from other pollutants.
- It does not include acidic pollutants other than sulfur dioxide.
- It does not consider climatic variations in UV radiation.

A significant factor affecting the corrosion of some metals and particularly steel is the chloride content of the environment. The main sources of chlorides are the sea and de-icing of roads. Airborne salinity is strongly dependent on the variables influencing the transport inland of sea-salt, such as wind direction, wind velocity, local topography and distance of the exposure site from the sea. Surfaces that are sheltered and not rain-washed in marine atmospheres where chlorides are deposited and accumulated can experience a higher corrosivity due to the presence of hygroscopic salts. Aluminium is much less affected by chlorides than steel, unless there is associated acidity or alkalinity.

The corrosivity of an atmosphere towards metals is not necessarily comparable to its severity in promoting the degradation of non-metallic coatings, which can affect the aesthetic properties of the product. However, coatings can be degraded by acids and alkalis, and associated time-of-wetness. The wetting of surfaces is caused by many factors, for example, dew, rainfall, melting snow, a high humidity level and condensation. Chemicals from the atmosphere can dissolve in surface films of water and become more concentrated as the water evaporates. Thus, although time-of-wetness is important, so is wet/dry cycling. Particulates on a surface can absorb water creating a poultice with persistent wetness depending on rain washing and drying.

Table 1 — Typical environments related to corrosivity categories

Corrosivity category	Corrosivity	Outdoor	Indoor
C1	Very low	Dry- or cold-zone atmospheric environment with very low pollution and time-of-wetness. EXAMPLE Certain deserts, central Arctic/Antarctica.	Heated spaces with low relative humidity (RH) and insignificant pollution. EXAMPLE Offices, shops, schools, hotels, museums.
C2	Low	Temperate-zone atmospheric environment with low pollution. EXAMPLE Rural areas, small towns. Dry- or cold-zone atmospheric environment with short time-of-wetness. EXAMPLE Deserts, subarctic areas.	Unheated spaces with varying temperature and RH. Low frequency of condensation and low pollution. EXAMPLE Depots, sports halls.
C3	Medium	Temperate-zone atmospheric environment with medium pollution or some effect of chlorides. EXAMPLE Urban areas, coastal areas with low deposition of chlorides. Subtropical- and tropical-zone atmosphere with low pollution.	Spaces with moderate frequency of condensation and moderate pollution from production processes. EXAMPLE Food-processing plants, laundries, breweries, dairies.
C4	High	Temperate-zone atmospheric environment with high pollution or substantial effect of chlorides. EXAMPLE Polluted urban areas, industrial areas, coastal areas without spray of salt water or exposure to strong effect of de-icing salts. Subtropical-zone and tropical-zone atmosphere with medium pollution.	Spaces with high frequency of condensation and high pollution from production processes. EXAMPLE Chemical plants, swimming pools, coastal ship and boatyards.
C5	Very high	Temperate- and subtropical-zone atmospheric environment with very high pollution and/or significant effect of chlorides. EXAMPLE Industrial areas, coastal areas, sheltered position on coastline.	Spaces with very high frequency of condensation and/or with high pollution from production processes. EXAMPLE Mines, caverns for industrial purposes, unventilated sheds in subtropical and tropical zones.
CX	Extreme	Subtropical- and tropical-zone (very high time-of-wetness) atmospheric environment with very high pollution including accompanying and production factors and/or strong effect of chlorides. EXAMPLE Extreme industrial areas, coastal and offshore areas, occasional contact with salt spray.	Spaces with almost permanent condensation or extensive periods of exposure to extreme humidity effects and/or with high pollution from production processes. EXAMPLE Unventilated sheds in humid tropical zones with penetration of outdoor pollution including airborne chlorides and corrosion-stimulating particulate matter.

The degradation of organic coatings is not only dependent on the amount of UV exposure but also the presence of water and oxygen. Whereas atmospheric oxygen levels may not be expected to vary significantly; time-of wetness as determined by the ambient temperature and relative humidity (RH) can have an important effect on degradation due to UV radiation. Inorganic materials are generally unaffected by UV radiation.

Inorganic materials can be degraded by the presence of water, particularly as an aqueous solution of an aggressive chemical. Considering acidic pollutants, the main sources of sulfur dioxide are emissions

from industrial plants using coal or oil. Traffic is the main source of nitrogen dioxide emissions. High levels of nitric acid are associated with high concentrations of nitrogen dioxide, organic compounds and UV light. The decreasing sulfur dioxide levels in many parts of the world and the elevated levels of nitrogen oxides caused by increasing traffic, together with ozone and particulates, has created a new multi-pollutant environmental situation. In other parts of the world, in relation to the rapid development of industry, the corrosive effect of sulfur dioxide pollution is intensifying and still dominating. Ozone is formed in the atmosphere by interactions between sunlight, oxygen and pollutants. The concentrations are higher in polluted rural atmospheres and lower in high-traffic urban areas. Particulates including aerosols arise from high-concentration traffic areas and industrial activities. They can contain high concentrations of corrosion-active components such as sulfate, nitrate and chloride anions. The burning of coal and wood is a major source of soot. There is also diesel soot from road vehicles.

EN 1396:2015 has certain advantages over ISO 9223:2012. It is concerned with painted aluminium and consequently categorizes end-use environments according to UV radiation intensity, as well as potential corrosivity (see Table 2). The indices are defined in terms of the performance of variously coated test panels during outdoor exposure testing carried out in compliance with EN 13523-19 and evaluated according to EN 13523-21. UV radiation indices correspond to colour change and retained gloss over two years of outdoor exposure. Corrosivity indices correspond to specific amounts of underfilm corrosion after specific times of outdoor exposure rather than rate data for uniform corrosion as used by ISO 9223:2012.

Table 2 — Corrosivity and UV radiation indices for different environments (EN 1396:2015)

Environment	Corrosivity index	UV radiation index (R_{UV})
High UV radiation with severe conditions	3	4
Tropical (high temperature, high humidity) outdoor areas	3	4
High UV radiation outdoor areas	2	4
Very severe coastal marine (less than 3 km from the sea, depending also on the topography)	3	3
Severe industrial – extreme conditions	3	3
Rural or urban light industrial (or light marine) outdoor areas	2	3
Wet corrosive indoor areas	3	2
Dry and wet non-corrosive indoor areas	1	2

EN 1396:2015 defines the UV radiation indices geographically and on the basis of altitude as follows.

- R_{UV2} . Regions located north of about latitude 45 °N with an altitude not greater than 900 m.
- R_{UV3} . Regions located south of about latitude 45 °N and north of about latitude 37 °N with an altitude not greater than 900 m.
- R_{UV4} . Regions located south of about latitude 37 °N. Every region with an altitude greater than 900 m.

Note that these criteria relate to the northern hemisphere. Because of the symmetry of the northern and southern hemispheres, the situation is equivalent in the southern hemisphere.

It also defines coating performance requirements appropriate for each UV radiation index. This enables the indices to be used for indoor as well as outdoor environments.

However, EN 1396:2015 includes a relatively small number of distinct categories for outdoor exposure. There are only two each for corrosivity and UV radiation compared with the six of ISO 9223:2012 for corrosivity alone.

The standards JIS H 8601:1999 and JIS H 8602:2010 relate specifically to anodized aluminium and combined coatings on aluminium. They classify outdoor environments into three classes:

- a) severe environment with strong UV radiation;

- b) severe environment;
- c) normal environment.

These are very broad classifications in comparison with those of [Table 1](#).

6 Classification of coatings

6.1 Specifications for coated aluminium products

The main objectives of coating aluminium for architectural applications are to modify the appearance of the aluminium to generate an aesthetic effect and to preserve the initial appearance of the product over a long service life.

The following international, national and voluntary product standards specify different types of coated aluminium.

- ISO 7599;
- ISO 28340;
- EN 1396;
- EN 12206-1;
- GB 5237.2;
- GB 5237.3;
- GB 5237.4;
- GB 5237.5;
- DIN 17611;
- JIS H 8601;
- JIS H 8602;
- BS 3987;
- BS 4842;
- AAMA 611;
- AAMA 612;
- AAMA 2603;
- AAMA 2604;
- AAMA 2605;
- GSB AL 631;
- Voluntary specification for paint coatings of architectural aluminium materials, Japan Aluminium Products Association (JAPA), Tokyo;
- Voluntary specification for baked paint coatings of architectural aluminium alloy materials, Japan Society for Finishing Technology (JSFT), Tokyo;
- Specifications for the QUALANOD quality label for sulphuric acid-based anodizing of aluminium, Qualanod, Zurich;

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