INTERNATIONAL STANDARD

ISO 18142

First edition
2014-02-01

Carbonaceous materials for the production of primary aluminium — Baked carbon bodies — Determination of the dynamic elasticity modulus by the resonance method

Carbonés utilisés pour la production d'aluminium primaire — Piéces carbonées cuites — Détermination du module d'élasticité dynamique par la méthode de résonance

Reference number
ISO 18142:2014(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

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*.

Introduction

Determining the dynamic modulus of elasticity of specimens made of carbonaceous or graphite materials (solids) at room temperature allows conclusions to be drawn on the elastic deformation behaviour and thermal shock resistance of the material under test.

This International Standard is based on the DIN method, DIN 51915:1997-10.

Carbonaceous materials for the production of primary aluminium — Baked carbon bodies — Determination of the dynamic elasticity modulus by the resonance method

1 Scope

This International Standard specifies a method to determine the dynamic modulus of elasticity of specimens made of solid carbonaceous or graphite materials at room temperature by the resonance method.

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 3611 — *Geometrical product specifications (GPS) — Dimensional measuring equipment: Micrometers for external measurements — Design and metrological characteristics*

ISO 4259, *Petroleum products — Determination and application of precision data in relation to methods of test*

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*

ISO 13385-1:2011, *Geometrical product specifications (GPS) — Dimensional measuring equipment — Part 1: Callipers; Design and metrological characteristics from individual units — Part 3: Sidewall blocks*

DIN 862, *Vernier callipers — Technical requirements and testing*

DIN 863-1, *Micrometers — Standard design micrometer callipers for external measurement — Concepts, requirements, testing*

3 Terms and definitions

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

3.1
modulus of elasticity
Young's modulus
E
quotient of the stress, σ, and the strain, ε, of a body

Note 1 to entry: Under static loading, the modulus of elasticity can be determined as static modulus of elasticity and expressed by the following formula:

$$E = \frac{\sigma}{\varepsilon} \tag{1}$$

where

E is the modulus of elasticity;

σ is the stress;

ε is the strain.

3.2
dynamic modulus of elasticity
modulus of elasticity determined from the sound velocity

Note 1 to entry: The dynamic modulus of elasticity is determined dynamically from the sound velocity and is expressed by the following formula:

$$E_{\mathrm{dyn}} = v_{\mathrm{s}}^2 \times \rho_{\mathrm{R}} \tag{2}$$

where

E_{dyn} is the dynamic modulus of elasticity;

v_{s} is the sound velocity of the specimen;

ρ_{R} is the apparent density of the specimen.

Note 2 to entry: The relationship between stress and strain is not linear in the case of carbonaceous and graphite materials. The static modulus of elasticity, which is determined from the slope of the straight line from the origin to a stress/strain data point to be defined (secant modulus) is always smaller than the dynamic modulus of elasticity which is derived from the tangent in the origin of the stress-strain curve (tangent modulus).

4 Principle

A rod-shaped specimen of uniform cross section and length, l, is excited to perform longitudinal oscillations. The excitation frequency is varied until the specimen oscillates with maximum amplitude (fundamental resonance frequency f_0). The frequency f_0 is used to calculate the sound velocity in accordance with Formula (3):

$$v_{\mathrm{s}} = 2 \times l \times f_0 \tag{3}$$

where

v_{s} is the sound velocity in the specimen, in m/s;

l is the length of the specimen, in mm;

f_0 is the fundamental resonance frequency, in Hz.

This shall be used to obtain the dynamic modulus of elasticity in accordance with Formula (4):

$$E_{\mathrm{dyn}} = 4 \times l^2 \times f_0^2 \times \rho_{\mathrm{R}} \tag{4}$$

where

E_{dyn} is the dynamic modulus of elasticity, in GPa;

l is the length of the specimen, in mm;

f_0 is the fundamental resonance frequency, in Hz;

ρ_{R} is the apparent density of the specimen, in g/cm^3.

5 Apparatus

The apparatus used (see Figure 1) shall consist of the following components:

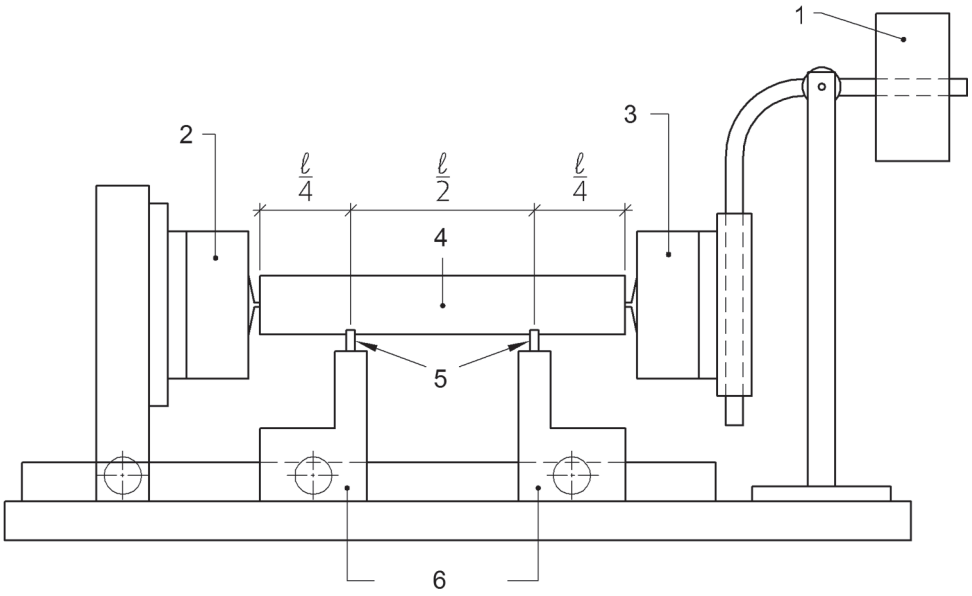
— frequency generator and receiver;

— vibration generator;

— vibration pickup;

— specimen support;

— linear measuring instrument accurate to within 0,2 %, e.g. vernier calliper in accordance with ISO 13385-1 or DIN 862 or micrometer calliper in accordance with ISO 3611 or DIN 863-1.



Key

1 adjustable counterweight
2 vibration pickup
3 vibration generator
4 specimen
5 support wires
6 support

Figure 1 — Principle mechanical layout of test apparatus

6 Sampling

Sampling and sample preparation shall be in accordance with ISO 8007-1 or ISO 8007-2 or ISO 8007-3 unless otherwise agreed.

If another sampling and method of sample preparation are agreed, then the specific procedures used shall be described in the test report.

7 Test specimen

7.1 Rod-shaped specimens of uniform cross section, preferably of circular or rectangular cross section, shall be used. The end faces shall be perpendicular to the longitudinal axis. The length shall be at least three times the largest cross-sectional dimension of the specimen. In no direction shall the specimen be smaller than two times the diameter of the largest particle size.

7.2 Some experimentation can be necessary to determine a suitable specimen length in accordance with 7.1 and the capability of the equipment.

8 Procedure

To achieve an undisturbed vibration, the specimen shall be supported at quarter length of the specimen from the ends (nodes of the first harmonic). Thin wires or foamed plastic strips have proven successful as supports (see Figure 1).

The vibration generator and the pickup shall be set with their probe tips touching the faces of the specimen approximately in the middle. To enable the specimen to be reliably excited to oscillate, the contact force of the probe tips shall be adjusted to a suitably low force, for example, by adjusting a counterweight.

The resonance frequency of the fundamental mode or of the first harmonic of the specimen is found by varying the frequency of the frequency generator until the receiver indicates a maximum value. To determine whether the resonance frequency found is actually the fundamental mode of the specimen, verify by measurements carried out at half and twice the frequency.

NOTE If the resonance frequency sought cannot be clearly detected, e.g. under unfavourable excitation conditions, the dynamic modulus of elasticity can be determined by ultrasonic measurements.

9 Evaluation

The dynamic modulus of elasticity[1)], E_{dyn}, expressed in GPa, shall be calculated in accordance with Formula (8):

$$E_{\mathrm{dyn}} = 4 \cdot 10^{-12} \cdot l^2 \cdot f_0^2 \cdot \rho_{\mathrm{R}} \tag{8}$$

where

ρ_{R} is the specimen apparent density, in g/cm^3;

l is the specimen length, in mm;

f_0 is the resonance frequency of the fundamental mode of the specimen, in Hz.

10 Test report

The test report shall include the following information:

a) a reference to this International Standard (i.e. ISO 18142:2013);

b) any agreed deviations from this International Standard;

c) the date of the test;

d) details necessary for the complete identification of the material tested;

e) the number of test specimens;

f) the dimensions of test specimens;

g) individual values and mean values of dynamic modulus of elasticity, E_{dyn}, in GPa, rounded to the nearest 0,1 GPa.

11 Precision

The reliability of the test results is determined in accordance with ISO 4259.

11.1 Repeatability (one operator, same apparatus)

If two results are obtained under repeatability conditions by the same operator, both results shall be considered acceptable and in conformity with this International Standard, if they differ by no more than the values given in Table 1.

1) 1 GPa = 1 kN/mm^2

11.2 Reproducibility (different operators, different apparatus)

If two separate laboratories each obtain a result under reproducibility conditions, both results shall be considered acceptable and in conformity with this International Standard, if they differ no more than the values given in Table 1.

Table 1 — Repeatability and reproducibility

Dynamic modulus of elasticity GPa	**Repeatability** GPa	**Reproducibility** GPa
1 to 10	0,1	0,2
Over 10	0,2	0,4

Bibliography

[1] DIN 51915:1997-10: *Determination of modulus of elasticity by the resonance method — Solid materials*

ICS 71.100.10

Price based on 7 pages