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Anodized aluminium and aluminium alloys — Measurement of mean specific abrasion resistance of anodic oxidation coatings with an abrasive jet test apparatus

Aluminium et alliages d'aluminium anodisés — Détermination de la résistance spécifique moyenne des couches d'oxyde anodiques à l'abrasion par essai au jet abrasif

Reference number
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Foreword

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International Standard ISO 8252 was prepared by Technical Committee ISO/TC 79, *Light metals and their alloys*.

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Anodized aluminium and aluminium alloys — Measurement of mean specific abrasion resistance of anodic oxidation coatings with an abrasive jet test apparatus

0 Introduction

The resistance of anodic oxidation coatings to abrasion can be an important property in that it may give information about the quality of the coating and its potential resistance to erosion or wear.

In order to make valid comparisons between 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 comparing the resistance to abrasion of anodic oxidation coatings on aluminium and its alloys with that of a standard test specimen or, alternatively, an agreed specimen, by the use of a jet of particles. The mean specific abrasion resistance of the anodic oxidation coating may be determined thereby.

NOTES

1 Different batches of abrasive particles are liable to give different results and this is the main reason for the test being a comparative one.

2 With suitably designed abrasive jets and film thickness measuring devices with a small probe, it is possible to conduct a depth survey which indicates how the abrasion resistance varies through the film thickness. However, this is preferably measured using the abrasive wheel wear test method (ISO 8251).

2 Field of application

The method is applicable to all anodic oxidation coatings of thickness not less 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 test method (ISO 8251) is preferred. Production components may be tested without cutting if the apparatus chamber can accommodate them.

NOTE — The test method is particularly suitable for small test specimens in that the individual test area required is only about 2 mm in diameter.

3 References

ISO 565, *Test Sieves — Woven metal wire cloth and perforated plate — Nominal sizes of aperture.*

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

ISO 8251, *Anodizing of aluminium and its alloys — Measurement of wear index and wear resistance of anodic oxidation coatings with an abrasive wheel wear 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 annex C.

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 anodic oxidation coating is to be evaluated.

5 Principle

A jet of dry silicon carbide particles is projected in a stream of dry air or inert gas under carefully controlled conditions onto a small area of the surface to be tested. The test is continued until the basis metal is exposed, after which the abrasion resistance of the coating is calculated from either the time taken or the mass of silicon carbide used. This result is compared with that obtained using a specially prepared standard anodized specimen (see annex C) or some other agreed reference specimen.

6 Apparatus

6.1 Abrasion test apparatus (see figures 1-3), comprising:

6.1.1 Abrasive jet assembly, constructed from glass, brass or stainless steel, or any other similar hard material (or a combination of these). It consists essentially of two tubes supported rigidly and coaxially. The outer tube is connected to a supply of clean, dry, compressed air or inert gas which can be delivered at a carefully regulated flow rate by means of a control valve. Dry abrasive particles are supplied to the inner tube at the exit end of which they mix with the air stream to form an abrasive jet which is directed onto the anodized test specimen.

No restriction is placed upon the design of the abrasive jet assembly except that it shall give reproducible results in successive tests and that it shall allow reasonably accurate measurements to be made.

A number of satisfactory designs of jet assembly have been constructed but it has proved difficult in practice to manufacture a series of jets which gives identical results, or to make any that are not subject to drift and variations for many reasons. Recommended designs that have proved satisfactory are given in annex A.

6.1.2 Test specimen support, comprising an inclined platform on which the test specimen is firmly and rigidly supported such that the angle between the plane of the test area and of the jet axis is in the range 45° to 55°.

The jet axis is normally vertical.

NOTE — Clause A2 of annex A describes an apparatus where the angle is 55°; clause A3 of annex A describes a different form of apparatus where the angle is approximately 45°. The larger angle produces a less elliptical test area, more rapid abrasion, and a sharper end point.

6.1.3 Air or inert gas supply, fed to the outer tube from a compressor or gas cylinder and accurately controlled by means of a regulating valve and a flow meter or manometer situated near the apparatus. The air or inert gas used shall be dry, or have a constant low humidity.

Compressed air passed through a holding reservoir where condensed water vapour is collected will have a satisfactory and fairly constant humidity. Typical flow rates used in practice are from 40 to 70 l/min, with a pressure typically about 15 kPa.

It is recommended that once the flow rate has been selected for any particular jet assembly, it should, as far as possible, be maintained throughout the life of that jet.

NOTE — The gas can be conveniently dried by passing it through tubes containing silica gel.

6.1.4 Hopper, to store the abrading medium and to supply it at a steady rate of 20 to 30 g/min ± 1 g/min.

6.2 Abrading medium: Silicon carbide particles of the grade recommended for the apparatus used. Suitable grades of abrasive are those marketed commercially as 106 and 150 μm mesh size (see ISO 565).

NOTE — In the case of a commercially manufactured apparatus, this information would normally be supplied by the manufacturer.

The medium shall be free from moisture and before use it shall be dried in a shallow tray at 105 °C and then passed through a coarse sieve (for example 180 or 300 μm nominal aperture size respectively) to ensure freedom from large particles or fibres which might interfere with the rate of abrasive flow. The dried medium can be stored in a clean, tightly closed container. It may be used again up to 50 times. After each usage it shall be dried and passed through the coarse sieve before being used again.

NOTE — The ambient humidity has little effect on the test result, but it may have a very considerable effect if the powder is used again without drying.

6.3 Timer

7 Procedure

7.1 Standard test specimen

Prepare the standard test specimen using the method specified in annex C.

7.2 Test specimen

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

7.3 Calibration of apparatus

7.3.1 Select and mark the areas of the standard test specimen (7.1) to be abraded. Accurately measure the anodic oxidation coating thickness (d) in each test area by means of an eddy current meter in accordance with the method specified in ISO 2360.

7.3.2 Fix the standard test specimen in position in the test apparatus (6.1) with the selected test area beneath the jet orifice and at the correct angle to the jet axis.

7.3.3 Fill the hopper (6.1.4) with sufficient silicon carbide (6.2) for the test. If the abrasion resistance is being determined in terms of the mass of abrasive used, weigh the hopper and contents to the nearest 1 g.

7.3.4 Set the air flow rate, or the pressure, to the specified (or selected) value (see 6.1.3), which shall be accurately maintained throughout each test and any series of tests.

NOTE — The air or gas flow rate should be adjusted to give a rate of abrasion that is convenient for both the standard test specimen being tested and the test specimen. The preferred rate, or pressure, is normally indicated by the instrument manufacturer but it may be necessary to vary this for hard anodizing, or for very soft films, or for thin films.

7.3.5 Start the flow of abrading medium (6.2) and, at the same time, the timer (6.3). During the test, ensure that the abrasive flows freely.

7.3.6 Keep the test specimen under observation, and when a small black spot appears in the centre of the abraded area and rapidly enlarges to about 2 mm in diameter, terminate the test by stopping the abrasive flow, and the timer.

7.3.7 Record the time, in seconds, taken for the test, and also if required, weigh the hopper and residual contents to the nearest 1 g.

From the two weighings (7.3.3 and 7.3.7), the mass, in grams, of silicon carbide used to penetrate the coating may be calculated.

These measurements give the abrasion measurement, S, of the standard specimen which is recorded in either seconds or grams.

7.3.8 Carry out at least two further tests on other parts of the standard test specimen (7.3.1 to 7.3.7 inclusive).

7.4 Calibration of jet

NOTE — Since individual jets may vary with use and one with another, it is necessary to correct each set of measurements by means of calibration determinations using a standard specimen, as in 7.3. This enables the jet factor (see 8.1) for the set of measurements to be calculated.

7.4.1 Change of jet or abrasive characteristics with time

In any series of test measurements, repeat the procedure specified in 7.3 once or twice daily, in order to allow corrections to be made for changes of jet or abrasive characteristics with time.

7.4.2 Jet replacement

After jet replacement, repeat the procedure specified in 7.3 to allow correction for changes in jet characteristics.

7.5 Determination

Carry out the procedures described in 7.3 using the test specimen (4.3) instead of the standard specimen (4.1).

7.6 Use of an agreed reference specimen

Under some circumstances, for example for control purposes, it is the practice to use an agreed reference specimen for comparison and, if required and agreed between the purchaser and the anodizer, the procedure specified in 7.3 shall be followed, using the agreed reference specimen in place of the standard test specimen.

8 Expression of results

8.1 Abrasive jet factor

The abrasive jet factor K, expressed in micrometres per gram or micrometres per second, is given by the equation

$$K = \frac{d_s}{S_s} \times 10$$

where

d_s is the original film thickness, in micrometres, of the standard test specimen in the area tested;

S_s is the abrasion measurement, in seconds or grams, of the standard test specimen.

NOTE — When the factor has been determined for an abrasive jet used under any specified set of conditions, it is essential that measurements made with the jet should be multiplied by this factor.

8.2 Mean specific abrasion resistance

The mean specific abrasion resistance R of the coating at any test point, expressed with reference to the value obtained on a standard test specimen, is given by the equation

$$R = \frac{KS}{d}$$

where

K is the abrasive jet factor (see 8.1);

S is the abrasion measurement (see 7.3.7), in seconds or grams, of the test specimen;

d is the original coating thickness, in micrometres, of the test specimen in the area tested (see 5.3.1).

The value quoted shall be the mean of not less than three determinations.

NOTES

1 The specific abrasion resistance is a ratio with no dimensions. The standard test specimen has been assigned an arbitrary value of 10 (see 8.1).

2 The term mean specific abrasion resistance implies that anodized coatings may be variable through their thickness and the measured value is an average property for the whole coating thickness.

8.3 Results based on comparison with an agreed reference specimen

If the abrasive jet apparatus is being used for comparison with an agreed reference specimen, then the relative mean specific abrasion resistance, R_{rel}, expressed as a percentage, is given by the equation

$$R_{rel} = \frac{S}{d} \times \frac{d_r}{S_r} \times 100$$

where

S_r is the abrasion measurement, in seconds or grams, of the reference specimen;

d_r is the original film thickness, in micrometres, of the reference specimen in the area tested;

S and d are as defined in 8.2.

The value quoted shall be the average of not less than three determinations for both the test specimen and the reference specimen.

9 Test report

The test report shall include the following information:

a) identification of the test specimen;

b) a reference to this International Standard;

c) a reference to the particular apparatus used and the angle between the plane of the test area and the jet axis;

d) details of the abrading medium particle size, and the gas flow rate and pressure applied;

e) the number of test points and their location on the test surface;

f) the calculated value of the mean specific abrasion resistance, R, or the relative mean specific abrasion resistance, R_{rel};

g) any other observation concerning the conduct of the test or the nature of the test piece area.

Annex A

Design of abrasive jet test apparatus

(This annex forms an integral part of the Standard.)

A.1 No restriction is placed upon the design of the jet apparatus provided that it complies with the general principles given in clause 6.

Many jet assembly designs have been used for abrasion testing of anodic oxidation coatings and these have varied with regard to the sharpness of the end-point, sensitivity to small changes in the operating conditions, and tendency to drift owing to wear. Two designs (see clauses A.2 and A.3) have been satisfactory and are recommended.

A.2 Figure 1 shows the basic design and lay-out of a suitable test apparatus, but excludes the cabinet which houses the jet assembly and test specimen in order to contain the abrasive powder. The jet nozzle shown in detail in figure 2 is constructed from brass and stainless steel and the design ensures minimum wear of the nozzle; in conjunction with a sample angle of 55°, it produces rapid abrasion and a sharp end-point.

A.3 Figure 3 shows an alternative design of jet assembly which has also proved satisfactory. The materials of construction are optional. It is recommended, however, that the outer (8,5 mm) tube should be made of glass. It should also be removable from the metal collar as the outer tube is subject to wear, with consequent drifting of results and loss of sharpness of the end-point. It is recommended that a specific glass tube should be used for each rate of air flow. The sample angle is generally 45° but within the terms of this International Standard may be from 45 to 55°.

NOTE — Dimensions are in millimetres and are not critical where no tolerances are given.

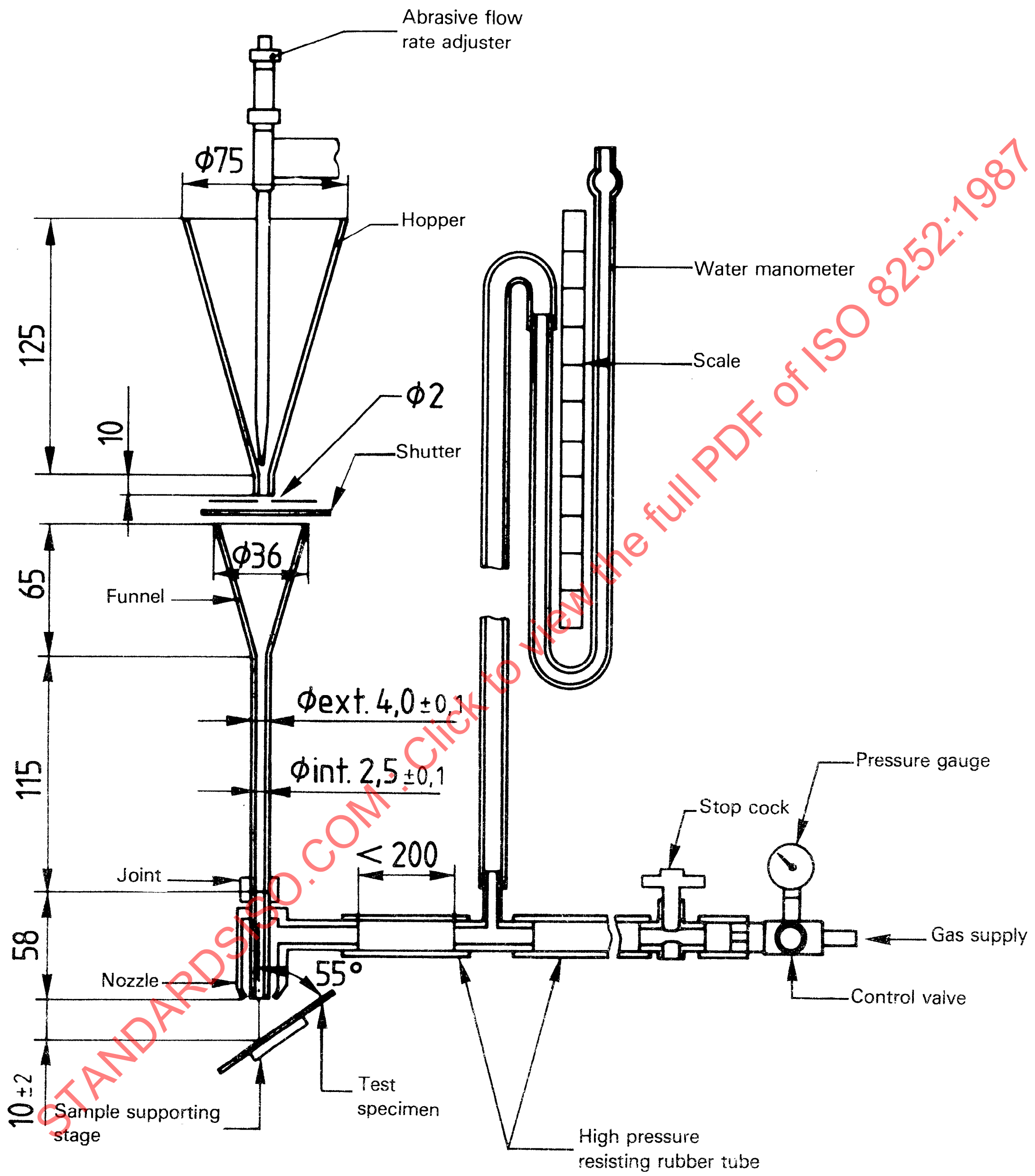

Figure 1 — General layout of abrasive jet test apparatus

Dimensions in millimetres

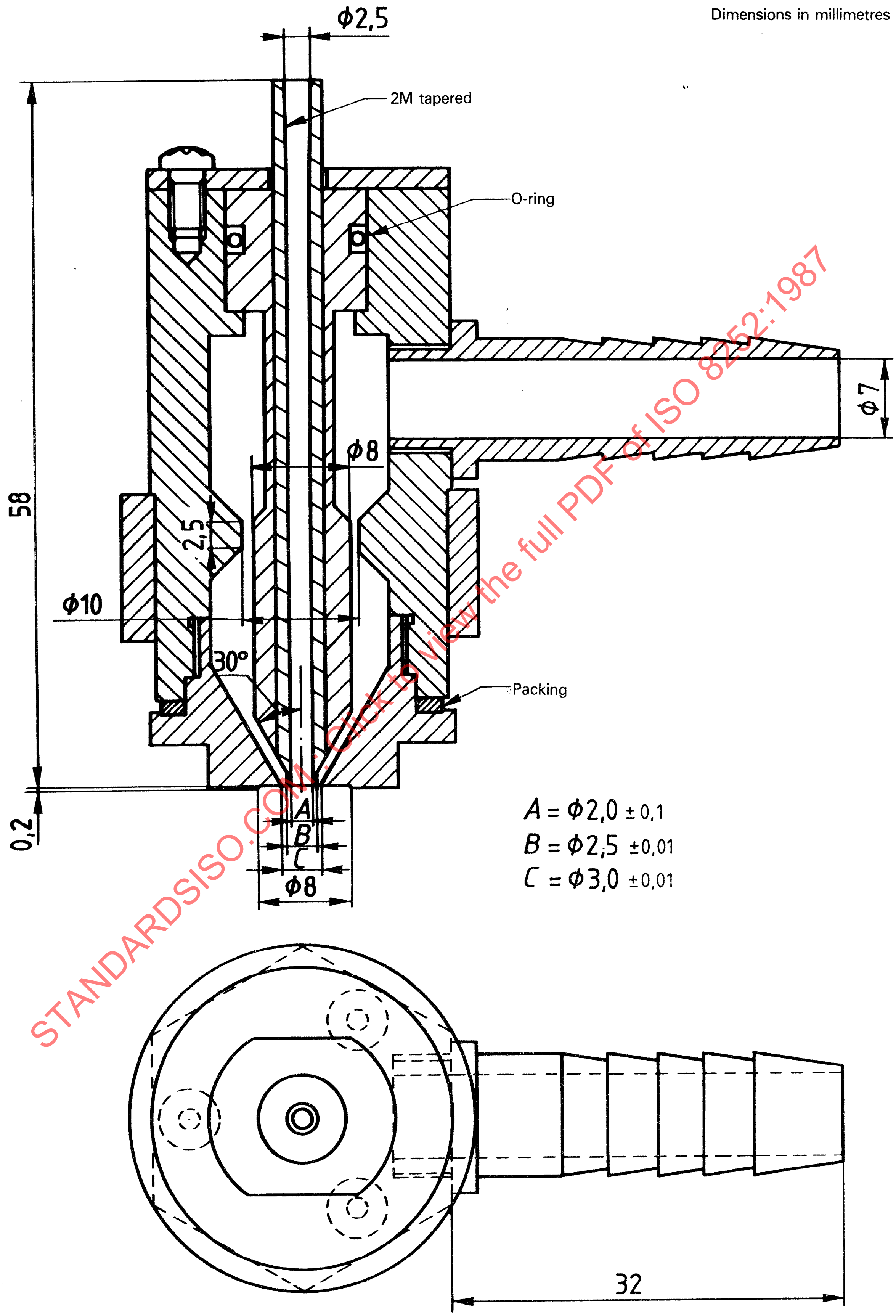

Figure 2 — Details of suitable jet nozzle