INTERNATIONAL STANDARD

ISO 12986-1

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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

Produits carbonés utilisés pour la production de l'aluminium — Anodes précuites et blocs cathodiques —

Partie 1: Détermination de la résistance à la flexion par une méthode trois points

Reference number
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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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.

Attention is drawn to the possibility that some of the elements of this part of ISO 12986 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 12986-1 was prepared by Technical Committee ISO/TC 47, *Chemistry*, Subcommittee SC 7, *Aluminium oxide, cryolite, aluminium fluoride, sodium fluoride, carbonaceous products for the aluminium industry.* ISO 12986-1 describes a three-point method which is applicable to prebaked anodes, but which may be used for cathode blocks. A further method is being developed as ISO 12986-2, which will describe a four-point method for use with cathode blocks only.

ISO 12986 consists of the following parts, under the general title *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*

The determination of bending/shear strength by a four-point method will be the subject of a future part 2 to ISO 12986.

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

1 Scope

This part of ISO 12986 describes a method for the determination of the bending/shear strength (flexural strength) of prebaked anodes and cathode blocks at temperatures in the range 20 °C to 30 °C. The method is particularly applicable to prebaked anodes, but can be applied to cathode blocks.

NOTE For the practical application of this International Standard the terms 'bending/shear strength' and 'flexural strength' may be considered equivalent.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 12986. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 12986 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 8007-1:1999, *Carbonaceous materials used in the production of aluminium — Sampling plans and sampling from individual units — Part 1: Cathode blocks*.

ISO 8007-2:1999, *Carbonaceous materials used in the production of aluminium — Sampling plans and sampling from individual units — Part 2: Prebaked anodes*.

DIN 51220, *Werkstoffpruefmaschinen — Allgemeines zu Anforderungen an Werkstoffpruefmaschinen und zu deren Pruefung und Kalibrierung*. [Materials testing machines — General guide for requirements and for verification and calibration of materials testing machines].

DIN 51221-1, *Werkstoffpruefmaschinen; Zugpruefmaschinen, Allgemeine Anforderungen*. [Tensile testing machines; general requirements].

DIN 51221-2, *Werkstoffpruefmaschinen; Zugpruefmaschinen; Besondere Anforderungen und Ausruestung*. [Tensile testing machines; special requirements and equipment].

DIN 51223, *Werkstoffpruefmaschinen; Druckpruefmaschinen; Anforderungen*. [Compression testing machines; requirements].

3 Principle

The bending/shear strength is measured using a three-point method. A test specimen is placed on two supports and a force is applied in the centre until it fractures.

The bending/shear strength is calculated from the load at fracture, the distance between the supports and the transverse cross-section of the test piece.

The bending/shear strength, S_B, is the quotient of the deflection-moment, M_d, at the point of fracture of the test specimen and its resistance-moment, M_R, from the general equation:

$$S_B = \frac{M_d}{M_R}$$

NOTE The deflection-moment, M_d, at fracture is the maximum deflection-moment calculated from the maximum load indicated by the testing equipment. In general for carbon and graphite materials, the maximum load and load at fracture are close to each other.

4 Apparatus

4.1 Testing equipment, consisting of:

— testing equipment for compressive strength conforming to DIN 51223, meeting the requirements of class 2 of DIN 51220; or

— universal testing equipment conforming to DIN 51221-2, meeting the requirements of class 2 of DIN 51221-1; or

— testing equipment for bending/shear strength, meeting the requirements of class 2 of DIN 51220.

The radius of the curved surface of the supports and the centre load-bar shall be between 5 mm and 10 mm.

4.2 Measuring equipment, consisting of vernier callipers capable of measuring the linear dimensions of the test specimen to 0,5 % absolute.

5 Sampling of anodes or cathodes

The sampling programme and taking of the sample shall be agreed between seller and buyer in accordance with ISO 8007-1 or ISO 8007-2. The positions on the anode or cathode where samples are taken shall be included in the agreement. Samples shall be of sufficient size for preparation of the test specimen(s) used in the test described in this part of ISO 12986.

6 Preparation of test specimens

6.1 Number of test specimens

Unless there is a separate agreement between user and supplier, five dried test specimens shall be tested. Where there is a separate agreement to the contrary, the number of specimens tested shall be included in the test report (see clause 10).

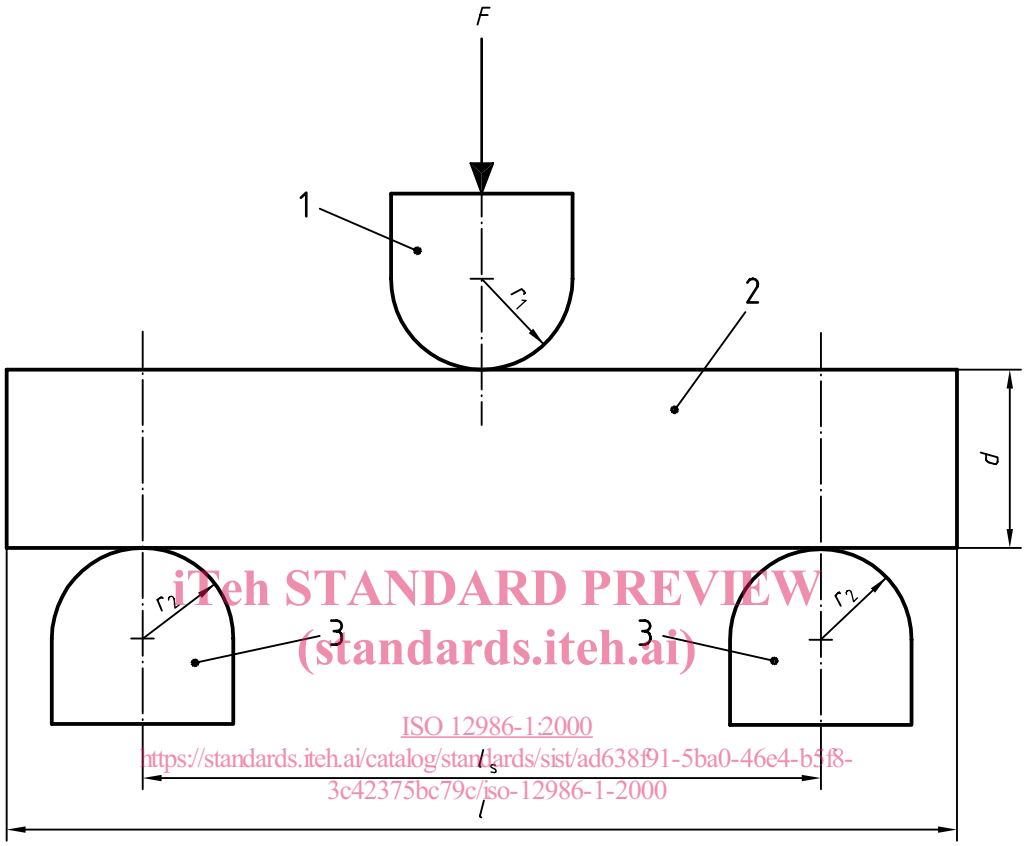
6.2 Preparation

Cylindrical test specimens with a circular cross-section only shall be used. The test specimens shall have a diameter of (50 ± 5) mm and a minimum length of 130 mm.

Prepare the test specimens by turning or core drilling. The faces of the finished test specimens shall be parallel and free from imperfections which may have been caused when the test specimens were taken from the anode or cathode. Test specimens shall have a uniform diameter throughout their length and their end-faces shall be parallel.

7 Determination

Set up the test specimen and the testing equipment as shown in Figure 1, setting the distance between the supports, l_s, to $(100 \pm 0{,}1)$ mm.



Key

1	Load bar
2	Test specimen
3	Support

l	= length of test specimen
d	= diameter of test specimen
l_s	= distance between supports
r_1, r_2	= radii of supports

Figure 1 — Three-point testing set-up

Carry out the test at a temperature in the range 20 °C to 30 °C.

Choose or adjust the measuring range of the testing equipment so that the expected load-force at fracture is at least 1/10 of the measuring range.

Place the test specimen in the centre of the supports with the longitudinal axis at a 90° angle to the supports. Ensure that the load-bar applies the force at 90° angle to the longitudinal axis of the test specimen. Increase the force steadily and smoothly with a load-bar speed of 5 mm/min or 1 MPa/s until the test specimen fractures. Record the load at fracture.

Repeat the determination for the remaining test specimens (see 6.1).

8 Expression of results

Calculate the bending/shear strength, S_B, in megapascals, from the following equation:

$$S_B = \frac{F \cdot l_s}{4M_t} \cdot 10^{-6}$$

where

F is the load, expressed in newtons, at fracture;

l_s is the distance, expressed in millimetres, between the supports;

M_t is the moment of resistance, expressed in cubic millimetres, of the test specimen calculated from the following equation:

$$M_t = \frac{\pi d^3}{32}$$

where d is the diameter, expressed in millimetres, of the test specimen.

Report the result as the mean of five determinations (see 6.1) to two decimal places.

9 Precision

Mean values measured to this method made under repeatable test conditions for test specimens with the recommended dimensions shall differ by no more than 5 % absolute for a statistical confidence level of 95 %.

10 Test report

The test report shall include the following information:

a) all details necessary for the identification of the sample;

b) a reference to this International Standard, i.e. ISO 12986-1:2000;

c) the date of the test;

d) the type of electrode, the position and orientation of the sample(s) taken from the electrodes;

e) the number of samples taken from the electrode(s) and the number of test specimens tested;

f) the radii of the curved surface of the supports and centre load bar of the testing apparatus;

g) the rate of application of the test load (5 mm/min or 1 MPa/s);

h) all dimensions, in millimetres, of the test specimens;

i) the bending/shear strength S_B, expressed in megapascals, giving single values, the mean and the standard deviation;

j) any unusual features noted during the determination;

k) any operation not included in this International Standard, or regarded as optional.