INTERNATIONAL STANDARD

ISO 18515

First edition
2007-03-15

Carbonaceous materials for the production of aluminium — Cathode blocks and baked anodes — Determination of compressive strength

Produits carbonés utilisés pour la production de l'aluminium — Blocs cathodiques et anodes cuites — Détermination de la résistance à la compression

Reference number
ISO 18515:2007(E)

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Published in Switzerland

Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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.

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.

ISO 18515 was prepared by Technical Committee ISO/TC 226, *Materials for the production of primary aluminium*.

This International Standard is based on a DIN method, DIN 51910:1997, *Testing of carbon materials — Determination of compressive strength — Solid materials*, prepared by Arbeitsausschuß NMP 281 “Test Methods for Carbon and Graphite”.

Carbonaceous materials for the production of aluminium — Cathode blocks and baked anodes — Determination of compressive strength

1 Scope

This International Standard specifies a method to determine the compressive strength of carbonaceous and graphite materials (solids), for the production of aluminium, at room temperature.

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 376, *Metallic materials — Calibration of force-proving instruments used for the verification of uniaxial testing machines*

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*

DIN 862, *Vernier callipers; requirements and testing*

3 Terms and definitions

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

3.1
compressive strength
σ_{dB}
ratio of the maximum force F_{max} during a compressive experiment leading to fracture and the initial cross-section A of the specimen

$$\sigma_{dB} = \frac{F_{max}}{A} \tag{1}$$

4 Principle

The compressive strength is determined using cylindrical or cubic test specimens. A test specimen with plane parallel end planes is pressed between the pressure plates of a testing machine. The compressive strength is calculated from the breakage load and the initial cross-section of the test specimen.

5 Apparatus and testing agents

5.1 Testing equipment

Compression-testing machine, (typically hydraulic) in accordance with ISO 7500-1, satisfying at least the requirements of Class 2 in accordance with ISO 376; or **material-testing machine,** in accordance with ISO 7500-1, Insertion 1, satisfying at least the requirements of Class 2 in accordance with ISO 376.

Pressure plates, in accordance with ISO 7500-1. The device shall ensure a uniform load over the whole surface by cardanic suspension.

Load cell, with an uncertainty of measurements below 0,1 %.

5.2 Measuring instrument

Longitude-measuring device, (for example, vernier calliper in accordance with DIN 862) for the determination of the linear dimensions of the test specimens, accurate to within 0,5 %.

6 Sampling

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.

7 Sample preparation

7.1 Size and geometry

Cylindrical or cubic test specimens of any size may be used, subject only to the requirement that the smallest dimension shall be at least three times the diameter of the largest structural constituent (e.g., maximum grain size) of the material to be tested, but not smaller than 5 mm. When cylindrical test specimens are used, their height shall be equal to the diameter (isometrical cylinders). Similarly, when using hollow cylinders, the height shall be equal to the outer diameter.

8 Procedure

8.1 The measurement is performed at room temperature.

8.2 The measuring range of the testing machine is chosen or adjusted such that the expected breakage load is at least 1/10 of full scale. The test specimen is centred between the pressure plates of the testing machine (allowed deviation 1 mm).

The load has to be increased uniformly and shock-free at a rate of less than 5 mm per minute or 5 N/mm^2 per second until the test specimen breaks. The load at failure is determined to the nearest 0,1 N/mm^2.

NOTE The static modulus of elasticity can be determined with the same procedure, if a micrometer measuring system is installed to measure the deformation of the test specimen during application of pressure.

9 Evaluation

The compressive strength, σ_{dB}, expressed in N/mm^2, is calculated according to Equation (2):

$$\sigma_{dB} = \frac{F}{A} \tag{2}$$

where

F is the load at failure, in N;

A is the initial cross-section, in mm^2.

10 Test report

The test report shall include the following information:

a) a reference to this International Standard;

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

c) the title of the test method;

d) the number and marking of test specimens;

e) the compressive strength, σ_{dB}, in N/mm^2; all individual test specimen values shall be reported together with the mean value rounded to the nearest 0,1 N/mm^2;

f) any agreed conditions deviating from this International Standard;

g) the test date.

11 Precision

11.1 General

A Round Robin was carried out with participants from 10 laboratories who submitted results for two materials, with four parallels for each. The precision calculation is according to document ISO/TC 226 N 1515.

11.2 Repeatability and reproducibility

The precision is given at the 95 % confidence level.

Repeatability r = 5,7 MPa

Reproducibility R = 9,8 MPa (between laboratories)

NOTE The test samples had similar material averages and it was not possible to determine the dependence on the material average.

11.3 Examples of use

Repeatability: Given a number of anodes, all with a compression strength of 42,0 N/mm^2, measured by the same operator in the same laboratory, the difference between two measurements will be within the range 42,0 $\pm$ 5,7 N/mm^2 in 95 out of 100 instances.

Reproducibility: Given a number of anodes, all with a compression strength of 42,0 N/mm^2, measured by different laboratories, the difference between two measurements will be within the range 42,0 $\pm$ 9,8 N/mm^2 in 95 out of 100 instances.

Bibliography

[1] DIN 1319-1, *Fundamentals of metrology — Part 1: Basic terminology*

[2] ASTM C695:2005, *Standard Test Method for Compressive Strength of Carbon and Graphite*

[3] MAIDIC, A., HAGEMANN, L. and LICHOMSKI, H.: Influence of the surface finish of the test specimens and the roughness of the pressure plates on the average and the variability of compressive strength of refractories at room temperature (in German), *Tonindustrie Zeitung* 97 (1973), pp. 237 to 243