
**Carbonaceous materials used in the
production of aluminium — Prebaked
anodes and cathode blocks —**

Part 1:
**Determination of bending/shear
strength by the 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 la méthode
trois points*



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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).

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).

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

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 226, *Materials for the production of primary aluminium*.

This second edition cancels and replaces the first edition (ISO 12986-1:2000), which has been technically revised.

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 strength by the three-point method*
- Part 2: *Determination of bending strength by the four-point method*

Carbonaceous materials used in the production of aluminium — Prebaked anodes and cathode blocks —

Part 1: Determination of bending/shear strength by the three-point method

1 Scope

This part of ISO 12986 specifies a three-point method to determine the flexural strength of carbon and solid graphite materials at room temperature.

NOTE ISO 12986 is based on DIN 51902.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 4288, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Rules and procedures for the assessment of surface texture*

ISO 7500-1, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of the force-measuring system*

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

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

ISO 8007-3, *Carbonaceous materials used in the production of aluminium — Sampling plans and sampling from individual units — Part 3: Sidewall blocks*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1 flexural strength

σ_b
maximum flexural stress developed in a specimen during a flexural test to rupture

Note 1 to entry: The flexural strength is calculated as the quotient of the bending moment at maximum force, before or at rupture of the specimen under the conditions of the three-point method and its section modulus.

$$\sigma_b = \frac{M_b}{Z}$$

where

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M_b is the bending moment at maximum force, in Newton millimetres;

Z is the section modulus, in cubic millimetres.

Note 2 to entry: The flexural strength is expressed in megapascals (MPa).

Note 3 to entry: Generally, the maximum force displayed on the test machine and the force at fracture are similar; if they are different, the term refers to the maximum force displayed.

3.2 bending moment

M_b

component of moment of force perpendicular to the longitudinal axis of a beam or a shaft

Note 1 to entry: M_b is the maximum moment at fracture, calculated from the maximum force displayed by the testing machine and the geometry of the test specimen. Generally, the maximum force displayed on the test machine and the force at fracture are similar; if they are different, the term refers to the maximum force displayed.

3.3 section modulus

Z

ratio of the second axial moment of area to the maximum radial distance of any point in the surface considered from the Q-axis with respect to which the second axial moment of area is defined

Note 1 to entry: The section modulus can be expressed mathematically as shown in the following formula.

$$Z = I_a / r_{Q,\max}$$

where

I_a is the second axial moment of area;

$r_{Q,\max}$ is the maximum radial distance considered from the Q-axis with respect to which I_a is defined.

Note 2 to entry: The section modulus is calculated for the most common cross sections in [Figure 2](#).

4 Principle

A bar-shaped test specimen is placed on two bearing blocks and a force is applied to its centre until the test specimen ruptures; the force is equally distributed on two points. The flexural strength is calculated from the maximum force, the distance between the supports, and the dimensions of the cross-section of the test specimen.

5 Apparatus

5.1 Compression-testing machine, which meets at least the demands of class 2 in accordance with ISO 7500-1.

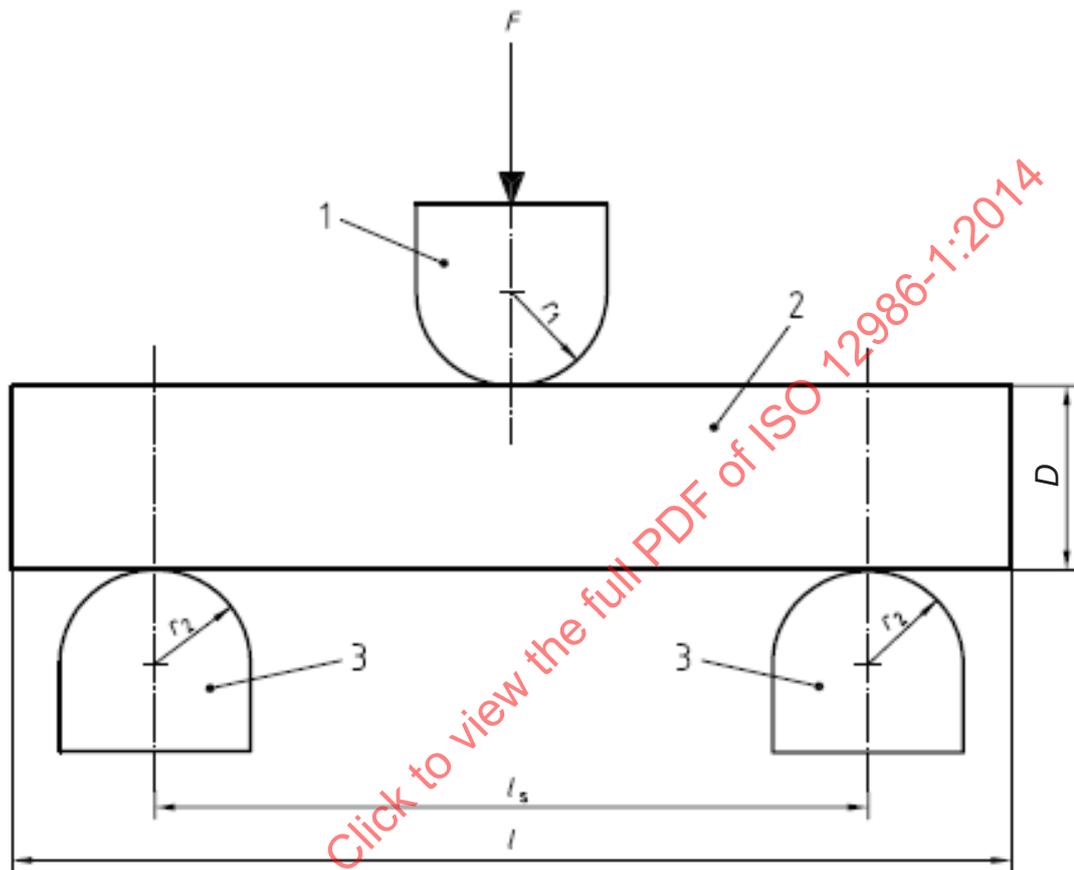
5.2 Measuring device, with two bearing blocks and one force edge.

The device shall ensure a cardanic suspension and movable support blocks; see [Figure 1](#). The radius of curvature of the bearing blocks and of the force edges shall be in the range 2 mm to 5 mm.

The distance between the points of support should be variable in order to adjust the measuring device to different sample geometries.

5.3 Measuring device, (e.g. vernier calliper in accordance with ISO 13385-1) capable of measuring the linear dimensions of the test specimens with an accuracy of $\pm 0,5$.

5.4 Measuring device, capable of measuring the surface roughness (peak-to-valley height) of test specimens.



Key

- 1 force edge
- 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 test setup

6 Test specimen

6.1 Sampling and sample preparation

Sampling shall be in accordance with the appropriate method i.e. ISO 8007-1, ISO 8007-2, ISO 8007-3, or be agreed with the applicant. The number of specimens shall be defined with respect to the homogeneity of the material to be tested.

The side faces of the specimens shall be machined such that the surface roughness in terms of the peak-to-valley height Ra , when measured in accordance with ISO 4288, is smaller than 15 μm . Depressions that can clearly be regarded as surface pores are not considered.

6.2 Size and geometry

Cylindrical or prismatic specimens can be used, provided that the smallest dimension be at least twice the diameter of the largest structural constituent (e.g. maximum particle size) of the material to be tested, but not smaller than 4 mm. The length of the specimens shall be at least 3,5 times their width or diameter.

7 Procedure

7.1 Perform all measurements at room temperature, i.e. in the range 10 °C to 35 °C.

7.2 Choose the measuring range of the testing machine such that the expected load at failure is at least 1/10 of full scale. Centre the test specimen on the support, with the longitudinal axis perpendicular to the support edges. The width between supports shall be at least three times the width or diameter of the specimen. The distance between the force edges shall be equal to the width or diameter of the test specimen.

In the case of prismatic specimens, ensure that the specimens rest entirely on the support edges, that at least one loading edge is movable and that the loading edges transmit the force uniformly over the whole width to the test specimens. In the case of cylindrical specimens, it is recommended that support edges be used with a diameter about 2 mm larger than the diameter of the test specimens to prevent the specimens from rolling away.

Increase the force uniformly and shock-free at a rate (velocity of the force edge) of about 5 mm/min or about 0,5 N/mm²/s until the test specimen fractures. Determine the maximum force.

8 Calculation and expression of results

Calculate the flexural strength, S_B , in megapascals, from Formula (1).

$$S_B = \frac{F \cdot l_s}{4M_t} \cdot 10^{-6} \quad (1)$$

where

F is the force, in N at fracture;

l_s is the distance, in mm between the supports;

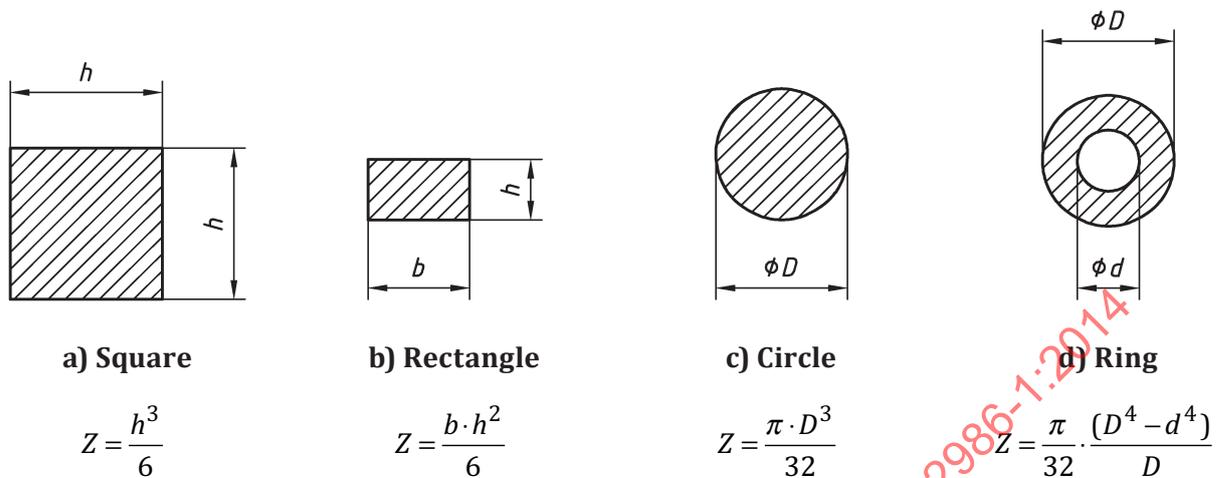
M_t is the moment of resistance of the test specimen, in mm³.

M_t is calculated from Formula (2).

$$M_t = \frac{\pi \cdot D^3}{32} \quad (2)$$

where

D is the diameter of the test specimen, expressed in mm.

**Key**

- Z section moment, in mm³
 h height of a rectangular cross-section, in mm
 b breadth of a rectangular cross-section, in mm
 D external diameter of a circular cross-section, in mm
 d internal diameter of a ring cross-section, in mm

Figure 2 — Calculation of section moments for cross-sections of the most common geometries

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 contain the following information.

- a reference to this part of ISO 12986;
- type, position, and orientation of test specimens during the sampling procedure;
- designation of the test specimens;
- number of test specimens;
- linear dimensions of test specimens, in mm;
- flexural strength, σ_b , in MPa, rounded to the nearest 0,1 MPa, individual values and mean value;
- additionally agreed conditions deviating from this part of ISO 12986;
- test date.