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Carbonaceous materials for the production of aluminium — Prebaked anodes — Determination of the fracture energy

Produits carbonés pour la production de l'aluminium - Anodes précuites - Détermination de l'énergie de rupture

Reference number
ISO 11706:2012(E)

Foreword

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The main task of technical committees is to prepare International Standards. 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.

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ISO 11706 was prepared by Technical Committee ISO/TC 226, *Materials for the production of primary aluminium*.

Carbonaceous materials for the production of aluminium — Prebaked anodes — Determination of the fracture energy

1 Scope

This International Standard describes a method for the determination of the fracture energy at room temperature. This property is relevant for the thermal shock resistance of prebaked anodes used in the electrolytic cell.

2 Normative references

The following referenced documents are indispensable for the application 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 8007-2, *Carbonaceous materials used in the production of aluminium — Sampling plans and sampling from individual units — Part 2: Prebaked anodes*

ISO 12986-1, *Carbonaceous materials used in the production of aluminium — Prebaked anodes and cathode blocks — Part 1: Determination of bending/shear strength by a three-point method*

ISO 12985-1, *Carbonaceous materials used in the production of aluminium — Baked anodes and cathode blocks — Part 1: Determination of apparent density using a dimensions method*

3 Principle

The amount of energy needed to fracture a notched cylindrical test piece is determined by integrating the force-displacement signals of the testing machine.

Notching of the test piece allows to minimize the elastic energy stored in the specimen and therefore guarantees controlled and smooth crack propagation.

The same arrangement and testing equipment as required for the determination of the bending/shear strength by a 3-point method can be used, see ISO 12986-1.

A length measurement device for the vertical displacement, a data acquisition system and software able to integrate the force-displacement curve are additionally needed.

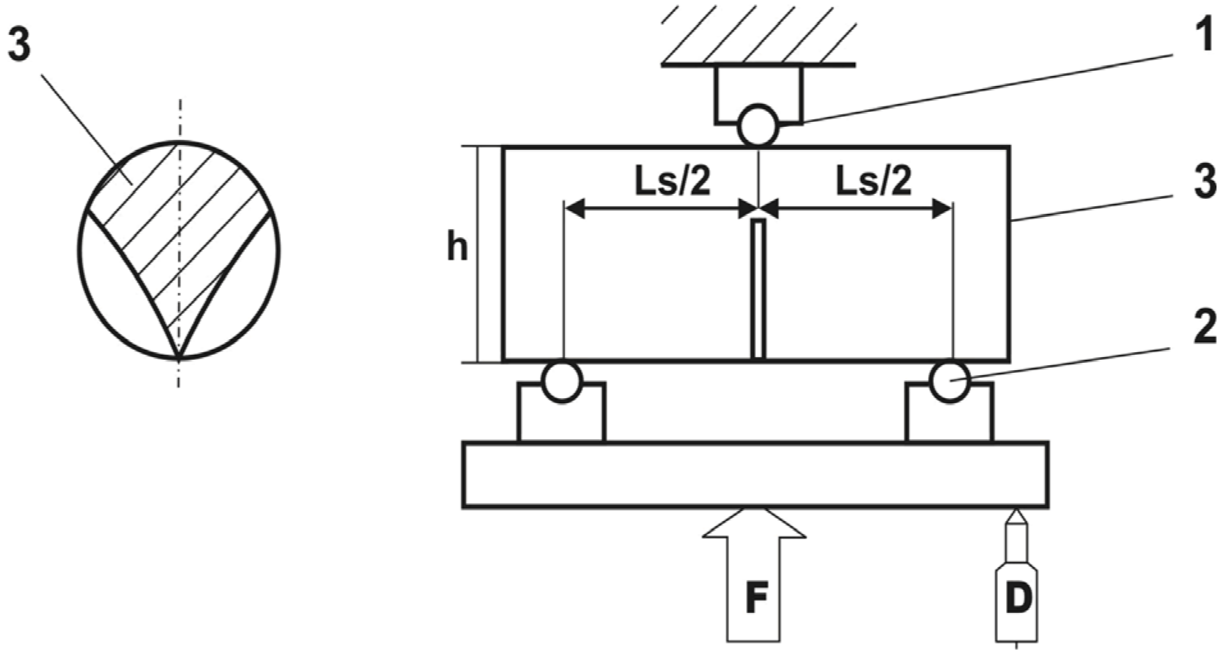
4 Apparatus

4.1 Testing equipment

The testing machine has a hydraulic system that can be adjusted to control the load increase rate. The maximum achieved load should lie above 1 kN and the precision of the load sensor better than 5 N.

The 3-point cell complies with ISO 12986-1. The displacement measurement unit shall cover a range of 10 mm with a precision better than 5 µm.

The arrangement of the cell with the notched sample and the recorded signals are shown in the following figure.



Key

1	pier bar (Ø 5 to 10 mm)
2	support bar (Ø 5 to 10 mm)
3	test piece (Ø 50 mm, length 130 mm, 60° notched, 2 mm slots)
L_S	= 100 mm
F	= force applied to the bottom table
D	= displacement sensor

Figure 1 — 3-point testing set-up

The maximum load reached for typical anodes lies in the range of 500 N to 1000 N while a typical displacement difference between the load increase and the total fracture of the sample is around 0,5 mm and 1 mm. The typical value of the fracture energy of worldwide anodes is around 200 J/m^2.

5 Sampling

The sampling program and the drilling location of the sample shall be agreed between the seller and buyer in accordance with ISO 8007-2.

6 Preparation of the test pieces

6.1 Drilling and cutting

Cylindrical test pieces with a circular cross-section only shall be used. The test pieces shall have a diameter of 50 mm ±1 mm and a minimum length of 130 mm.

Drilling shall be performed with a machine and set-up guaranteeing a uniform diameter throughout the sample length.

Cutting is made by using a saw unit providing parallel end-faces of the test piece.

6.2 Notching

A 60° angle notched cross-sectional area shall be prepared. The slot thickness shall be 2 mm.

A convenient and simple way to prepare the notch is to use a saw having a 2 mm thick blade of 250 mm diameter. The sample positioning is given by fixing the test pieces to a support fitting in the saw table. After sawing the first slot reaching the precise highest position of the cylinders, the support device with its fixed test piece is turned by 180° for preparing the second slot.

6.3 Drying

The test pieces are cleaned and dried overweight at 120 °C and cooled to room temperature.

7 Testing procedure

The diameter of the test piece is measured using a caliper according to ISO 12985-1.

Set up the piece, with the notch tip aligned to the bottom support bars, on the testing table.

Increase the force steadily and smoothly in such a way that the sample breaks totally in a time period between 5 s and 10 s. Record continuously the load and the displacement of the table.

8 Expression of results

Calculate the fracture energy in J/m^2 by integrating the force/displacement signals according to the following principle and equations:

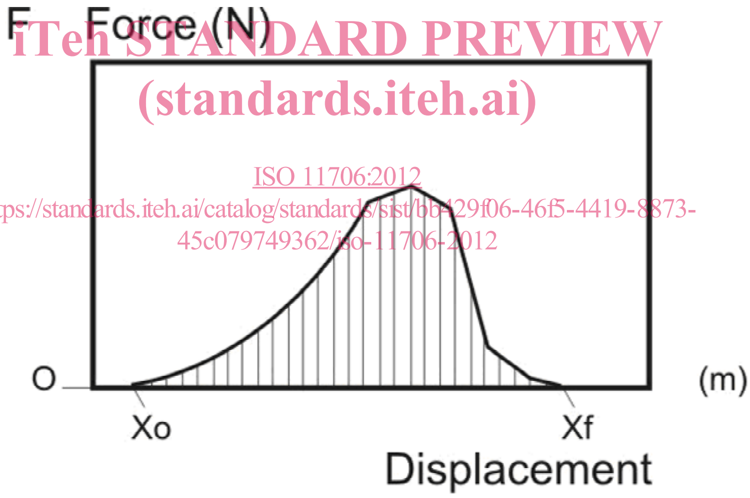


Figure 2 — Integration of the force/displacement curve

The zero displacement *Xo* corresponds to the table position where the first significant sign of load is noticed. The displacement *Xf* corresponds to the table position where the decreasing load still had a significant positive value.

The fracture energy FE can be calculated using the integral formula shown below:

$$\mathrm{FE} = \frac{1}{2 \cdot S} \cdot \int_{Xo}^{Xf} F \cdot dx$$

where

F = force in newtons

X = displacement in metres

S = broken surface area, equal for an angle of 60° to 0,478 h^2 (h = sample diameter)

Report the result rounded to the unit of J/m^2.

9 Precision

The repeatability of this destructive method cannot be tested.

The reproducibility of the mean value of a given sample population, with a minimum number of test pieces above 30, is 20 J/m^2. (RDC round robin 1997 on anodes.)

10 Test report

The test report shall contain the following information:

a) a reference to this International Standard;

b) type, position and orientation of test specimens during the sampling;

c) designation of the test piece;

d) single fracture energy value of each test piece;

e) number of test piece, average and the standard deviation of the population;

f) additionally agreed conditions deviating from the standard method;

g) sampling and test date.