
**Sodobna tehnična keramika - Termomehanske lastnosti monolitske keramike - 5.
del: Ugotavljanje elastičnih modulov pri povišanih temperaturah**

Advanced technical ceramics - Thermomechanical properties of monolithic ceramics -
Part 5: Determination of elastic moduli at elevated temperatures

Hochleistungskeramik - Thermomechanische Eigenschaften monolithischer Keramik -
Teil 5: Bestimmung der elastischen Moduln bei erhöhten Temperaturen

Céramiques techniques avancées - Méthodes d'essai des céramiques monolithiques -
Propriétés thermomécaniques - Partie 5: Détermination des modules élastiques à
températures élevées

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des céramiques monolithiques - Propriétés
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modules élastiques à températures élevées

Hochleistungskeramik - Thermomechanische
Eigenschaften monolithischer Keramik - Teil 5:
Bestimmung der elastischen Moduln bei erhöhten
Temperaturen

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prEN 820-5:2026 (E)**European foreword**

This document (prEN 820-5:2026) has been prepared by Technical Committee CEN/TC 184 “Advanced technical ceramics”, the secretariat of which is held by DIN.

This document is currently submitted to the CEN Enquiry.

This document will supersede EN 820-5:2009.

This document includes the following main significant technical changes with respect to EN 820-5:2009:

- a) update of the normative references;
- b) revised Formula (8) and Formula (9) for the calculation of the dynamic shear modulus of a rectangular prism in the resonance method (Method B) and impulse excitation method (Method C);
- c) addition of Formula (10) for the calculation of the dynamic shear modulus of a cylindrical rod in torsional resonance in 5.5.2.2;
- d) addition of a new Annex A addressing the Young’s modulus correction for edge treatments of rectangular cross section test piece;
- e) addition of a new Annex B addressing the simultaneous determination of Young’s and shear modulus at elevated temperatures using the impact excitation method;
- f) editorial revision.

A list of all parts in the EN 820 series, published under the general title *Advanced technical ceramics — Thermomechanical properties of monolithic ceramics*, can be found on the CEN website.

1 Scope

This document specifies methods for the determination of the elastic moduli, specifically Young's modulus, shear modulus and Poisson's ratio, of advanced monolithic technical ceramics at temperatures above room temperature. The document specifies three alternative methods for determining some or all of these three parameters:

- a) Method A - the determination of Young's modulus by static flexure of a thin beam in three- or four-point bending;
- b) Method B - the determination of Young's modulus by forced longitudinal resonance, or Young's modulus, shear modulus and Poisson's ratio by forced flexural and torsional resonance, of a thin beam;
- c) Method C - the determination of Young's modulus from the fundamental natural frequency of a struck bar (impulse excitation method).

This part of EN 820 extends the above-defined room-temperature methods described in EN 843-2 to elevated temperatures. All the test methods assume the use of homogeneous test pieces of linear elastic materials. The test assumes that the test piece has isotropic elastic properties. At high porosity levels all of the methods can become inappropriate. The maximum grain size measured in accordance with EN ISO 13383-1, excluding deliberately added whiskers, is less than 10 % of the minimum dimension of the test piece.

NOTE 1 Method C in EN 843-2 based on ultrasonic time of flight measurement has not been incorporated into this part of EN 820. Although the method is feasible to apply, it is specialized, and outside the capabilities of most laboratories. There are also severe restrictions on test piece geometries and methods of achieving pulse transmission. For these reasons this method has not been included in EN 820-5.

NOTE 2 The upper temperature limit for this test depends on the properties of the test pieces, and can be limited by softening within the timescale of the test. In addition, for method A there can be limits defined by the choice of test jig construction materials.

NOTE 3 It is possible that Methods B and Method C are not appropriate for materials with significant levels of porosity (i.e. > 15 %) which cause damping and an inability to detect resonances or natural frequencies, respectively.

NOTE 4 This method does not provide for the effects of thermal expansion, i.e. the measurements are based on room temperature dimensions. Depending upon the use to which the data are put, it can be necessary to make a further correction by multiplying each dimensional factor in the relevant formulae by a factor $(1 + \bar{\alpha} \Delta T)$ where $\bar{\alpha}$ is the mean linear expansion coefficient over the temperature interval ΔT from room temperature.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

EN 820-1, *Advanced technical ceramics - Methods of testing monolithic ceramics - Thermomechanical properties - Part 1: Determination of flexural strength at elevated temperatures*

EN 843-1, *Advanced technical ceramics - Mechanical properties of monolithic ceramics at room temperature - Part 1: Determination of flexural strength*

EN 60584-1, *Thermocouples - Part 1: EMF specifications and tolerances (IEC 60584-1)*

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EN ISO 463, *Geometrical Product Specifications (GPS) - Dimensional measuring equipment - Design and metrological characteristics of mechanical dial gauges (ISO 463)*

EN ISO 3611, *Geometrical product specifications (GPS) - Dimensional measuring equipment - Design and metrological characteristics of micrometers for external measurements (ISO 3611)*

EN ISO 7500-1, *Metallic materials - Calibration and verification of static uniaxial testing machines - Part 1: Tension/compression testing machines - Calibration and verification of the force-measuring system (ISO 7500-1)*

EN ISO 13383-1, *Fine ceramics (advanced ceramics, advanced technical ceramics) - Microstructural characterization - Part 1: Determination of grain size and size distribution (ISO 13383-1)*

EN ISO 13385-1, *Geometrical product specifications (GPS) - Dimensional measuring equipment - Part 1: Design and metrological characteristics of callipers (ISO 13385-1)*

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1 Young's modulus

stress required in a material to produce unit strain in uniaxial extension or compression

3.2 shear modulus

shear stress required in a material to produce unit angular distortion

3.3 Poisson's ratio

negative value of the ratio of lateral strain to longitudinal strain in an elastic body stressed longitudinally

3.4 static elastic moduli

elastic moduli determined in an isothermal condition by stressing statically or quasi-statically

3.5 dynamic elastic moduli

elastic moduli determined non-quasi-statically, i.e. under quasi-adiabatic conditions, such as in the resonant or impulse excitation methods

4 Method A: Static flexure method**4.1 Principle**

Using three- or four-point bending of a thin beam test piece, the elastic distortion is measured, from which Young's modulus can be calculated according to thin-beam formulae.

4.2 Apparatus

4.2.1 Test jig, in accordance with that described in EN 820-1 for flexural strength testing at elevated temperatures in terms of its function, i.e. the support and loading rollers shall be free to roll, and to articulate to ensure axial and even loading as described in EN 843-1. The test jig shall be made of materials which do not interact with the test piece, and which remain essentially elastic at the maximum test temperature. A typical arrangement is shown in Figure 1.

NOTE 1 Articulation is not essential for carefully machined flat and parallel-faced test pieces.

The outer span of the test jig shall be 40 mm or greater.

NOTE 2 If the displacement is to be measured by Method A.1 (see 4.2.5), a span of up to 100 mm, or a span to thickness ratio in excess of 20, is recommended to obtain large displacements and to ensure that the compliance of the machine is a small correction if displacement is recorded as a machine cross-head movement.

The test jig may be either for three-point or four-point flexure. The latter method is required if displacement is determined by differential transducer.

4.2.2 Test machine, capable of applying a force to the test jig at a constant displacement rate. The test machine shall be equipped for recording the load applied to the test jig at any point in time. The accuracy of the test machine shall be in accordance with EN ISO 7500-1, Grade 1 (1 % of indicated load), and shall be capable of recording to a sensitivity of better than 0,1 % of the maximum load employed. The calibration shall have been checked within the previous year.

4.2.3 Thermal enclosure and control system, surrounding the test piece, capable of achieving the maximum desired temperature and maintaining it to ± 2 °C for test temperatures up to 1 000 °C, and ± 4 °C at higher temperatures.

The system can operate with an air or inert atmosphere, or with a vacuum inside the thermal enclosure. Especially with regard to use in vacuum, efforts should be made to ensure that the force applied at the test piece is correctly recorded by the load cell outside the enclosure, taking account of friction or elastic resistances in seals or bellows systems.

4.2.4 Thermocouple, conforming to EN 60584-1 for measuring the test piece temperature. The thermocouple shall be in close proximity to but shall not touch the test piece.

4.2.5 Displacement measuring device, for recording the displacement of the loaded test piece by one of two methods, Method A.1 or Method A.2:

– Method A.1

Recording the apparent displacements of the test machine as the test piece is loaded in the test jig, and again with the test piece replaced by a ceramic bar at least 15 mm thick with flat and parallel faces to within 0,05 mm. The difference between these displacements is equivalent to the displacement of the test piece in the test jig. The displacement recording device (chart recorder, digital indicator, etc.) shall be calibrated by comparing machine cross-head displacement with the movement indicated on a dial gauge contacting the cross-head, or other suitable calibrated displacement measuring device. The dial gauge shall be in accordance with EN ISO 463, or the alternative device otherwise certified as accurate to 0,01 mm.

The parts of the load train subjected to elevated temperatures shall be made of materials which remain elastic at the maximum test temperature.

– Method A.2