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Anodizing of aluminium and its alloys — General specifications for anodic oxidation coatings on aluminium

Anodisation de l'aluminium et de ses alliages — Spécifications générales pour couches anodiques sur aluminium

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 7599 was prepared by Technical Committee ISO/TC 79, *Light metals and their alloys*, Subcommittee SC 2, *Organic and anodic oxidation coatings on aluminium*.

This second edition cancels and replaces the first edition (ISO 7599:1983), which has been technically revised.

Anodizing of aluminium and its alloys — General specifications for anodic oxidation coatings on aluminium

1 Scope

This International Standard lays down 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 oxidation coatings of the barrier layer type,

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

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

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 referenced documents are indispensable for the application 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 basis materials — 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 phosphoric acid/chromic acid solution*

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 — Vocabulary*

ISO 8251:—[1)], *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, *Aluminium and aluminium alloys — Rating system for the evaluation of pitting corrosion — Grid 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 and the following apply.

3.1
anodized aluminium
aluminium with an anodic oxidation coating, produced by an electrolytic oxidation process in which the surface of the aluminium is converted to a mainly oxidation coating having protective, decorative or functional properties

3.2
clear anodized aluminium
anodized aluminium with a substantially colourless, translucent anodic oxidation coating

3.3
colour anodized aluminium
anodized aluminium coloured either during anodizing or by subsequent colouring processes

3.4
integral colour anodized aluminium
anodized aluminium that has been anodized using an appropriate (usually organic acid-based) electrolyte which produces a coloured oxidation coating during the anodizing process itself

3.5
electrolytically coloured anodized aluminium
anodized aluminium with an anodic oxidation coating that has been coloured by the electrolytic deposition of a metal or metal oxide into the pore structure

3.6
dyed anodized aluminium
anodized aluminium with an anodic oxidation coating, coloured by absorption of dye-stuff or pigments into the pore structure

1) To be published. (Revision of ISO 8251:1987 and ISO 8252:1987)

3.7
combination colour anodized aluminium
anodized aluminium with an anodic oxidation coating, coloured by electrolytic colouring or produced by integral colour anodizing followed by absorption dyeing

3.8
interference colour anodized aluminium
electrolytically coloured anodized aluminium, coloured by means of optical interference effects

3.9
bright anodized aluminium
anodized aluminium with a high specular reflectance as its primary characteristic

3.10
protective anodizing
anodizing where protection against corrosion or wear is the primary characteristic and appearance is secondary or of no importance

3.11
decorative anodizing
anodizing where a decorative finish with a uniform or aesthetically pleasing appearance is the primary characteristic

3.12
sealing
treatment of anodic oxidation coatings on aluminium, applied after anodizing to reduce the porosity and absorption capacity of the coating, including but not limited to hydrothermal sealing and cold sealing (cold impregnation)

3.13
significant surface
part of the article covered or to be covered by the coating and for which the coating is essential for serviceability and/or appearance

[ISO 2064:1996, definition 3.1]

3.14
measuring area
area of the significant surface over which a single measurement is made

[ISO 2064:1996, definition 3.2]

NOTE The measuring area is the point at which a single measurement is made for the microscopical method, and is the probe area, or area influencing the reading, for non-destructive methods.

3.15
reference area
area within which a specified number of single measurements is required to be made

[ISO 2064:1996, definition 3.3]

3.16
local thickness
mean of the thickness measurements, of which a specified number is made within a reference area

[ISO 2064:1996, definition 3.4]

3.17
minimum local thickness
lowest value of the local thickness found on the significant surface of a single article

[ISO 2064:1996, definition 3.5]

3.18
maximum local thickness
highest value of the local thickness found on the significant surface of a single article

[ISO 2064:1996, definition 3.6]

3.19
average thickness
mean value of a specified number of local thickness measurements that are evenly distributed over the significant surface of a single anodized piece

[ISO 2064:1996, definition 3.7]

4 Information supplied by customer to 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.

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 International Standard;

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 required;

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

h) whether the product is to be hydrothermally sealed, cold sealed or left unsealed.

Significant surfaces as per d) above are indicated preferably by drawings or by suitably marked samples; 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;

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 pieces

Wherever practicable, test pieces shall be production components. However, if by agreement special test pieces are prepared for convenience in referee or acceptance tests, they shall be produced in the same way 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 International Standard 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 µm	Minimum local thickness 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
The interpretation of average and local thickness requirements on a piece being tested 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 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;

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 should be calibrated using the standard test panels described in Annex D before any measuring is performed.

In cases of dispute, method a) shall be the referee method for coatings of thickness 5 µm and thicker. For coatings of thickness less than 5 µm, the microscopical method cannot normally be used and a minimum mass of coating per unit area, measured by the gravimetric method (see Clause 16), shall be agreed between the interested parties.

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

The quality of hydrothermal sealing is of great importance and sealing is always essential, whether specified or not, except where an unsealed or cold sealed coating is expressly requested.

NOTE Anodic oxidation coatings sealed in dichromate solutions cannot be evaluated by the methods described in 7.2.2.1 and 7.2.2.2.

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 the test method specified in ISO 3210, which is the referee test. 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 coating.

For most applications, especially architectural, the maximum accepted loss of mass of anodic oxidation coatings should not exceed 30 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.

For anodic oxidation coatings sealed in steam or hot water, sealing should normally be considered to be satisfactory if the corrected admittance value is less than 20 µS relative to a 20 µm coating.

NOTE This value is sometimes difficult to achieve with dark electrolytically coloured coatings. Other values might need to be agreed between the anodizer and the customer.

Where additives to hot water sealing baths affect the admittance values, the referee method (see 7.2.1) should be used to determine the quality of sealing.

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

Where required, loss of absorptive power shall be determined in accordance with ISO 2143.

Sealing is normally considered to be satisfactory if dye absorption ratings of 0,1 or 2 on the colour scale are obtained.

Where additives to hot water sealing baths affect the dye absorption tests, the referee test (see 7.2.1) should be used to determine the quality of sealing.

7.3 Assessment of quality of cold sealing

If hydrothermal sealing is not required, appropriate cold sealing processes based on nickel fluoride may be specified. The quality of cold sealing is also very important, with the test methods to be used being those specified in 7.2.1 for the referee tests and 7.2.2.2 for production control tests.

In critical applications, such as externally in architecture, the cold sealing process should be followed by an additional hydrothermal sealing step, or by immersion in a nickel sulfate solution at above 60 °C.

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 interested parties. 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 from the direction of higher latitudes. If the coloured coatings are to be used in artificial light, this lighting shall be used for colour comparison.

The agreed colour control 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 samples 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 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 tests in accordance with ISO 8251:—, Clause 5, the customer shall specify the method to be used and the values required, such as wear resistance, wear resistance coefficient, wear index, mass wear index or mean specific abrasion resistance, as appropriate. For tests in accordance with ISO 8251:—, Clause 6, the customer shall specify the mean specific abrasion resistance or the relative mean specific abrasion resistance.

The abrasive wheel method given in ISO 8251:—, Clause 5, is the preferred method but is only suitable for flat specimens; the abrasive jet method given in ISO 8251:—, Clause 6, should be used for specimens that are not flat.

NOTE Measurement of abrasion resistance can give important guidance on the performance of external architectural coatings. 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 method given in ISO 8251:—, Clause 5, might not perform satisfactorily.

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.

The test method 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 may be measured:

a) total reflectance (or total reflectivity);

b) specular reflectance for surfaces with high gloss:

   — at 45°;

   — at 30°;

   — at 20°;

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

   — at 85°;

   — at 60°;

   — 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 pieces (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 co-operation with the aluminium supplier is essential.

13.2 Total reflectance

Total reflectance may 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 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.

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 co-operation 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.

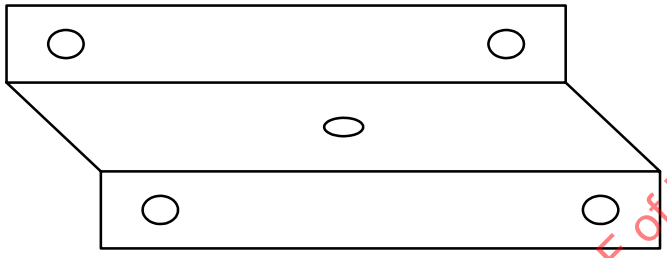
Table B.1 — Surface preparation designation system

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 piece 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 piece is shown in Figure C.1



Key

measuring area

Figure C.1 — An example of appropriate spread of measuring areas

Three to five readings shall be made at each measuring area.

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 minimum local thickness is 20 µm. This sample 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 minimum local thickness is 18 µm. This sample 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 minimum local thickness is 18 µm. This sample 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 minimum local thickness is 15 µm. This sample 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)

Standard test panels for calibrating test apparatus for measuring the thickness of anodic oxidation coatings on aluminium

D.1 General

This annex describes standard test specimens for calibrating eddy-current test apparatus used to measure the thickness of anodic oxidation coatings on aluminium.

D.2 Specification of standard panels

Standard test anodized panels (standard panels) are anodized test panels for which the thickness of the anodic oxidation coating is known, used for the calibration of eddy-current apparatus used to measure the thickness of anodic oxidation coatings on aluminium.

Depending on their purpose, they are classified as standard panels for maintaining the test apparatus (see D.2.1) or standard panels for calibrating measurements (see D.2.2).

D.2.1 Maintenance standards

Standard panels for maintaining the test apparatus, or maintenance standards, are standard panels for which the coating thickness has been previously determined using the microscopical method, and which are used for the periodic maintenance of eddy-current test apparatus.

Aluminium panel

Aluminium: Al 99,5 or, if necessary, another aluminium alloy on which even anodic oxidation coatings can be made

Heat treatment: H24 (or H14)[2]

Thickness: 1,5 mm to 2,0 mm

Surface roughness: 0,1 Ra or less

Standard size: 40 mm × 40 mm

Anodic oxidation coating

Thickness: Select the thickness, taking into account the calibrating method for the test apparatus and the thickness of the coatings to be tested.

Anodizing process: Choose an appropriate process for the alloy to be used. Note that the surface roughness of the anodized aluminium should not become more than the specified limit. In the case of Al.99.5, the following anodizing conditions should be used.

Pretreatment: degreasing and light alkaline etching and desmutting

Bath component:	free sulfuric acid concentration: 180 g/l ± 2 g/l
Dissolved aluminium concentration:	5 g/l to 10 g/l
Deionized water:	rest
Bath temperature:	20 °C ± 0,5 °C
Current density:	1,5 A/dm^2 ± 0,1 A/dm^2
Agitation:	by compressed air and/or solution recirculation

In order to identify appropriate anodizing conditions, preliminary anodizing should be used to assess the uniformity of the coating thickness on a test specimen. This should be done initially using the eddy-current technique and finally using the microscopical method. It is important to confirm the uniformity of the coating thickness of maintenance standards, not only within the area to provide the standard panel, but also over adjacent areas.

The variation in coating thickness should be less than ± 2 µm.

Sealing: hot water sealing with deionized water. Sealing time should be 3 min per micrometre of coating thickness.

Coating thickness: the coating thickness to be indicated should be determined according to the following procedure.

a) Measure the coating thickness at several points adjacent to the area to provide the standard panel using the microscopical method.

b) Record the average thickness and the maximum and minimum local thicknesses.

D.2.2 Calibration standards

Standard panels for calibrating measurement, or calibration standards, are standard panels used for calibrating eddy-current test apparatus when the thickness of anodized aluminium products is measured.

NOTE These can be anodized aluminium panels where the thickness of the anodic oxidation coating has been previously determined using the microscopical method, or polymer films whose thickness has been previously determined by comparison with maintenance standards.

D.2.2.1 Calibration standard panels of anodized aluminium

Aluminium panel: the alloy should be the same as real aluminium products and the thickness should be 0,8 mm or more.

Coating thickness: to be chosen taking into account the calibration method and the coating thickness of the anodized aluminium products to be tested.

Anodizing process: to be carried out according to the process specified in D.2.1.

Sealing: to be carried out according to the process specified in D.2.1.

Indicated coating thickness: it should be determined using the following procedure.

a) With the eddy-current test apparatus calibrated by means of a maintenance standard or other calibration standard, measure the coating thickness (A_E) in the central area of a panel randomly chosen from standard panels which have been anodized in the same lot.