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**Anodizing of aluminium and its  
alloys — Assessment of resistance of  
anodic oxidation coatings to cracking  
by deformation**

*Anodisation de l'aluminium et de ses alliages — Évaluation de la  
résistance des couches anodiques à la formation de criques par  
déformation*

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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.

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](http://www.iso.org/directives)).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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](http://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 fourth edition cancels and replaces the third edition (ISO 3211:2010), which has been technically revised. The main changes compared to the previous edition are as follows:

- the unit of length has been changed from cm to mm;
- the information of the test specimen has been added;
- the title of [Clause 7](#) “Determination” has been changed to “Procedure”.

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](http://www.iso.org/members.html).

# Anodizing of aluminium and its alloys — Assessment of resistance of anodic oxidation coatings to cracking by deformation

## 1 Scope

This document specifies an empirical method for assessing the resistance of anodic oxidation coatings to cracking by deformation.

The method is applicable particularly to sheet material with anodic oxidation coatings of thickness less than 5 µm, and is useful for development purposes.

NOTE If the test specimen is thick, more than 5 µm of coating can be measured (see [Clause 9](#)).

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

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 7583 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/>

## 4 Principle

A test specimen is bent along a spiral, graduated with a radius of curvature index, using a simple instrument. The radius of curvature corresponding to the region where the first cracks in the oxide layer appear is determined and the percentage elongation of the test specimen corresponding to this radius is calculated.

## 5 Apparatus

### 5.1 Measuring instruments.

- a) **Spiral plate**, mounted on a suitable base, in the shape of a spiral (see [Figure 1](#)), graduated in deformation indexes,  $E$ , from 1 to 18. These indexes,  $E$ , correspond to radii of curvature,  $R$ , as shown in [Table 1](#), and are derived from [Formula \(1\)](#):

$$R = 210 - 10E \quad (1)$$

where

$R$  is the radius of curvature, in millimetres;

$E$  is the deformation index corresponding to the region where the first cracks appear.

b) **Screws**, for clamping either end of the test specimen.

**Table 1 — Relationship between deformation index  $E$  and radius of curvature  $R$**

Deformation index $E$	Radius of curvature $R$ mm	Deformation index $E$	Radius of curvature $R$ mm
1	200	10	110
2	190	11	100
3	180	12	90
4	170	13	80
5	160	14	70
6	150	15	60
7	140	16	50
8	130	17	40
9	120	18	30

## 6 Test specimen

### 6.1 Sampling

The test specimen shall be taken from a flat significant surface of the product. It shall not be taken from the edges for possible distortion and/or non-uniformity.

Where it is impossible to test the product itself, a test specimen representative of the product may be used. In this case, the test specimen used 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 and anodizing shall be performed in the same bath and under the same conditions as the treatment of the product.

Where the substrate of the test specimen is composed of extruded aluminium, the extruded direction to the bending direction (i.e. orthogonal or parallel to the bending direction) shall be reported in the test report.

### 6.2 Size

The standard size of the test specimen should be 250 mm in length, 20 mm in width and 3 mm in thickness in maximum.

### 6.3 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. Organic solvents that can corrode the test specimen or generate a protective film on the test specimen shall not be used.

Dimension in millimetres

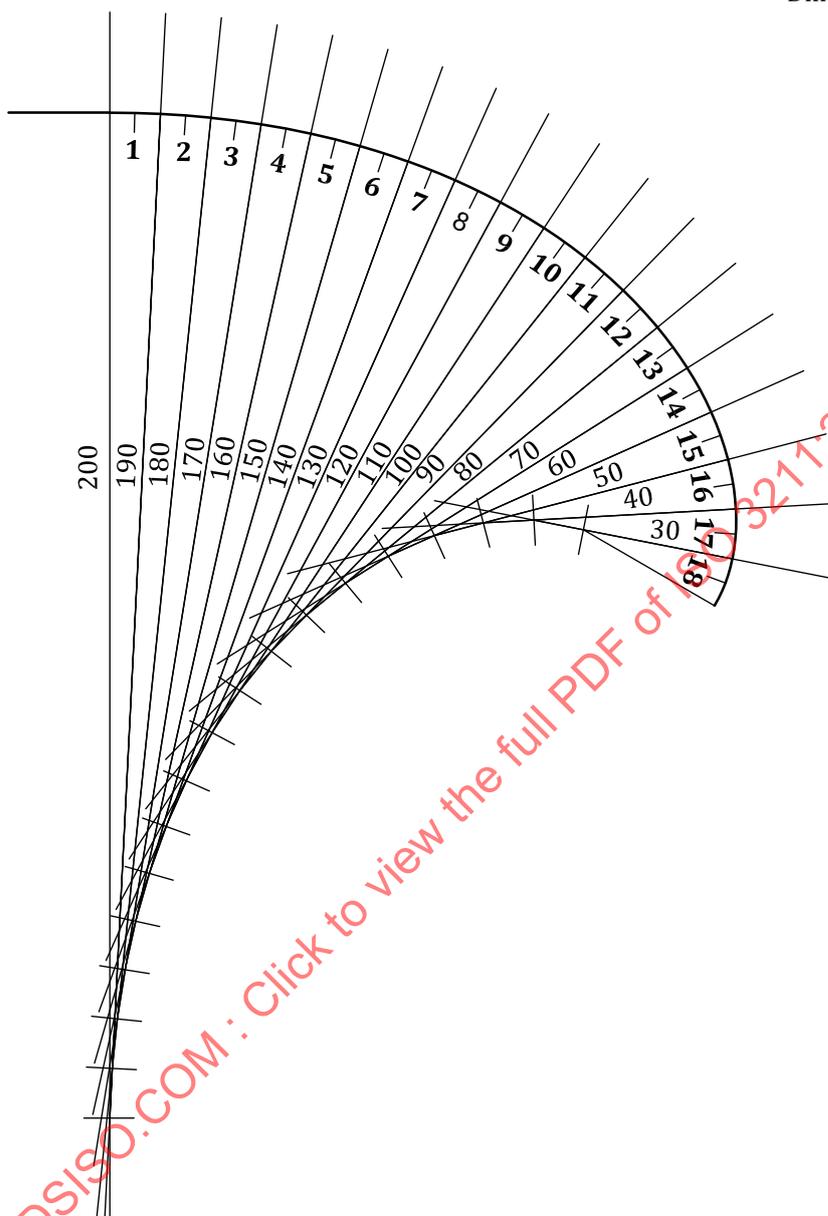


Figure 1 — The changing of the radii of curvature

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**7 Procedure**

Clamp the test specimen with one of the clamping screws 3 or 5 (see [Figure 2](#)) with the significant surface outwards.

Bend the test specimen progressively over the spiral, in such a way that the test specimen remains in contact with the spiral.

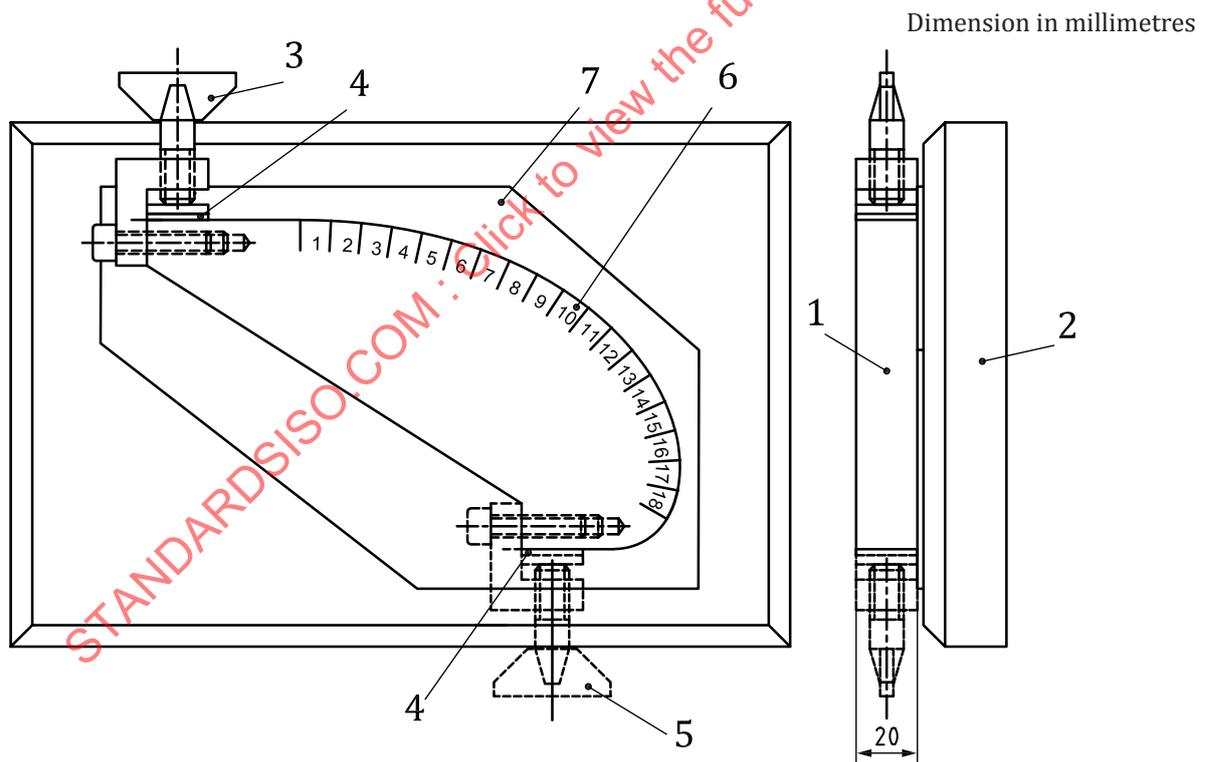
If the bending started with clamping at screw 3, as the curvature of the spiral becomes large near the clamping screw 5, it may be difficult to bend the test specimen along the spiral by hand. In that case, the test specimen should be clamped with clamping screw 5 to start bending.

Examine the anodic oxidation coatings and mark the region where the first cracks appear:

If the cracks are difficult to detect, they can be rendered visible using the procedure described in ISO 2085 by removing the bent test specimen and immersing it in copper sulfate solution for 5 min, then rinsing with clean water and drying it.

The test specimen is then set on the apparatus and the deformation index corresponding to the region where the first cracks appear is marked.

The clamping screw to start bending shall be reported in the test report.



**Key**

- |                             |                             |
|-----------------------------|-----------------------------|
| 1 spiral plate              | 5 clamping screw, removable |
| 2 wooden base               | 6 deformation index         |
| 3 clamping screw, removable | 7 metal base plate          |
| 4 rubber pad                |                             |

**Figure 2 — Example of deformation index measuring instrument**

## 8 Expression of results

Express the elongation,  $A$ , of the anodic oxidation coatings as a percentage using [Formula \(2\)](#):

$$A = \frac{100d}{2R+d} \quad (2)$$

where

$d$  is the thickness, in millimetres, of the test specimen;

$R$  is the radius of curvature, in millimetres, given by [Formula \(1\)](#).

## 9 Test report

The test report shall include at least the following information:

- a) a reference to this document, i.e. ISO 3211:2018;
- b) the type and identification of the product tested;
- c) the result of the test (see [Clause 8](#));
- d) the thickness of the test specimen, the anodic coating thickness and the index,  $E$ , in the case of a thick test specimen with an anodic coating greater than 5  $\mu\text{m}$ ;
- e) the extruded direction of the substrate to the bending direction (orthogonal or parallel/where the substrate is composed of the extruded aluminium);
- f) the clamping screw to start bending (clamping screw 3 or 5);
- g) anything unusual noticed during the determination;
- h) any operations not included in the procedure described in this document, or considered to be optional;
- i) the date of the test.