INTERNATIONAL STANDARD

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Second edition
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Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for elastic moduli of monolithic ceramics at room temperature by sonic resonance

Céramiques techniques — Méthode d'essai des modules d'élasticité des céramiques monolithiques, à température ambiante, par résonance acoustique

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.

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).

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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 World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 206, *Fine ceramics*.

This second edition cancels and replaces the first edition (ISO 17561:2002), which has been technically revised. It also incorporates the Technical Corrigendum ISO 17561:2002/Cor.1:2007.

Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for elastic moduli of monolithic ceramics at room temperature by sonic resonance

1 Scope

This International Standard describes the method of test for determining the dynamic elastic moduli of fine ceramics at room temperature by sonic resonance. This International Standard is for fine ceramics that are elastic, homogeneous and isotropic.[2]

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 13385 (all parts), *Geometrical product specifications (GPS) — Dimensional measuring equipment*

3 Terms and definitions

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

3.1
dynamic elastic moduli
adiabatic elastic moduli, which are dynamic Young's modulus, shear modulus and Poisson's ratio

Note 1 to entry: Adiabatic elastic moduli are obtained by the sonic resonance method.

3.1.1
Young's modulus
E
elastic modulus in tension or compression

$$E = \sigma / \varepsilon$$

where

E is Young's modulus in pascals;

σ is the tension or compression stress in pascals;

ε is the tension or compression strain.

3.1.2
shear modulus
G
elastic modulus in shear or torsion

$$G = \tau / \gamma$$

where

G is the shear modulus in pascals;

τ is the shear or torsional stress in pascals;

γ is the shear or torsional strain.

3.1.3
Poisson's ratio
ν
ratio of transverse strain to the corresponding axial strain resulting from uniformly distributed axial stress below the proportional limit of the material

Note 1 to entry: In isotropic materials, Young's modulus (E), shear modulus (G) and Poisson's ratio (ν) are related by the following formula:

$$\nu = E/(2G) - 1$$

3.2 vibration

3.2.1
flexural vibration
vibration apparent when the oscillation in a slender bar is in plane normal to the length dimension

Note 1 to entry: Also defined as vibration in a flexural mode.

3.2.2
torsional vibration
vibration apparent when the oscillation in each cross-section plane of a slender bar is such that the plane twists around the length dimension axis

Note 1 to entry: Also defined as vibration in a torsional mode.

3.3
resonance
state if, when a slender bar driven into one of the above modes of vibration, the imposed frequency is such that the resultant displacements for a given amount of driving force are at a maximum

Note 1 to entry: The resonant frequencies are natural vibration frequencies which are determined by the elastic modulus, mass and dimensions of the test piece.

3.4
fundamental frequency
lowest frequency of a periodic waveform

3.5
nodes
location(s) in slender rod or bar in *resonance* (3.3) having a constant zero displacement

Note 1 to entry: For the fundamental flexural resonance, the nodes are located at 0,224 L from each end, where L is the length of the rod or bar.

4 Summary of test method

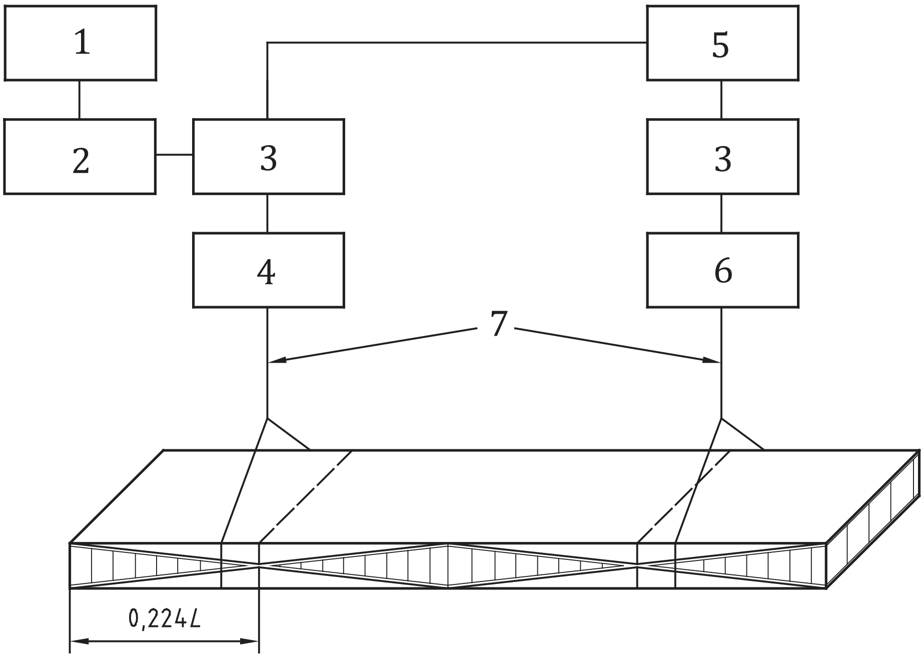
This test method measures the flexural or torsional frequencies of test specimens of rectangular prism or cylindrical geometry by exciting them at continuously variable frequencies. Mechanical excitation of the specimens is provided through the use of a transducer that transforms a cyclic electrical signal into a cyclic mechanical force on the test piece. A second transducer senses the resulting mechanical vibrations of the test piece and transforms them into an electrical signal. The amplitude and the frequency of the signal are measured by an oscilloscope or other means to detect resonance. The peak response is obtained at the resonant frequency. The fundamental resonant frequencies, dimensions and mass of the specimen are used to calculate the dynamic elastic moduli. The Young's modulus is determined from the flexural resonance frequency, and the shear modulus is determined from the torsional resonance frequency, together with the test piece dimensions and mass. Poisson's ratio is determined from the Young's modulus and the shear modulus.

5 Apparatus

5.1 General

There are various techniques that may be used to determine the resonant frequency of the test piece. The test piece may be excited by direct mechanical contact of a vibrator, or it may be suspended by a wire from a vibrator. It may be driven electromagnetically by attaching thin foils of magnetic material to one surface, or electrostatically by attaching an electrode to one surface.

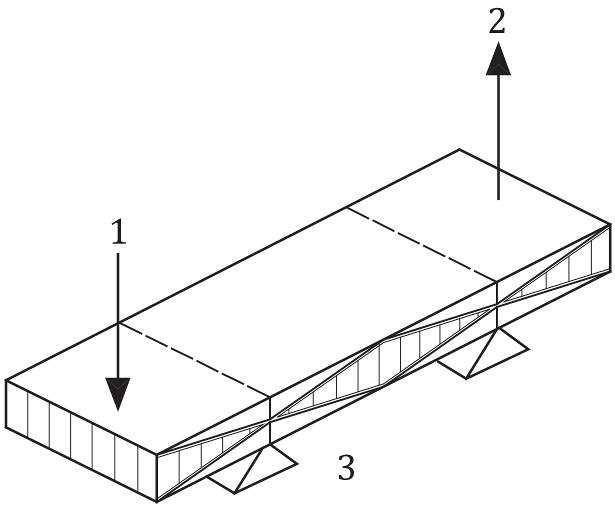
One example of the test apparatus is shown in Figure 1. The driving circuit consists of an oscillator, an amplifier, a driver and a frequency counter. The detecting circuit consists of a detector, an amplifier and an oscilloscope. Figure 1 shows the suspension style of the apparatus. The direct contact support style of the test apparatus, shown in Figure 2, is also possible. It consists of a variable-frequency audio oscillator, used to generate a sinusoidal voltage, and a power amplifier and suitable transducer to convert the electrical signal to a mechanical driving vibration. A frequency meter (preferably digital) monitors the audio oscillator output to provide accurate frequency determination. A suitable suspension coupling system supports the test piece. A transducer detector acts to detect mechanical vibration in the specimen and to convert it into an electrical signal which is passed through an amplifier and displayed on an indicating meter. The meter may be a voltmeter, a microammeter or an oscilloscope. An oscilloscope is recommended because it enables the operator to positively identify resonances, including higher order harmonics, by Lissajous figure analysis, which is a superposition of two perpendicular harmonics. If a Lissajous figure is desired, the output of the oscillator is also coupled to the horizontal plates of the oscilloscope.



Key

1 frequency counter
2 oscillator
3 amplifier
4 driver
5 oscilloscope
6 detector
7 suspending string

Figure 1 — Example of the test apparatus and the suspension for fundamental flexural resonance



Key

1 driving

2 detecting

3 flexural

Figure 2 — Example of the direct contact support of the test piece for fundamental flexural resonance

5.2 Oscillator

The oscillator shall be able to vary the frequency from 100 Hz to at least 30 kHz, with a frequency resolution of 1 Hz and a maximum frequency drift of 1 Hz/min.

5.3 Amplifier

The audio amplifier shall have a power output sufficient to ensure that the type of transducer used can excite any specimen, the mass of which falls within a specified range. A power amplifier in the detector circuit shall be impedance-matched with the type of detector transducer selected and shall serve as a prescope amplifier.

5.4 Driver

The driver shall be able to convert electrical vibration to mechanical vibration. The frequency response of the driver transducer across the frequency range of interest shall have at least a 6,5 kHz bandwidth before −3 dB power loss occurs.

NOTE For flexibility in testing, the bandwidth can, with advantage, be at least as large as the frequency range given in Table 1.

5.5 Detector

The detector shall generate a voltage proportional to the amplitude, velocity or acceleration of the mechanical vibration of the specimen. The frequency response of the detector across the frequency range of interest shall have at least a 6,5 kHz bandwidth before a −3 dB power loss occurs.

NOTE For flexibility in testing, the bandwidth can, with advantage, be at least as large as the frequency range given in Table 1.