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Anodizing of aluminium and its alloys — Method for specifying decorative and protective anodic oxidation coatings on aluminium

Anodisation de l'aluminium et de ses alliages — Méthode de spécification des caractéristiques des revêtements décoratifs et protecteurs obtenus par oxydation anodique sur aluminium

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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.

This document was prepared by Technical Committee ISO/TC 79, *Light metals and their alloys*, Subcommittee SC 2, *Organic and anodic oxidation coatings on aluminium*.

This third edition cancels and replaces the second edition (ISO 7599:2010), which has been technically revised.

The main changes compared to the previous edition are as follows:

— certain terms and definitions have been deleted;

— Annex D has been revised.

Anodizing of aluminium and its alloys — Method for specifying decorative and protective anodic oxidation coatings on aluminium

1 Scope

This document specifies a method for specifying decorative and protective anodic oxidation coatings on aluminium (including aluminium-based alloys). It defines the characteristic properties of anodic oxidation coatings, lists methods of test for checking the characteristic properties, provides minimum performance requirements, and gives information on the grades of aluminium suitable for anodizing and the importance of pretreatment to ensure the required appearance or texture of the finished work.

It is not applicable to

a) non-porous anodic oxidation coatings of the barrier layer type,

b) anodic oxidation coatings produced by chromic acid or phosphoric acid anodizing,

c) anodic oxidation coatings intended merely to prepare the substrate for subsequent application of organic coatings or for the electrodeposition of metals, and

d) hard anodic oxidation coatings used mainly for engineering purposes, for which abrasion and wear resistance are the primary characteristics (see ISO 10074).

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 1463, *Metallic and oxide coatings — Measurement of coating thickness — Microscopical method*

ISO 2085, *Anodizing of aluminium and its alloys — Check for continuity of thin anodic oxidation coatings — Copper sulfate test*

ISO 2106, *Anodizing of aluminium and its alloys — Determination of mass per unit area (surface density) of anodic oxidation coatings — Gravimetric method*

ISO 2128, *Anodizing of aluminium and its alloys — Determination of thickness of anodic oxidation coatings — Non-destructive measurement by split-beam microscope*

ISO 2143, *Anodizing of aluminium and its alloys — Estimation of loss of absorptive power of anodic oxidation coatings after sealing — Dye-spot test with prior acid treatment*

ISO 2360, *Non-conductive coatings on non-magnetic electrically conductive base metals — Measurement of coating thickness — Amplitude-sensitive eddy-current method*

ISO 2376, *Anodizing of aluminium and its alloys — Determination of electric breakdown potential*

ISO 2931, *Anodizing of aluminium and its alloys — Assessment of quality of sealed anodic oxidation coatings by measurement of admittance*

ISO 3210, *Anodizing of aluminium and its alloys — Assessment of quality of sealed anodic oxidation coatings by measurement of the loss of mass after immersion in acid solution(s)*

ISO 3211, *Anodizing of aluminium and its alloys — Assessment of resistance of anodic oxidation coatings to cracking by deformation*

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

ISO 8251, *Anodizing of aluminium and its alloys — Measurement of abrasion resistance of anodic oxidation coatings*

ISO 8993, *Anodizing of aluminium and its alloys — Rating system for the evaluation of pitting corrosion — Chart method*

ISO 8994, *Anodizing of aluminium and its alloys — Rating system for the evaluation of pitting corrosion — Grid method*

ISO 9220, *Metallic coatings — Measurement of coating thickness — Scanning electron microscope method*

ISO 9227, *Corrosion tests in artificial atmospheres — Salt spray tests*

3 Terms and definitions

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

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

4 Information supplied by the customer to the anodizer

4.1 General

The information required from the customer by the anodizer in order to anodize the product correctly is given in 4.2 and 4.3: 4.2 specifies information that is essential whenever a product is to be anodized; 4.3 identifies additional information required for particular product applications. A summary of the subclause references relating to this information is given in Annex F.

NOTE Certain properties (for example, high specular reflectance) are only obtainable by the use of special alloys, and some properties can be incompatible with others.

The customer and the anodizer can share the information about cleaning in case of external architectural application (see Annex E).

4.2 Essential information

The following information shall be supplied by the customer to the anodizer, if necessary in consultation with the aluminium supplier and/or anodizer:

a) a reference to this document, i.e. ISO 7599;

b) the intended service use of the article to be anodized;

c) the specification of the aluminium to be anodized;

d) an indication of the significant surface(s) of the article to be anodized;

e) the surface preparation to be used on the aluminium before anodizing;

f) the anodic oxidation coating thickness class required (see 6.2);

g) whether a clear or coloured anodized finish is required;

h) whether the product is to be sealed or left unsealed, and if it is to be sealed, what sealing method is to be used.

Significant surfaces as per d) above are indicated preferably by drawings or by suitably marked test specimens; in some cases, there can be different requirements for the finish on different parts of the significant surface(s).

The surface preparation as per e) above is indicated preferably by agreed samples; guidance on surface preparation is given in Annex B.

NOTE Guidance on the choice of aluminium is given in Annex A.

4.3 Additional information

Additional information can be required for certain applications and, if so, shall be specified by the customer, if necessary in consultation with the anodizer. It includes the following:

a) the type of anodizing and the colouring process to be used;

b) details of any formal sampling plans required;

c) the preferred position and maximum size of contact marks;

d) any limits of variation of final surface finish on the significant surface(s);

e) the colour of the anodized article(s) and maximum limits of colour variation (see 8.2);

f) any requirements for quality of sealing;

g) any requirements for corrosion resistance and the method of test to be used;

h) any requirements for abrasion resistance, the property to be tested and the measurements required (i.e. wear resistance, wear resistance coefficient, wear index, mass wear index, mean specific abrasion resistance) and the method of test to be used;

i) any requirements for resistance to cracking by deformation;

j) any requirements for fastness to light or ultraviolet radiation of coloured anodic oxidation coatings;

k) any requirements for light reflection properties, i.e. total reflectance, specular reflectance, specular gloss, diffuse reflectance and image clarity;

l) any requirements for electric breakdown potential;

m) any requirements for the continuity of the anodic oxidation coating;

n) any requirements for the mass per unit area (surface density) of the coating.

Acceptable limits of variation of final surface finish as per d) above are identified preferably by agreed limit samples.

Acceptable maximum limits of colour variation as per e) above are identified preferably by agreed limit samples.

5 Tests

5.1 Sampling procedures

Sampling procedures shall be specified by the customer. Guidance on the choice of suitable sampling procedures is given in ISO 2859-1.

5.2 Test specimens

Wherever practicable, test specimens shall be production components. However, if by agreement special test specimens are prepared for convenience in referee or acceptance tests, they shall be of the same alloy as the production components and processed through the anodizing line at the same time as the production components.

5.3 Acceptance tests

Acceptance tests shall be as specified by the customer.

5.4 Referee tests

In cases of dispute, the appropriate referee tests specified in this document shall be used.

5.5 Production control tests

Tests for production control purposes shall be at the discretion of the anodizer.

6 Coating thickness

6.1 General

Anodic oxidation coatings are designated by their thickness class. The required thickness of a coating is of the utmost importance and shall always be specified.

6.2 Classification

Anodic oxidation coatings are graded according to the minimum allowed value of the average thickness (minimum average thickness) in micrometres. The thickness classes are designated by the letters "AA", followed by the thickness grade; typical thickness classes are given in Table 1.

For anodic oxidation coatings designed to impart particular surface properties, an average thickness higher than typical may be selected, and additional intermediate values of average thickness may be specified if necessary, but in no case shall the minimum local thickness be less than 80 % of the minimum average thickness. The choice of thickness class will depend on relevant national standards.

Table 1 — Typical coating thickness classes

Class	Minimum average thickness[a] µm	Minimum local thickness[a] µm
AA 5	5,0	4
AA 10	10,0	8
AA 15	15,0	12
AA 20	20,0	16
AA 25	25,0	20

a The interpretation of average and local thickness requirements on a test specimen shall be in accordance with Annex C.

For certain applications, such as those where resistance to corrosion is paramount, the anodizer and the customer may agree to specify a minimum local thickness, with no restriction as to the average thickness.

The use of some dyestuffs necessitates the specification of class AA 20 or higher to obtain adequate dye absorption and light fastness.

For anodized aluminium, the degree of protection against pitting corrosion of the aluminium increases with an increase in coating thickness. Thus, product life time is very dependent on the coating thickness. Specifiers should consider the full life cycle impact of the product, including the energy expenditure associated with manufacture, in-service maintenance procedures and recycling.

6.3 Measurement of thickness

Thickness measurements shall be carried out by one or more of the following methods:

a) examination of cross-section using microscopy in accordance with ISO 1463 or ISO 9220;

b) eddy-current method in accordance with ISO 2360;

c) split-beam microscope method specified in ISO 2128.

When using method b), the measurement apparatus shall be calibrated in accordance with the manufacturer's instructions using calibration standards before any measuring is performed. Calibration standards are described in Annex D.

In cases of dispute, method a) shall be the referee method.

Thickness measurements shall be made on the significant surfaces in accordance with Annex C, but no measurements shall be made within 5 mm of the areas of anodic contact or in the immediate vicinity of a sharp edge.

7 Quality of sealing

7.1 General

Sealing is a treatment applied to an anodic oxidation coating to reduce its porosity and absorption capacity (as defined in ISO 7583). In many applications, anodic oxidation coatings are expected to resist degradation by aqueous solutions. Sealing can provide that resistance. Where the retention of the initial appearance is important, for example, in outdoor architectural applications, sealing at the surface of the anodic oxidation coating is important. Where the anodized aluminium is expected to resist strongly acidic or alkaline conditions over a short time period, for example, car-wash fluids, sealing throughout the thickness of the coating can be important.

Hydrothermal sealing is very well established and quality control methods have been developed for anodic oxidation coatings sealed using such treatments. These test methods can be appropriate where other sealing treatments are used.

7.2 Assessment of quality of hydrothermal sealing

7.2.1 Referee test

In cases of dispute, the quality of hydrothermal sealing of anodic oxidation coatings shall be determined by one of the test methods specified in ISO 3210. The necessity of prior acid treatment and maximum accepted loss of mass shall be agreed between the anodizer and the customer.

The test should be carried out without prior acid treatment for internal architectural and decorative coatings and with prior acid treatment for external architectural coatings.

These methods are surface-specific. They test the resistance of the surface of a sealed anodic oxidation coating to attack by certain acid solutions. They are not intended to test the quality of the whole thickness of the coating.

NOTE The maximum accepted loss of mass of anodic oxidation coatings is variously set at 30 mg/dm^2 or 40 mg/dm^2.

7.2.2 Production control tests

7.2.2.1 Admittance measurement

Where required, admittance shall be determined in accordance with ISO 2931. This method measures electrical properties of the whole thickness of a sealed anodic oxidation coating; it is sensitive to coating porosity.

Electrolytic colouring to produce dark colours and/or certain additives to hot-water sealing baths can affect admittance values. In such cases, the referee method (see 7.2.1) should be used.

NOTE For the hydrothermal sealing of clear anodic oxidation coatings, the maximum accepted corrected admittance value is variously set at 20 µS or 25 µS relative to the conventional coating thickness of 20 µm.

7.2.2.2 Estimation of loss of absorptive power of anodic oxidation coatings after sealing

Where required, loss of absorptive power of the surface of a sealed anodic oxidation coating shall be determined in accordance with ISO 2143.

Electrolytic colouring to produce dark colours and/or certain additives to hot-water sealing baths can affect dye absorption. In such cases, the referee method (see 7.2.1) should be used.

NOTE Sealing is normally considered to be satisfactory if dye absorption ratings of 0 to 2 on the colour scale are obtained.

7.3 Assessment of quality of cold sealing

A two-step cold sealing treatment with a first step based on a nickel fluoride solution and a second step of hydrothermal sealing or immersion in a nickel sulfate solution at above 60 °C may be specified. In such a case, the test method specified in 7.2.1 may be used as the referee test and the test method specified in 7.2.2.2 may be used as the production control test.

Other cold sealing treatments may be specified. Test methods shall be agreed by the anodizer and the customer.

7.4 Assessment of quality of other sealing treatments

Other sealing treatments may be specified. Test methods shall be agreed by the anodizer and the customer.

8 Appearance and colour

8.1 Visible defects

Anodized articles shall be free from visible defects on the significant surface(s) when viewed from a distance to be agreed between the anodizer and the customer. If requested by the customer, the position(s) and maximum size(s) of the contact mark(s) shall be agreed between the anodizer and the customer.

Visual inspection shall be carried out under diffuse light, the source and strength of which shall be agreed between the anodizer and the customer.

8.2 Colour and surface texture

The colour and surface texture and their tolerances shall be specified by the customer. If required for matching purposes, the acceptable limits of variation should be defined by agreed samples (see B.2).

Anodized aluminium has the property of double reflection from the surface of oxidation layer and of the basis metal. Therefore, when matching colour samples, they shall be held in the same plane and viewed as near to normal as is practicable, with the direction of working (e.g. rolling, extrusions or machining direction) always the same. A diffuse source of illumination shall be placed above and behind the viewer.

Unless otherwise agreed, the colours shall be compared in diffuse daylight with the sun behind the viewer. If the coloured coatings are to be used in artificial light, this lighting shall be used for colour comparison.

The agreed colour limit samples shall be stored in a dry space in the dark.

8.3 Production control

For production control purposes, it can be convenient to use colour measuring instruments for recording or grading colours.

9 Corrosion resistance

If it is required by the customer that the protection against corrosion of anodized aluminium be assessed, then the acetic acid salt spray (AASS) test method or the copper-accelerated acetic acid salt spray (CASS) test method specified in ISO 9227 shall be used. The choice of method, period of exposure and acceptance criteria shall be agreed between the anodizer and the customer.

If required by the customer, the neutral salt spray (NSS) test according to ISO 9227 may be used.

The rating of corroded specimens shall be decided using the systems specified in ISO 8993 or ISO 8994.

AASS testing is more appropriate for assessing the corrosion resistance of anodized aluminium because its test conditions are more similar to the natural environment than those of the CASS test. It should be used as the referee test.

NOTE CASS testing is more effective than the AASS test for detecting defects in the anodic oxidation coating and to produce a test result in a shorter time (8 h for AA 5 to 72 h for AA 25). It is useful as a production control test.

10 Abrasion (wear) resistance

Anodic oxidation coatings are very wear resistant. However, under aggressive conditions, they can suffer abrasive wear or erosive wear. ISO 8251 specifies three methods:

a) abrasive-wheel wear test method;

b) abrasive jet test method;

c) falling sand abrasion method.

The abrasive-wheel wear test method assesses resistance to abrasive wear of the coating near its surface, or of the whole coating thickness, or of any selected intermediate zone. The abrasive jet test method and the falling sand abrasion method assess resistance to erosive wear of the whole coating thickness. By convention, all three methods are said to assess abrasion resistance.

If specified by the customer, the abrasion resistance of the anodic oxidation coating shall be determined using the most appropriate method selected from those given in ISO 8251. The test to be carried out and the acceptable value for abrasion resistance shall be specified by the customer to the anodizer.

For abrasive-wheel wear tests in accordance with ISO 8251, the customer shall specify the method to be used and the values required, such as wear resistance, wear resistance coefficient, wear index or mass wear index, as appropriate. For abrasive jet tests in accordance with ISO 8251, the customer shall specify the mean specific abrasion resistance or the relative mean specific abrasion resistance.

The abrasive-wheel wear test is the preferred method but is only suitable for flat specimens; the abrasive jet test can be used for specimens that are not flat.

NOTE Measurement of abrasion resistance of the surface of an anodic oxidation coating can give important guidance on the performance in external architectural applications. In particular, coatings which are likely to show chalking on external exposure can have a lower than normal abrasion resistance. In this regard, a coating with a wear index of greater than 1,4, when measured by the abrasive-wheel wear test method given in ISO 8251 can perform unsatisfactorily.

11 Resistance to cracking by deformation

If required by the customer, the resistance to cracking by deformation of the anodic oxidation coating shall be tested by the method specified in ISO 3211. The performance requirements shall be agreed between the anodizer and the customer.

12 Fastness to light and ultraviolet radiation

12.1 General

For evaluating colour fastness for exterior applications, only outdoor exposure under conditions comparable to actual service use is satisfactory. Accelerated testing is only suitable as a production control test of coloured anodic oxidation coatings where the fastness of the specific colouring system has already been established by outdoor exposure tests.

If required by the customer, the test method or methods to be used and the performance requirements shall be specified by the customer to the anodizer.

The light fastness of colour anodized aluminium depends upon the method of colouring and the type of colouring material used, and — particularly in the case of dyed anodized aluminium — only a limited range of coloured finishes are suitable for any particular application. Advice from the anodizer should be sought.

12.2 Fastness to light

An accelerated method of testing the light fastness of coloured anodic oxidation coatings is specified in ISO 2135. The performance of colour anodized aluminium, when tested by this method, shall be specified by the customer, if necessary in consultation with the anodizer.

12.3 Fastness to ultraviolet radiation

A method of testing the fastness to ultraviolet radiation of coloured anodic oxidation coatings is specified in ISO 6581. This is a relatively severe test in comparison with other tests for fastness to light and colour changes take place with many colour anodized finishes in very short exposure times. The method is particularly suitable as a production control test for assessing the fastness to light of the extremely light-resistant anodic oxidation coatings used in architecture.

The customer shall specify the performance requirement, if necessary in consultation with the anodizer.

13 Light reflection properties

13.1 General

If required by the customer, the light reflection properties of anodic oxidation coating may be carried out as follows. The test method and performance requirements shall be agreed between the anodizer and the customer.

The following characteristic properties can be measured:

a) total reflectance (or total reflectivity);

b) specular reflectance for surfaces with high gloss:

   1) at 45°;

   2) at 30°;

   3) at 20°;

c) specular gloss for surface with medium or low gloss:

   1) at 85°;

   2) at 60°;

   3) at 45°;

d) diffuse reflectance;

e) image clarity.

These properties can be determined using a variety of optical instruments, which differ in degree of sophistication, cost and the type of surface for which they are designed to be used. These differences relate to the illumination system, the angle of the incident light, the angle at which the reflected light is measured and the geometry of the light collecting system. The properties are not, therefore, completely independent of the instrument used for measurement.

Several methods require the provision of very flat surfaces and measurements can only be carried out on special test specimens (see 5.2).

The customer shall inform the anodizer of the properties to be measured, as necessary, agreeing on the instrument that is to be employed and its method of use.

Bright finishes with a high specular gloss can only be obtained by the use of special grades of aluminium (see A.3) and cooperation with the aluminium supplier is essential.

13.2 Total reflectance

Total reflectance can be measured using the integrating sphere method given in ISO 6719.

13.3 Specular reflectance (high gloss)

The determination of the specular reflectance of bright anodized surfaces, where a high specular reflectance is the primary characteristic, can be carried out on flat surfaces by measurement of the following.

a) Specular reflectance at 45°, using method E as specified in ISO 7668: this method employs a low-cost instrument of good discrimination which can be used for this one function only.

b) Specular reflectance at 30°, using the method specified in ISO 7759: the abridged goniophotometer is a costly, sophisticated instrument, but it measures a number of optical parameters with great accuracy.

c) Specular gloss at 20°, using method A as specified in ISO 7668: this method employs a more sophisticated instrument than method E according to ISO 7668.

13.4 Specular gloss (medium or low gloss)

The determination of the specular gloss of surfaces which are semi-diffuse, or which are mainly diffuse, can be carried out as given in ISO 7668 by the measurement of

a) specular gloss at 60°, using method C,

b) specular gloss at 85°, using method D, or

c) specular gloss at 45°, using method B.

The 60° method relies on a good general-purpose instrument applicable over the range of 30 gloss units to 70 gloss units and also classifies other surfaces as high or low gloss. On matt surfaces below 30 gloss units, the 45° or 85° geometry is more suitable. Above 70 gloss units, the methods given in 13.3 should be used.

13.5 Diffuse reflectance

By definition, the diffuse reflectance and the specular reflectance together give the total reflectance. It is not therefore an independent property and can be measured by the integrating sphere method specified in ISO 6719.

13.6 Image clarity

The determination of image clarity can be carried out using the method specified in ISO 10215, which describes a visual method using a simple apparatus, or the method specified in ISO 10216, which describes an instrumental method. If required by the customer, the test method and the performance requirement shall be agreed between the anodizer and the customer.

14 Electrical breakdown potential

If required by the customer, the electrical breakdown potential of the anodic oxidation coating shall be determined by the method specified in ISO 2376. The acceptable breakdown potential shall be agreed between the anodizer and the customer.

15 Continuity of coating

If required by the customer, the continuity of the anodic oxidation coating shall be determined by the method specified in ISO 2085. The requirements for continuity shall be agreed between the anodizer and the customer.

16 Mass per unit area (surface density) of coating

If required by the customer, the mass per unit area of the anodic oxidation coating shall be determined by the method specified in ISO 2106 (see also 6.3). This is a destructive test.

WARNING — The method specified in ISO 2106 requires the use of a reagent containing chromium(VI). Chromium(VI) is toxic and its solutions are hazardous to the environment and severely hazardous to waters.

The requirements for mass per unit area shall be agreed between the anodizer and the customer.

Annex A
(informative)

Guide to grades of aluminium for anodizing

A.1 General

Most aluminium, in any of its forms, can be anodized (see A.4), but the results differ widely in appearance, colour, maximum coating thickness, reflectivity, abrasion resistance, corrosion resistance and electric breakdown potential. The protective value of the coating is excellent on much aluminium produced for general engineering purposes, but for uniformity of appearance or other special effects (for example, bright finishes), special grades of aluminium have been developed where close control of chemical composition and metallurgical practices is combined with special production procedures to provide high standards of surface finish and a guaranteed response to anodizing. These grades cannot readily be classified because companies have developed their range of products to meet the requirements of particular industries or customers and there is no clear dividing line between the various categories.

The grades identified in A.2, A.3 and A.4 are given for general guidance and are based on the end-use of the aluminium. The anodizer should be aware of the end-use and it is stressed that, for this reason, there should be close cooperation between the supplier of the aluminium, the customer and the anodizer.

A.2 Architectural and decorative quality

Semi-finished products of this grade will have a good appearance after anodizing.

Some variations in appearance and colour on anodized aluminium surfaces can be expected between different batches of the same material and between different forms of the same material. It is sometimes possible to observe on close inspection, or from certain viewing angles, variations in brightness, banding, streaking and other visual defects. These do not affect in any way the quality of the coating. The extent to which such defects can be accepted should be specified by the customer (see 8.1 and Annex B).

A.3 Bright anodizing quality

Materials in this grade will normally be based on aluminium of high purity (99,7 % or more). Proper manufacturing control of the metal is essential. Special mechanical, chemical or electrochemical treatments can be used to produce a highly specular or mirror finish.

A.4 General engineering quality

Most aluminium will come within this grade; that is to say, it will anodize to give a continuous coating of good protective value but with no guarantee of appearance, although for many applications, the properties will be satisfactory.

Alloys containing high proportions of copper, silicon or zinc are likely to present problems in anodizing and advice should be sought from the manufacturer and the anodizer. In particular, if the copper content is high (>3 %), coatings will offer only limited protection.

Annex B
(informative)

Guidance on surface preparation

B.1 General

The pretreatment given before anodizing largely determines the final appearance and texture of the anodized aluminium surface. Different surface textures can be obtained by a variety of treatment processes.

Usually, the product, whether polished or unpolished, is subjected to a chemical etching procedure to provide a range of textures — from light satin with varying degrees of gloss to full matt — according to the type of etch used. Surface effects, such as corrosion which has occurred before pretreatment or different material characteristics, can become visible after etching.

Alternatively, the texture can be produced mechanically by brushes, abrasive belts or wheels to give a range of matt finishes which are lined or directional, in contrast with the essentially non-directional etched finishes. Mechanical finishes have good reproducibility and are less dependent on metal structure and composition than chemical pretreatments. Surface irregularities, if not too deep, can be removed by mechanical means.

Aluminium can be mechanically polished to obtain a smooth or bright surface.

Chemical or electrochemical brightening can be employed with special aluminium alloys to obtain a very bright finish.

NOTE 1 Very rough surfaces, either chemically or mechanically produced, are best avoided in external applications as they tend to hold dirt and have an adverse effect on the durability of anodic oxidation coatings.

NOTE 2 Surface preparation methods can result in the removal of considerable quantities of aluminium from the parts to be anodized. This aluminium cannot be easily recovered in metallic form. Often, the surface preparation method produces a waste that has no value and represents a cost for disposal. Thus, it is important to use metal of good surface quality to minimize the extent of surface preparation and for the specifier to consider the environmental impact associated with the processes necessary to achieve the aesthetic effect sought.

B.2 Surface texture

The desired surface texture should be agreed between the anodizer and the customer, if necessary on the basis of agreed limit samples.

The provision of limit samples is a useful guide in production, but it should be recognized that such samples are of restricted value in assessing surface finish, since different forms and sizes of material can respond to pretreatments in slightly different ways.

B.3 Surface preparation designation system

A designation system for different types of surface preparation before anodizing has been used in certain European countries. This designation system is summarized in Table B.1.

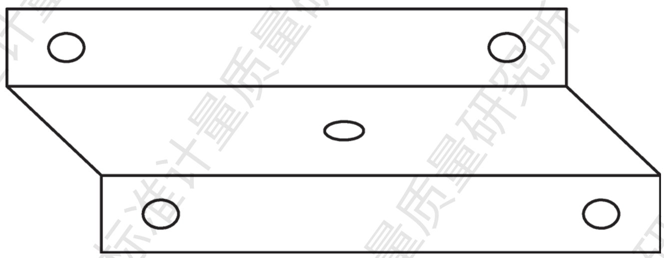
Table B.1 — Surface preparation designation system

Symbol	Type of pretreatment	Remarks
E0	Degreased and deoxidized only	Surface preparation before anodizing in which the surface is degreased and deoxidized without further pretreatment. Mechanical marks such as scoring and scratching will remain visible. Corrosion effects, which might have been hardly visible before treatment, can become visible after processing.
E1	Ground only	Grinding produces a comparatively uniform but somewhat dull appearance. Any surface defects present are largely eliminated; however, depending on the coarseness of the abrasive, grinding grooves could be visible.
E2	Brushed only	Mechanical brushing results in a uniform bright surface with visible brush marks. Surface defects are only partially removed.
E3	Polished only	Mechanical polishing results in a shiny, polished surface, but surface defects are only partially removed.
E4	Ground and brushed	Grinding and brushing gives a uniform bright surface with mechanical surface defects eliminated. Corrosion effects, which can become visible as a result of E0 or E6 treatments, are eliminated.
E5	Ground and polished	Grinding and polishing gives a smooth, shiny appearance with mechanical surface defects eliminated. Corrosion effects, which can become visible as a result of E0 or E6 treatments, are eliminated.
E6	Chemically etched	After degreasing, the surface is given a satin or matt finish by treatment in special alkaline etching solutions. Mechanical surface defects are smoothed out but not entirely eliminated. Any corrosion effect on the metal surface can become visible as a result of this treatment. Mechanical pretreatment before etching can eliminate these effects, but it is preferable to handle and store the metal correctly to avoid corrosion.
E7	Chemically or electrochemically brightened	After degreasing the surface in a vapour degreaser or non-etching cleaner, the surface is given a very bright finish by treatment with special chemical or electrochemical brightening processes. Surface defects are removed only to a limited extent and corrosion effects can become visible.
E8	Ground, polished and chemically or electrochemically brightened	Grinding and polishing followed by chemical or electrochemical brightening. This gives a very smooth bright appearance and mechanical surface defects and incipient corrosion are normally eliminated.

Annex C
(normative)

Interpretation of average and local thickness requirements

The average thickness, unless otherwise agreed, shall be determined on each test specimen being tested by measuring the local thickness at not less than five measuring areas spread over the significant surface of the component. At each measuring area, three to five readings shall be taken and averaged to determine the local thickness value. An example of appropriate measuring areas on a typical test specimen is shown in Figure C.1.



Key

⬭ measuring area

Figure C.1 — Example of appropriate spread of measuring areas

For small pieces (such as accessories) and complex-surface pieces, the number of measuring areas may be reduced.

The following examples illustrate conformity or non-conformity with the requirements of 6.2 for a specification requirement of class AA 20.

Example 1: Measured values of local thickness, in micrometres (µm): 20, 22, 23, 21, 20.

The average thickness is 21,2 µm and the minimum local thickness is 20 µm. This test specimen conforms to the requirements in every respect.

Example 2: Measured values of local thickness, in micrometres (µm): 20, 23, 22, 22, 18.

The average thickness is 21,0 µm and the minimum local thickness is 18 µm. This test specimen conforms to the requirements. It has an average thickness above 20 µm, and all local thicknesses are above 16 µm (80 %, see 6.2).

Example 3: Measured values of local thickness, in micrometres (µm): 18, 21, 19, 21, 20.

The average thickness is 19,8 µm and the minimum local thickness is 18 µm. This test specimen does not conform to the requirements. The average thickness value is below 20,0 µm.

Example 4: Measured values of local thickness, in micrometres (µm): 20, 24, 22, 22, 15.

The average thickness is 20,6 µm and the minimum local thickness is 15 µm. This test specimen does not conform to the requirements. The average thickness value is above 20,0 µm but one local thickness value falls below 16 µm (80 %; see 6.2).

Annex D
(informative)

Calibration standards for eddy-current apparatus used to measure the thickness of anodic oxidation coatings on aluminium

D.1 General

The thickness of anodic oxidation coatings on aluminium may be measured following the method of ISO 2360 which also describes the procedure for the calibration of eddy-current apparatus.

This annex describes calibration standards for use with eddy-current apparatus. For the purposes of this document, there are two types of calibration standards: primary standards and secondary standards. Primary calibration standards are used to calibrate eddy-current apparatus that is used to measure the coating thickness of secondary calibration standards. They should be certified and traceable. Secondary calibration standards are used routinely to calibrate eddy-current apparatus that is used to measure the coating thickness of production material.

Anodized aluminium or polymer film on an aluminium substrate may be used as either a primary or a secondary calibration standard as described below.

D.2 Standard specimens of anodized aluminium

D.2.1 Preparation of primary calibration standard specimens

D.2.1.1 Producer

Primary standard specimens may be produced by an authorized organization which can certify the coating thickness. They may then be supplied to anodizers.

If an anodizer can measure coating thickness using the method of ISO 1463 or ISO 9220, it may produce primary standard specimens.

D.2.1.2 Alloy and physical parameters

Aluminium alloy: AA 1050-H24, AA 1050-H14, AA 6063-T5 or, if necessary, another alloy on which uniform anodic oxidation coatings can be produced. Alloy nomenclature is described in ISO 2107.

Thickness:	1,5 mm to 2,0 mm.
Surface roughness (R_a):	0,1 µm or less.
Size:	40 mm × 40 mm.

D.2.1.3 Surface preparation

The standard specimens should be pretreated by degreasing, light alkaline etching and desmutting.

The anodizing process should be chosen as appropriate for the alloy. Note that the surface roughness (R_a) of the anodized aluminium should not be more than 0,1 µm. For AA 1050, the bath should comprise a solution of 180 g/l ± 2 g/l free sulfuric acid, 5 g/l to 10 g/l dissolved aluminium and deionized water held at 20 °C ± 0,5 °C. The solution should be agitated with a large volume of low pressure air or solution circulation. The current density should be 1,5 A/dm^2 ± 0,1 A/dm^2.

The anodizing time should be chosen to produce a coating thickness similar to that of the secondary standard specimens. It is important that the coating thickness should be uniform over the standard specimen surface. The method of anodizing should be chosen to ensure a variation less than ±2 µm.

Hydrothermal sealing should be carried out for 3 min per micrometre of coating thickness in a solution made up with deionized water.

D.2.1.4 Determining the coating thickness of a primary calibration standard specimen

The coating thickness of a primary standard specimen should be measured to the nearest determined 0,1 µm at several points adjacent to the area of the primary standard specimen using a microscopical method of ISO 1463 or of ISO 9220. The coating thickness of the primary standard specimen is the average of the coating thicknesses of the several points.

Figure D.1 illustrates a method that can be used to determine the coating thickness of four primary standard specimens (labelled A, B, C and D) cut from a single piece of aluminium alloy. The coating thicknesses of the parts labelled a1, a2, a3, b1, etc. are measured. Using the labels to represent coating thickness values, then the coating thicknesses of *A* and *B* are

$$A = (a1 + a2 + a3 + b1) / n$$

$$B = (b1 + b2 + b3 + c1) / n$$

where n is the number of measurements (in this example, $n = 4$).

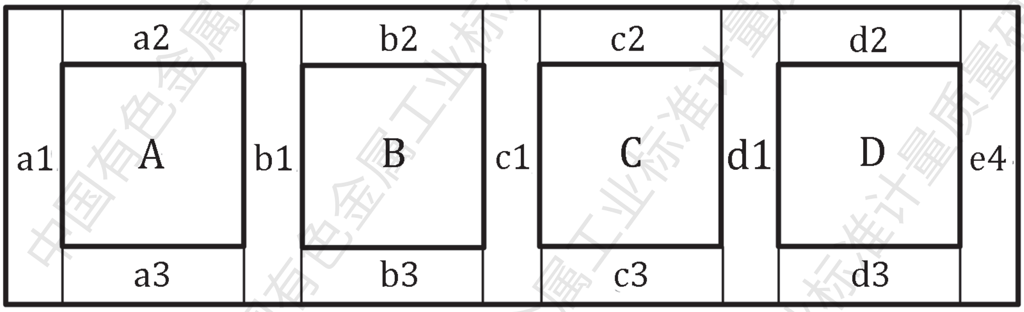


Figure D.1 — Example of the preparation of four primary standard specimens from a single piece of aluminium

D.2.2 Preparation of secondary calibration standard specimens

D.2.2.1 Producer

Secondary standard specimens may be produced by an anodizer.

D.2.2.2 Alloy and physical parameters

The aluminium alloy should be the same as the production material to be tested.

The standard specimens should be at least 0,8 mm thick.

D.2.2.3 Surface preparation

The surface preparation should be the same as D.2.1.3 but the anodizing time should be chosen to produce a coating thickness similar to that of the production material to be tested.

D.2.2.4 Determining the coating thickness of a secondary calibration standard specimen

The coating thickness of a secondary standard specimen shall be measured using eddy-current apparatus that has been calibrated using a primary standard specimen of the same alloy or other calibration standards. The coating thickness of the secondary standard specimen is the average of not less than five measurements.

Figure D.2 illustrates a method that can be used to determine the coating thickness of 12 secondary standard specimens (labelled C1, C2, C3, etc.) cut from a single piece of aluminium alloy. As secondary standard specimens are used very frequently and can deteriorate, this method enables a large number to be produced with similar coating thicknesses.

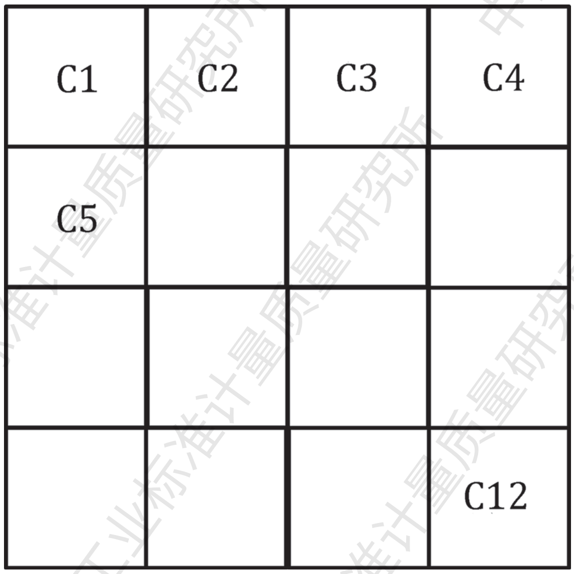


Figure D.2 — Example of the preparation of 12 secondary standard specimens from a single piece of aluminium

Further, since the surface roughness of aluminium influences on the coating thickness, the coating thickness of the secondary calibration standard specimen should be preferably determined using the following procedure.

a) With the eddy-current apparatus calibrated by means of a primary calibration standard specimen, measure the coating thickness (A_E) in the central area of a specimen A randomly chosen from a batch of secondary calibration standard specimens (e.g. specimen C1 in Figure D.2).

b) Using the microscopical method, measure the coating thickness (A_M) in the central area of specimen A.

c) If the coating thickness values obtained in a) and b) are different, calculate the compensation rate (f) as shown in Formula (D.1):

$$f = \frac{A_M}{A_E} \quad \text{(D.1)}$$

d) Using the eddy-current apparatus, measure the coating thickness (X_E) in the central area of secondary calibration standard specimen X taken from the same batch as A, and determine the corrected coating thickness (X_C) of X by compensating the thickness value with the compensation rate (f) obtained in c):

$$X_C = X_E \times f \quad (D.2)$$

For example, $A_{C1} = A_{EC1} \times f$, where A_{C1} is the corrected coating thickness of secondary calibration standard specimen C1 as shown in Figure D.2.

D.3 Polymeric calibration standards

A calibration standard may comprise a polymer film placed on a clean, uncoated specimen of the substrate material. The pretreatment described in D.2.1.3 produces a clean metal surface. Polyester film, such as polyethylene terephthalate (PET), can have good durability and uniform thickness. However, as calibration standards and, particularly, secondary calibration standards are subject to wear and deterioration with time and use, polymer films should be replaced periodically as established locally or after consultation with the supplier.

For primary standards, the thickness of the polymer film should be certified to the nearest 0,1 µm by the supplier. The thickness of the film should be similar to that of the secondary standard or the coating thickness of the secondary standard specimens. The substrate should conform to D.2.1.2.

For secondary standards, the thickness of the film should be similar to the coating thickness of the production material to be tested. The substrate material should be the same alloy as the production material to be tested.

Annex E
(informative)

Guidance on cleaning materials for external architectural applications

E.1 pH value of cleaning materials

Only neutral cleaning agents with a pH value in the range of five to eight should normally be used, since cleaning agents with a pH value outside this range can damage anodic oxidation coatings. Cleaning agents should always be tested by contact with anodized aluminium before use.

Highly alkaline cleaning agents will damage anodic oxidation coatings very rapidly and should never be used. Less alkaline cleaning agents can cause damage if left in contact with anodized aluminium for long periods.

Acid solutions with a pH value of less than five, as well as damaging anodic oxidation coatings, can also cause corrosion of other elements in a construction (e.g. galvanized steel behind an aluminium facade).

Cleaning operations should not be carried out in strong sunshine.

E.2 Abrasive cleaning materials

Anodic oxidation coatings can be affected by the use of highly abrasive compounds and only cleaning materials which have been found not to scratch or otherwise damage the coating should be used.

Annex F
(informative)

Summary of information to be supplied by the customer to the anodizer

Table F.1 — Summary of information to be supplied by the customer to the anodizer

Information required	Subclause reference		Other related clauses/annexes
	Essential information	Additional information	
Reference to this document	4.2 a)	—	—
Intended service use	4.2 b)	—	—
Aluminium specification	4.2 c)	—	Annex A
Significant surface(s)	4.2 d)	—	—
Surface preparation before anodizing	4.2 e)	—	Annex B
Anodic oxidation coating thickness class	4.2 f)	—	Clause 6
Clear or colour anodized finish	4.2 g)	—	—
Sealing treatment or unsealed	4.2 h)	—	Clause 7
Type of anodizing and/or colouring process	—	4.3 a)	—
Sampling plan	—	4.3 b)	Clause 5
Position and maximum size of contact marks	—	4.3 c)	—
Variation of final surface finish on significant surfaces	—	4.3 d)	Clause 8; Annex B
Colour of anodized articles and maximum limits of colour variation	—	4.3 e)	Clause 8
Requirements for sealing quality	—	4.3 f)	Clause 7
Requirements for corrosion resistance	—	4.3 g)	Clause 9
Requirements abrasion (wear) resistance	—	4.3 h)	Clause 10
Requirements for resistance to cracking by deformation	—	4.3 i)	Clause 11
Requirements for fastness to light and ultraviolet light	—	4.3 j)	Clause 12
Requirements for light reflection properties	—	4.3 k)	Clause 13
Requirements for electric breakdown potential	—	4.3 l)	Clause 14
Requirements for continuity of the coating	—	4.3 m)	Clause 15
Requirements for mass per unit area (surface density) of the coating	—	4.3 n)	Clause 16

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[2] ISO 2135, *Anodizing of aluminium and its alloys — Accelerated test of light fastness of coloured anodic oxidation coatings using artificial light*

[3] ISO 2859-1, *Sampling procedures for inspection by attributes — Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

[4] ISO 6581, *Anodizing of aluminium and its alloys — Determination of the comparative fastness to ultraviolet light and heat of coloured anodic oxidation coatings*

[5] ISO 6719, *Anodizing of aluminium and its alloys — Measurement of reflectance characteristics of aluminium surfaces using integrating-sphere instruments*

[6] ISO 7668, *Anodizing of aluminium and its alloys — Measurement of specular reflectance and specular gloss of anodic oxidation coatings at angles of 20°, 45°, 60° or 85°*

[7] ISO 7759, *Anodizing of aluminium and its alloys — Measurement of reflectance characteristics of aluminium surfaces using a goniophotometer or an abridged goniophotometer*

[8] ISO 10074, *Anodizing of aluminium and its alloys — Specification for hard anodic oxidation coatings on aluminium and its alloys*

[9] ISO 10215, *Anodizing of aluminium and its alloys — Visual determination of image clarity of anodic oxidation coatings — Chart scale method*

[10] ISO 10216, *Anodizing of aluminium and its alloys — Instrumental determination of image clarity of anodic oxidation coatings — Instrumental method*

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