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МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ

Anodized aluminium and aluminium alloys — Measurement of wear resistance and wear index of anodic oxide coatings with an abrasive wheel wear test apparatus

Aluminium et alliages d'aluminium anodisés — Détermination de la résistance à l'usure et de l'indice d'usure des couches d'oxyde anodiques par essai à la roue abrasive

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 8251 was prepared by Technical Committee ISO/TC 79, *Light metals and their alloys.*

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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0 Introduction

Wear resistance can be closely related to the quality of the coating and its performance in service, since it is dependent on the composition of the metal, the thickness of the coating, and the conditions of anodizing and sealing. For example, the effect of an abnormally high anodizing temperature (potential deterioration in service with chalking of the surface layers) can be readily detected by means of an abrasive wear resistance test.

In order to make valid assessments of coatings, it is necessary to use a standard method of test. Accordingly, the method specified herein has been selected for standardization.

1 Scope

This International Standard specifies a method of test for determining the wear resistance and the wear index of anodic oxidation coatings on flat specimens of aluminium and its alloys by means of an abrasive wheel wear test apparatus. The wear resistance or the wear index of the layers of oxide near the surface, of the whole oxidation coating thickness, or of any selected intermediate zone may be determined thereby.

This method is not applicable to concave or convex specimens; these can be examined using the abrasive jet test method described in ISO 8252, which gives an average value for the abrasion resistance of the coating.

2 Field of application

The method is applicable to all anodic oxidation coatings of thickness not less than 5 µm on flat aluminium specimens.

NOTE — Minimum test specimen dimensions of 50 mm × 50 mm are normally required (see clause 6 and 7.1).

3 References

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

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

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

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

4 Definitions

For the purposes of this International Standard, the following definitions apply.

4.1 standard test specimen: A test specimen produced according to the conditions given in the annex.

4.2 agreed reference specimen: A reference test specimen produced under conditions agreed between the purchaser and the anodizer.

4.3 test specimen: The specimen on which the test is to be carried out.

4.4 double stroke (ds): One complete reciprocal movement made by the abrasive wheel.

5 Principle

The anodic oxidation coating on a test specimen is abraded under defined conditions by reciprocal motion against a strip of silicon carbide paper attached to the outer circumference of a wheel. After each complete reciprocal movement [double stroke (ds)], this 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 so obtained is used to calculate the wear index or wear resistance. This result is compared with that obtained using a specially prepared standard anodized specimen (see the annex) or some other agreed reference specimen.

NOTE — A complete representation of the wear characteristics of the anodic oxidation coating 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 coating (see 7.4).

6 Apparatus

6.1 Abrasive wheel wear test apparatus.

This apparatus consists of a clamping device or pressure plate for holding the test specimen (7.1.2) 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 (6.2). 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.

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 surface before making the next double stroke. The angle of rotation is such that after 400 double strokes 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 will be 40 ± 2 double strokes per minute. The number of double strokes may 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 surface shall be kept free from loose powder or abrasion detritus during the test.

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

6.2 Abrasive strip.

The abrasive strip consists of 45 µm (320 mesh) grade silicon carbide paper 12 mm wide. Its length shall be such that it covers the abrasive wheel without overlapping, and it shall be either bonded or mechanically clamped into position.

6.3 Eddy current meter, with suitable diameter probe.

7 Procedure

7.1 Testing of coatings produced by normal sulfuric acid anodizing

7.1.1 Standard test specimen

Prepare the standard test specimen using the method described in the annex.

7.1.2 Test specimen

Take the item to be tested and, where necessary and if possible, cut a suitably sized test specimen without damaging the test area.

NOTE — Test dimensions of 50 mm × 50 mm are usually required (but see also 7.1.4).

7.1.3 Calibration of apparatus

7.1.3.1 Select and mark the area of the standard test specimen (7.1.1) to be abraded. Accurately measure the anodic oxidation coating thickness in each of at least three positions along the test area by means of the eddy current meter (6.3) in accordance with the method specified in ISO 2360 and calculate the average value d_1.

7.1.3.2 Clamp the standard test specimen into position on the apparatus (6.1).

7.1.3.3 Attach a new strip of silicon carbide paper (6.2) to the circumference of the abrasion wheel. Adjust the abrasive wheel, according to the manufacturer's instructions, so that it gives uniform abrasion across the width of the test area. Adjust the force between the wheel and the test surface to 3,92 N.

7.1.3.4 Allow the apparatus to run for 400 double strokes (ds). Keep the abrasive action uniform by adjusting and maintaining the alignment of the abrasive wheel in accordance with the manufacturer's instructions. Continuously remove any abrasion detritus by suction, blowing or frequent wiping with a fine brush.

7.1.3.5 Remove the standard test specimen from the apparatus, wipe carefully to remove any loose oxide and determine the average coating thickness in the test area (d_2) according to 7.1.3.1.

NOTE — A 3 mm length at one extremity of the test area may 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.

7.1.3.6 Carry out at least two further determinations on the standard test specimen in test areas that do not overlap, using the procedure specified in 7.1.3.1 to 7.1.3.5.

7.1.3.7 Calculate the wear rate for the standard test specimen (see 8.3) from the average of the determinations.

* 4,9 N ≈ 500 gf

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7.1.4 Determination

Take the test specimen (7.1.2) and carry out the procedure specified in 7.1.3 using abrasive strips from the same batch as was used for the calibration. If the test specimen is too thin, bond it firmly with an adhesive to a rigid metal sheet with a flat surface before carrying out the determination. The minimum test specimen size for a single determination is 50 mm × 20 mm.

7.2 Testing of coatings produced by integral colour anodizing or by hard anodizing

7.2.1 Carry out the initial determination in accordance with 7.1.4. If the thickness loss in the test area is less than 3 µm, adjust the abrasion conditions either by increasing the force between the wheel and the test surface, or by employing a coarser grade of silicon carbide paper. Alternatively, an increased number of double strokes may be used.

NOTE — Unless a depth survey is being carried out (see 7.4), the abrasion conditions should be adjusted to give a coating thickness loss of 5 ± 3 µm after 400 double strokes.

If loss of mass is being used, then the mass equivalent of 5 ± 3 µm coating thickness needs to be known. This requires an assumption about the coating density or else it should be estimated by means of ISO 2106.

7.2.2 Calculate the comparative wear rate as specified in 8.5.

7.3 Comparative wear testing

7.3.1 Introduction

Comparison of abrasion of the test specimen (7.1.2) is made, as agreed between purchaser and anodizer, with that of an agreed reference specimen (see 4.2) or with the standard specimen. In these cases, either comparative loss in thickness or comparative loss in mass may be used. The comparative wear rate is expressed as a percentage of that of the agreed reference specimen.

7.3.2 Comparative loss of thickness

Determine the loss in thickness on the test specimen and on the agreed reference specimen using the procedure specified in 7.1.4.

Calculate the comparative wear rate as described in 8.3.

7.3.3 Comparative loss of mass

7.3.3.1 Select and mark the area of the test specimen to be abraded. Weigh the test specimen to the nearest 0,000 1 g (m_1). Carry out the procedure specified in 7.1.3.2 to 7.1.3.4.

7.3.3.2 Remove the test specimen from the apparatus, wipe to remove any loose oxide and again weigh to the nearest 0,000 1 g (m_2).

Carry out at least two further determinations on the test specimen in test areas that do not overlap.

NOTE — Freshly exposed oxide may gain in mass by absorbing water vapour. Multiple tests on a single panel may therefore be subject to errors dependent on variations in atmospheric humidity.

7.3.3.3 Repeat the procedure specified in 7.3.3.1 and 7.3.3.2 on the agreed reference specimen. Calculate the comparative wear rate as specified in 8.4.

7.4 Depth survey of wear resistance

7.4.1 Introduction

In some cases, it may be required to establish the way in which the wear resistance changes through the thickness of the anodic oxidation coating. In these cases, it will be necessary to carry out a depth survey of wear resistance.

7.4.2 Determination

7.4.2.1 Take the test specimen and measure the average coating thickness as specified in 7.1.3.1. Precisely locate the test specimen in the apparatus by means of positioning pins or stops attached to the specimen table so that successive abrasions can be carried out on a single test area.

7.4.2.2 Carry out the first abrasion as specified in 7.1.3.3 and 7.1.3.4 but use only 20 to 50 ds (according to the expected hardness). Remove the test specimen and determine the average coating thickness in the area as specified in 7.1.3.5.

7.4.2.3 Accurately relocate the test specimen in the apparatus and repeat the procedure specified in 7.4.2.2 for a further appropriate number (see note 1) of double strokes. Repeat the operation of abrasion and thickness determination using an appropriate number of double strokes until the basis metal is just revealed.

NOTES

1 A typical sequence of abrasion intervals is : 50 — 100 — 200 — 400 — 800 and 1 200 double strokes.

2 Where accurate relocation of the test specimen is difficult or doubtful, the same objective can be achieved by successive tests of increasing duration on a series of adjacent test areas. Such a test takes longer to perform.

7.4.2.4 Calculate the change in resistance to wear through the coating thickness, and appropriate wear indices or wear resistance coefficients for any part of coating using, if required, a graph of coating thickness plotted against the number of double strokes used.

The result of a depth survey can be related to that on a standard specimen, if required.

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8 Expression of results

8.1 Wear resistance

The wear resistance, WR, expressed as double strokes per micrometre, is given by the equation:

$$WR = \frac{400}{d_1 - d_2}$$

where

d_1 is the average thickness, in micrometres, before abrasion (see 7.1.3.1);

d_2 is the average thickness, in micrometres, after 400 ds abrasion (see 7.1.3.5).

8.2 Wear resistance coefficient

The wear resistance coefficient, WRC, is given by the equation

$$WRC = \frac{WR_t}{WR_s}$$

$$= \frac{d_{1s} - d_{2s}}{d_{1t} - d_{2t}}$$

where

WR_t is the wear resistance, in double strokes per micrometre, of the test specimen;

WR_s is the wear resistance, in double strokes per micrometre, of the standard test specimen;

d_{1s} is the average thickness, in micrometres, of the standard test specimen before abrasion (see 7.1.3.1);

d_{2s} is the average thickness, in micrometres, of the standard test specimen after 400 ds abrasion (see 7.1.3.5);

d_{1t} is the average thickness, in micrometres, of the test specimen before abrasion (see 7.1.3.1);

d_{2t} is the average thickness, in micrometres, of the test specimen after 400 ds abrasion (see 7.1.3.5).

The wear resistance coefficient of a standard test specimen is defined as being equal to 1.

NOTES

1 Wear resistance coefficient is the reciprocal of wear index and is a measure of resistance to abrasive wear.

2 The wear resistance coefficient is a measure of resistance to abrasive wear. Values greater than 1 indicate a lower degree of wear than that on the standard test specimen. Values less than 1 indicate a greater degree of wear than that on the standard test specimen.

8.3 Wear index

The wear index, WI, is given by the equation:

$$WI = \frac{W_t}{W_s}$$

$$= \frac{d_{1t} - d_{2t}}{d_{1s} - d_{2s}}$$

where

W_t is the wear rate of the test specimen;

$$W_t = \frac{d_{1t} - d_{2t}}{4} \ \mu m/100 \ ds$$

W_s is the wear rate of the standard test specimen;

$$W_s = \frac{d_{1s} - d_{2s}}{4} \ \mu m/100 \ ds$$

The wear index of a standard specimen is defined as being equal to 1.

NOTES

1 Wear index is a ratio and is dimensionless.

2 The wear index is an indication of the relative rate of wear and is the reciprocal of the wear resistance coefficient. Values greater than 1 indicate a greater degree of wear than that on the standard test specimen. Values less than 1 indicate a lower degree of wear than that on the standard test specimen.

8.4 Mass wear index

The mass wear index, MWI, is given by the equation

$$MWI = \frac{MW_t}{MW_s}$$

$$= \frac{m_{1t} - m_{2t}}{m_{1s} - m_{2s}}$$

where

MW_t is the mass wear rate of the test specimen;

MW_s is the mass wear rate of the standard test specimen;

m_{1t} is the average mass, in milligrams, of the test specimen before abrasion (see 7.3.3.1);

m_{2t} is the average mass, in milligrams, of the test specimen after 400 ds abrasion (see 7.3.3.2);

m_{1s} is the average mass, in milligrams, of the standard test specimen before abrasion (see 7.3.3.1);

m_{2s} is the average mass, in milligrams, of the standard test specimen after 400 ds abrasion (see 7.3.3.2).

The mass wear index of a standard test specimen is 1.

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