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Specification for hard anodic oxidation coatings on aluminium and its alloys

Spécification pour l'anodisation dure de l'aluminium et des alliages d'aluminium

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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.

International Standard ISO 10074 was prepared by Technical Committee ISO/TC 79, *Light metals and their alloys*, Subcommittee SC 2, *Anodized aluminium*.

Annexes A, B, C, D and E form an integral part of this International Standard. Annexes F, G, H and J are for information only.

Introduction

Hard anodizing is an electrolytic treatment which results in the formation of a hard and usually thick coating of alumina used primarily for engineering purposes.

Hard anodizing can be applied to cast or wrought aluminium and aluminium alloys; however, alloys containing more than 5 % copper and/or 8 % silicon and die casting alloys require special anodizing procedures. To obtain optimum microhardness, wear resistance or low surface roughness characteristics, low contents of alloy should be selected.

Unless otherwise specified, articles shall be anodized after all heat-treatment, machining, welding, forming and perforating operations. The best results are achieved on machined surfaces. Sharp edges should be machined to a radius of at least 10 times the intended thickness to avoid "burning" and/or spalling.

Hard anodizing will usually result in a dimensional increase on each surface equal to about 50 % of the coating thickness. The dimensions of the component prior to anodizing should allow for this, if necessary.

The thickness is generally within the range of 25 µm to 150 µm. Low thickness (up to 25 µm) is sometimes used in a variety of applications, such as splines and threads. Normal thickness (50 µm to 80 µm) is used for wear or insulation requirements. High thickness (150 µm) is used for repairing purposes, but thick coatings tend to be softer in outer regions. Very hard coatings reduce the fatigue strength. This phenomena can be minimized by reducing thickness and/or by sealing. Hard anodizing tends to increase surface roughness. This can be limited with low alloy contents and/or mechanical finishing.

Hard anodic oxidation coatings are mainly used to obtain

— resistance to wear through abrasion or erosion;

— electrical insulation;

— thermal insulation;

— build-up (to repair parts out of tolerance on machining or worn parts);

— resistance to corrosion (when sealed).

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Specification for hard anodic oxidation coatings on aluminium and its alloys

1 Scope

This International Standard specifies requirements for hard anodic oxidation coatings on aluminium and its alloys, including test methods.

Information to be supplied by the purchaser to the anodizer is given in annex A.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 1463:1982, *Metallic and oxide coatings — Measurement of coating thickness — Microscopical method.*

ISO 2106:1982, *Anodizing of aluminium and its alloys — Determination of mass per unit area (surface density) of anodic oxide coatings — Gravimetric method.*

ISO 2360:1982, *Non-conductive coatings on non-magnetic basis metals — Measurement of coating thickness — Eddy current method.*

ISO 2376:1972, *Anodization (anodic oxidation) of aluminium and its alloys — Insulation check by measurement of breakdown potential.*

ISO 2859-0:—[1], *Sampling procedures for inspection by attributes — Part 0: Introduction to the ISO 2859 attribute sampling system.*

ISO 2859-1:1989, *Sampling procedures for inspection by attributes — Part 1: Sampling plans indexed by acceptable quality level (AQL) for lot-by-lot inspection.*

ISO 4516:1980, *Metallic and related coatings — Vickers and Knoop microhardness tests.*

ISO 7583:1986, *Anodizing of aluminium and its alloys — Vocabulary.*

ISO 8251:1987, *Anodized aluminium and aluminium alloys — Measurement of wear resistance and wear index of anodic oxidation coatings with an abrasive wheel wear test apparatus.*

ISO 8252:1987, *Anodized aluminium and aluminium alloys — Measurement of mean specific abrasion resistance of anodic oxidation coatings with an abrasive jet test apparatus.*

ISO 9227:1990, *Corrosion tests in artificial atmospheres — Salt spray tests.*

3 Definitions

For the purposes of this International Standard, the definitions in ISO 7583 and the following apply.

3.1 lot: Articles of the same nominal composition and temper which are processed together

3.2 lot acceptance tests: Tests on a production lot to determine its conformance to the requirements of this specification.

1) To be published.

3.3 significant surface: The part of the article covered or to be covered by the coating, for which the coating is essential for service and/or appearance.

4 Material classification

The properties and characteristics of hard anodic oxidation coatings are significantly affected by both the alloy and the method of production.

Consequently, for the purposes of this International Standard, materials are classified into five alloy groupings as follows:

Class 1: all wrought alloys except those in class 2

Class 2 (a): alloys of the 2000 series

Class 2 (b): alloys of the 5000 series containing 2 % or more magnesium and alloys of the 7000 series

Class 3 (a): casting alloys with less than 2 % copper and/or 8 % silicon

Class 3 (b): other casting alloys

5 Appearance

The significant surface shall be completely anodized and the visual appearance shall be substantially uniform. There shall be no spalling, blistering or powdery (burnt) areas. Visual examination shall be a lot acceptance test.

Crazing or microcracks shall not normally be a reason for rejection.

6 Thickness

Thickness measurements shall be made on the significant surfaces, but not within 5 mm of contact (jigging) marks, nor in the immediate neighbourhood of a sharp edge.

Measurement shall be made using either the non-destructive eddy current method described in ISO 2360, or the destructive microscopical method described in ISO 1463. In the case of a dispute, the microscopical method (ISO 1463) shall be used.

Measurement of thickness or, where relevant, final dimensions, shall be dealt with in a lot acceptance test.

The usual coating thickness shall be between 40 µm and 60 µm (see introduction and annex A).

7 Surface density

The surface density (coating mass per unit area), when measured in accordance with ISO 2106 on unsealed anodic oxidation coatings with a nominal thickness of 50 µm ± 5 µm, shall have the minimum values given in table 1.

Table 1 — Minimum surface density

Material class	Minimum acceptable value
Class 1	1 100 mg/dm^2
Class 2	950 mg/dm^2
Class 3 (a)	950 mg/dm^2
Class 3 (b)	By agreement
NOTE — If the coating thickness is not 50 µm, the surface density shall be corrected proportionately.	

8 Resistance to wear/abrasion

8.1 General

The resistance to wear/abrasion shall be measured on unsealed anodic oxidation coatings (see note 1). Due to good correlation achieved with other properties, resistance to wear/abrasion shall be tested in accordance with G.1, using the abrasive wheel test method described in ISO 8251.

NOTE 1 Resistance to abrasion can be measured on sealed anodic oxidation coatings but hydrothermal sealing and/or dyeing can reduce the resistance to abrasion/wear by over 50 %.

When the abrasive wheel is not appropriate (especially on some curved surfaces), resistance to wear/abrasion shall be tested in accordance with G.2, using the abrasive jet method described in ISO 8252. This test gives an average for the total coating thickness.

The TABER method (see annex B) mav only be used when specified.

8.2 Abrasive wheel test method

The resistance to wear/abrasion shall be determined by measurement of loss in coating thickness or loss in coating mass. When determined in accordance with G.1, using the abrasive wheel test method described in ISO 8251, the final value shall be an average of at least three tests using a load of 19,6 N and silicon carbide paper of 240 mesh size.

The acceptance values shall be in accordance with table 2.

The standard specimen shall be tested each day, under the same conditions as those used for the test specimen. When the loss in coating thickness is used, each thickness value shall be the average of ten readings in the test area.

The time between hard anodizing and abrasion testing shall be at least 24 h. During this period, the test pieces shall be stored in the test environment.

8.3 Abrasive jet test method

The resistance to wear/abrasion shall be determined by either the mass of silicon carbide or the time required to penetrate the coating. When determined in accordance with G.2, using the abrasive jet test method described in ISO 8252, the final value shall be an average of at least three tests.

The acceptance values shall be in accordance with table 3.

Table 2 — Acceptance values for the abrasive wheel test

Alloy	**Number of double strokes** (DS)	**Relative mean specific abrasion resistance acceptance value** % compared to standard specimen (see annex C)
Class 1	800 to 100	⩾ 80 %
Class 2 (a)	400 to 100	⩾ 30 %
Class 2 (b)	800 to 100	⩾ 55 %
Class 3 (a)	400 to 100	⩾ 55 % } or by agreement (see notes)
Class 3 (b)	400 to 100	⩾ 20 % } or by agreement (see notes)

NOTES

1 Castings are not always suitable for abrasion/wear testing because of the surface condition and/or the structure of the anodic oxidation coating. In the unusual event of class 3 alloys requiring to be tested, the abrasion/wear resistance acceptance values shall be agreed upon between the anodizer and purchaser and may require special reference panels.

2 The relative mean specific abrasion resistance is given by the equation

$$\text{RMSAR} = \frac{\text{Mean wear rate of test specimen}}{\text{Mean wear rate of standard specimen}} \times 100$$

where the wear rate is the loss in thickness (or mass) per unit double stroke.

Table 3 — Acceptance values for the abrasive jet test

Alloy	Relative mean specific abrasion resistance acceptance value % compared to standard specimen (see annex C)
Class 1	⩾ 80 %
Class 2 (a)	⩾ 30 %
Class 2 (b)	⩾ 55 %
Class 3 (a)	⩾ 55 % } or by agreement (see notes)
Class 3 (b)	⩾ 20 % } or by agreement (see notes)

NOTES

1 Castings are not always suitable for abrasion/wear testing because of the surface condition and/or the structure of the anodic oxidation coating. In the unusual event of class 3 alloys requiring to be tested, the abrasion/wear resistance acceptance values shall be agreed upon between the anodizer and purchaser and may require special reference panels.

2 The relative mean specific abrasion resistance is given by the equation

$$\text{RMSAR} = \frac{\text{Mean wear rate of test specimen}}{\text{Mean wear rate of standard specimen}} \times 100$$

where the wear rate is the duration, in seconds, or mass of abrasive, in grams, necessary to remove 1 µm of coating thickness.

The time between hard anodizing and abrasion testing shall be at least 24 h. During this period, the test pieces shall be stored in the test environment.

8.4 TABER test method

When determined in accordance with annex B, the TABER abrasion acceptance values shall be in accordance with table 4.

Table 4 — Acceptance values for the TABER abrasion resistance test

Alloy	**Acceptance value** (maximum loss in mass) mg
Class 1	15
Class 2 (a)	35
Class 2 (b)	25
Class 3	See note

NOTE — Castings are not always suitable for abrasion/wear testing because of the surface condition and/or the structure of the anodic oxidation coating. In the unusual event of class 3 alloys requiring to be tested, the abrasion/wear resistance acceptance values shall be agreed upon between the anodizer and purchaser and may require special reference panels.

9 Vickers microhardness

The Vickers microhardness of the anodic oxidation coating, when measured in accordance with ISO 4516 on a coating with a thickness of 25 µm to 50 µm, shall have the minimum values given in table 5.

Table 5 — Acceptance values for the Vickers microhardness test

Alloy	Microhardness HV 0,05
Class 1	400
Class 2 (a)	250
Class 2 (b)	300
Class 3 (a)	250
Class 3 (b)	By agreement
NOTE — Coatings thicker than 50 µm may have lower microhardness values, especially in the outer regions.	

10 Resistance to corrosion

This test is only applicable to sealed oxidation coatings.

If a corrosion test is required (see annex A), the anodic oxidation coating shall be tested for 336 h in accordance with ISO 9227 (NSS test).

A test piece with a nominal anodic oxidation coating thickness of 50 µm shall not show, after 336 h exposure to neutral salt spray, any corrosion pits except those within 1,5 mm of jigging marks or corners.