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

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

ISO 18142:2014

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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](http://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](http://www.iso.org/patents)).

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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*.

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## 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.

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# 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,  $\sigma$ , and the strain,  $\varepsilon$ , 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:

$$E = \frac{\sigma}{\varepsilon} \quad (1)$$

where

$E$  is the modulus of elasticity;

$\sigma$  is the stress;

$\varepsilon$  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:

$$E_{\text{dyn}} = v_s^2 \times \rho_R \quad (2)$$

where

$E_{\text{dyn}}$  is the dynamic modulus of elasticity;

$v_s$  is the sound velocity of the specimen;

$\rho_R$  is the apparent density of the specimen.

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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).

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## 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):

$$v_s = 2 \times l \times f_0 \quad (3)$$

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):

$$E_{\text{dyn}} = 4 \times l^2 \times f_0^2 \times \rho_R \quad (4)$$

where

$E_{\text{dyn}}$  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;

$\rho_R$  is the apparent density of the specimen, in g/cm<sup>3</sup>.

## 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.

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