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Anodizing of aluminium and its alloys — Measurement of abrasion resistance of anodic oxidation coatings

Anodisation de l'aluminium et de ses alliages — Détermination de la résistance à l'abrasion des couches d'oxyde anodiques

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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 of 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 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 8251:2011), which has been technically revised. The main technical changes are as follows:

— preparation for test specimens has been added;

— for expression of results, loss of mass has been added;

— some expressions of results have been moved to Annex B;

— standard specimen made of PMMA sheet has been added.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The resistance of anodic oxidation coatings to abrasion is an important property. As it is dependent upon the composition of the metal, the thickness of the coating and the conditions of anodizing and sealing, it can give information about the quality of the coating, its potential resistance to erosion or wear and its performance in service. For example, the effect of an abnormally high anodizing temperature, which could cause potential deterioration in service by chalking of the surface layers, can be readily detected by means of an abrasive wear resistance test.

The use of the term “abrasion resistance” is a convention of the industry. Strictly, the property should be described as “wear resistance”. There are different types of wear including abrasive wear and erosive wear.

Anodizing of aluminium and its alloys — Measurement of abrasion resistance of anodic oxidation coatings

1 Scope

This document specifies the following tests:

a) abrasive-wheel-wear test, determining the abrasion resistance of anodic oxidation coatings with abrasive wheel on flat specimens of aluminium and its alloys;

b) abrasive jet test, determining the comparative abrasion resistance of anodic oxidation coatings with jet of abrasive particles on anodic oxidation coatings of aluminium and its alloys;

c) falling sand abrasion test, determining the abrasion resistance of anodic oxidation coatings with falling sand on thin anodic oxidation coatings of aluminium and its alloys.

The use of abrasive-wheel-wear test and abrasive jet test for coatings produced by hard anodizing is described in 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 6344-1, *Coated abrasives — Grain size analysis — Part 1: Grain size distribution test*

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

ISO 7823-1, *Plastics — Poly(methyl methacrylate) sheets — Types, dimensions and characteristics — Part 1: Cast sheets*

ISO 8486-1, *Bonded abrasives — Determination and designation of grain size distribution — Part 1: Macrogrits F4 to F220*

3 Terms and definitions

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

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

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

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

3.1
standard specimen
specimen produced in accordance with specified conditions

Note 1 to entry: The conditions are specified in Annex A.

4 Characteristics of abrasion tests

4.1 General

In the scope of this document, there are three kinds of abrasion tests: abrasive-wheel-wear test (4.2), abrasive jet test (4.3) and falling sand abrasion test (4.4).

4.2 Abrasive-wheel-wear test

Determination of the abrasion resistance by movement of a test specimen relative to an abrasive paper under a specified pressure. The wear resistance or the wear index of the layers of oxide near the surface, or of the whole oxidation coating thickness, or of any selected intermediate zone may be determined by the test described.

NOTE 1 Abrasive-wheel-wear test determines the resistance to abrasive wear.

This test is applicable to all anodic oxidation coatings of thickness more than 5 µm on flat aluminium or its alloy specimens.

This test does not apply to concave or convex specimens; these may be examined using the abrasive jet test which will give an average value for the abrasive resistance of the coating.

NOTE 2 Minimum test specimen dimensions of 50 mm × 50 mm are normally used.

4.3 Abrasive jet test

Determination of the comparative abrasion resistance by the impact of abrasive particles projected onto a test specimen. The mean specific abrasion resistance of anodic oxidation coatings can be determined.

NOTE 1 Abrasive jet test determines the comparative resistance to erosive wear.

This test is applicable to all anodic oxidation coatings of thickness more than 5 µm on aluminium or its alloys. It is primarily intended for surfaces which are not flat. If suitable flat test surfaces are available, the abrasive-wheel-wear test is the preferred test. Production components may be tested without cutting if the apparatus chamber can accommodate these.

NOTE 2 This test is particularly suitable for small test specimens because the individual test area required is only about 2 mm in diameter.

4.4 Falling sand abrasion test

Determination of the abrasion resistance by the impact of freely falling abrasive particles onto anodic oxidation coatings.

This test is suitable to thin anodic oxidation coatings, generally less than 15 µm.

NOTE Falling sand abrasion test determines the resistance to erosive wear.

5 Abrasive-wheel-wear test

5.1 Principle

The anodic oxidation coatings on a test specimen are abraded, under defined conditions, by reciprocal motion against a strip of silicon carbide paper attached to the outer circumference of a wheel. After each double stroke, the wheel turns through a small angle to bring an unused portion of the abrasive strip into contact with the test area. The decrease in coating thickness or mass obtained is used to calculate the wear resistance, mass wear resistance, wear index or mass wear index. This result is compared with that obtained using a standard specimen or reference specimen.

The measuring method of coating thickness normally requires an eddy-current meter with a probe of less than 12 mm diameter. If this is not available, the method of loss in mass should be used.

NOTE A complete presentation of the wear characteristics of the anodic oxidation coatings can be obtained by progressively abrading the test area, until the substrate metal is revealed, and then constructing a graph to show the relation between the coating thickness removed and the number of double strokes used. This is referred to as a depth survey of the anodic oxidation coatings (see Annex C).

The testing environment should be at room temperature and the relative humidity should be under 65 %.

5.2 Apparatus

5.2.1 Abrasive-wheel-wear test apparatus

The apparatus consists of a clamping device or pressure plate for holding the test specimen level and rigid, and a 50 mm diameter wheel to the outer circumference of which is attached a 12 mm wide strip of silicon carbide paper. The force between the wheel and the test surface shall be capable of being varied from zero to at least 4,9 N with an accuracy of ± 0,05 N. The abrasive action is produced either by the fixed wheel sliding to and fro in a horizontal plane in parallel contact with the test surface over a 30 mm length or, alternatively, by the test specimen sliding in a similar way over the stationary wheel. Typical apparatus is illustrated in Figure D.1.

After each double stroke, the wheel is advanced through a small angle to bring a fresh area of the silicon carbide paper into contact with the specimen surface before making the next double stroke. The angle of rotation is such that, after 400 ds, the wheel will have made one complete revolution. At this stage, the strip of silicon carbide paper shall be renewed. The relative speed of movement shall be (40 ± 2) ds per minute. The number of double strokes can be registered by means of a counter, and provision is normally made for the apparatus to switch off automatically after a preset number of double strokes has been reached (400 ds maximum). The test specimen surface shall be kept free from loose powder or abrasion detritus during the test.

5.2.2 Abrasive strip

The abrasive strip consists of P320 silicon carbide paper (the specification of which shall be in accordance with ISO 6344-1) 12 mm wide. Its length, 158 mm, shall be such that it covers the abrasive wheel without overlapping, and it shall be bonded into position.

NOTE P320 paper is 45 µm grade (320 mesh).

5.2.3 Eddy-current meter

An eddy-current meter with a suitable diameter probe is described in ISO 2360.

5.2.4 Balance

Use a laboratory balance with a readability of 0,1 mg.

5.3 Procedure

5.3.1 Standard specimen

Prepare the aluminium standard specimen specified in Annex A.

If agreed between the interested parties, a standard specimen made of poly(methyl methacrylate) (PMMA) sheet in accordance with ISO 7823-1 may be used.

NOTE Aluminium standard specimen and PMMA standard specimen specified in Annex A have different abrasion resistance, about five times difference. For the purpose of comparison of the loss of mass, PMMA standard specimen is used by adjusting the number of double strokes.

5.3.2 Test specimen

5.3.2.1 Sampling

The test specimen shall be taken from a significant surface of the product, and shall not be taken near an edge of the part for possible distortion and/or non-uniformity.

Where it is impossible to test the product itself, a test specimen may be used. However, in this case, the test specimen used shall be one which is representative of the product, and it shall be made from the same material and prepared under the same conditions of finishing as those used for the preparation of the product.

The aluminium alloy, the manufacturing conditions (kind and temper of the material), and the surface condition before treatment shall be the same as those of the product.

Pretreatment, anodizing and sealing shall be performed in the same baths and under the same conditions as the treatment of the product.

5.3.2.2 Size

The standard size of the test specimen should be 50 mm × 50 mm.

5.3.2.3 Treatment before testing

The test specimen shall be clean, free from dirt, stains and other foreign matters. Any deposits or stains shall be removed with a clean, soft cloth or similar material which is wetted by water or an appropriate organic solvent such as ethanol. An organic solvent which can corrode the test specimen or generate a protective film on the test specimen shall not be used.

5.3.3 Test procedure

5.3.3.1 The standard specimen and/or the test specimen shall be tested by the following procedure. The abrasive strips used for the test specimen shall be the same lot as the one for the standard specimen. A reference specimen may be used by agreement between the interested parties (see Annex B).

5.3.3.2 Select the test area of the standard specimen and/or the test specimen to be abraded. Measure the anodic oxidation coating thicknesses of the standard specimen and/or the test specimen in each of at least three positions along the test area by means of the eddy-current meter and calculate an average thickness value (d_1). For change in mass, weigh the mass (m_1) of the standard specimen and/or the test specimen to the nearest 0,1 mg by means of the balance.

5.3.3.3 Clamp the standard specimen and/or the test specimen into the position on the apparatus. If the test specimen is not rigid, bond it firmly with an adhesive to a rigid metal sheet with a flat surface before carrying out the test.

5.3.3.4 Attach a new abrasive strip to the circumference of the abrasive wheel. Adjust the force between the wheel and the test surface to 3,9 N ± 0,1 N.

5.3.3.5 Allow the apparatus to run for 400 ds or an adequate number of double strokes corresponding to the coating thickness and the kind of aluminium alloys.

5.3.3.6 Remove the standard specimen and/or the test specimen from the apparatus, wipe carefully to remove any debris. Determine the average thickness value (d_2) or weigh the mass (m_2). A 3 mm length at one extremity of the test area can be subject to extra wear because of the continual wheel rotation which takes place at this point; this area should be ignored when taking the thickness measurements.

Freshly exposed anodic oxidation coatings can gain in mass by absorbing water vapour. The determination shall be carried out as early as possible after the test is finished.

5.3.3.7 Carry out at least two further tests on the same standard specimen and/or the test specimen with test areas that are not overlapped. Follow the procedure specified in 5.3.3.2 to 5.3.3.6.

Determine the average thickness and/or mass of at least three standard specimens and/or test specimens, before abrasion (d_1 and/or m_1) and after abrasion (d_2 and/or m_2).

5.4 Expression of results

5.4.1 General

The expression of results should be chosen from 5.4.2 to 5.4.5.

Other expression of results may be chosen by agreement between the interested parties (see Annex B).

5.4.2 Wear resistance

The wear resistance, R_W, in double strokes per micrometre, can be expressed using Formula (1):

$$R_W = \frac{N}{d_1 - d_2} \quad (1)$$

where

N is the number of double strokes;

d_1 is the average thickness, in micrometres, before abrasion;

d_2 is the average thickness, in micrometres, after abrasion.

5.4.3 Mass wear resistance

The mass wear resistance, R_{MW}, in double strokes per milligram, can be expressed using Formula (2):

$$R_{MW} = \frac{N}{m_1 - m_2} \quad (2)$$

where

N is the number of double strokes;

m_1 is the average mass, in milligrams, before abrasion;

m_2 is the average mass, in milligrams, after abrasion.

5.4.4 Wear index

The wear index, I_W, can be expressed using Formula (3):

$$I_W = \frac{d_{1t} - d_{2t}}{d_{1s} - d_{2s}} \quad (3)$$

