TECHNICAL SPECIFICATION

SPÉCIFICATION TECHNIQUE

TECHNISCHE SPEZIFIKATION

CEN/TS 820-5

February 2004

ICS 81.060.30

English version

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

Céramiques techniques avancées - Céramiques monolithiques - Propriétés thermomécaniques - Partie 5: Détermination du module élastique à température élevée

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

This Technical Specification (CEN/TS) was approved by CEN on 19 October 2003 for provisional application.

The period of validity of this CEN/TS is limited initially to three years. After two years the members of CEN will be requested to submit their comments, particularly on the question whether the CEN/TS can be converted into a European Standard.

CEN members are required to announce the existence of this CEN/TS in the same way as for an EN and to make the CEN/TS available promptly at national level in an appropriate form. It is permissible to keep conflicting national standards in force (in parallel to the CEN/TS) until the final decision about the possible conversion of the CEN/TS into an EN is reached.

CEN members are the national standards bodies of Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No. CEN/TS 820-5:2004: E

Contents

Page

Foreword

This document (CEN/TS 820-5:2004) has been prepared by Technical Committee CEN/TC 184 “Advanced technical ceramics”, the secretariat of which is held by BSI.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

EN 820 *Advanced technical ceramics — Methods of testing monolithic ceramics — Thermomechanical properties* comprises five parts:

Part 1: *Determination of flexural strength at elevated temperatures*

Part 2: *Determination of self-loaded deformation*

Part 3: *Determination of resistance to thermal shock by water quenching*

Part 4: *Determination of flexural creep deformation at elevated temperatures*

Part 5: *Determination of elastic moduli at elevated temperatures*

Part 4 is a European Prestandard (ENV) and Part 5 is a Technical Specification (CEN TS).

This document includes a bibliography.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to announce this Technical Specification: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

1 Scope

This part of EN 820 describes methods for determining the elastic moduli, specifically Young's modulus, shear modulus and Poisson's ratio, of advanced monolithic technical ceramics at temperatures above room temperature. The Technical Specification prescribes three alternative methods for determining some or all of these three parameters:

A - the determination of Young's modulus by static flexure of a thin beam in three- or four-point bending.

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 - the determination of Young's modulus from the fundamental natural frequency of a struck bar (impulse excitation method).

This Technical Specification extends the above-defined room-temperature methods described in ENV 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 (see EN 623-3), excluding deliberately added whiskers, should be less than 10 % of the minimum dimension of the test piece.

NOTE 1 Method C in ENV 843-2 based on ultrasonic time of flight measurement has not been incorporated into this Technical Specification. Although the method is feasible to apply, it is specialised, 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 CEN/TS 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 Methods B and C may not be 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 equations by a factor $(1 + \overline{\alpha}\,\Delta T)$ where $\overline{\alpha}$ is the mean linear expansion coefficient over the temperature interval ΔT from room temperature.

2 Normative references

This Technical Specification incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this Technical Specification only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 820-1, *Advanced technical ceramics — Method of testing monolithic ceramics — Thermo-mechanical properties — Part 1: Determination of flexural strength at elevated temperatures*

EN 843-1:1995, *Advanced technical ceramics — Monolithic ceramics — Mechanical properties at room temperature — Part 1: Determination of flexural strength*

EN 60584-2, *Thermocouples — Part 2: Tolerances (IEC 60584-2:1982 + A1:1989)*

EN ISO 7500-1, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of th eforce-measuring system (ISO 7500-1:1999)*

EN ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories (ISO/IEC 17025:1999)*

ISO/R 463, *Dial gauges reading in 0,01 mm, 0,001 in and 0,0001 in*

ISO 3611, *Micrometer callipers for external measurement*

ISO 6906, *Vernier callipers reading to 0,02 mm*

3 Terms and definitions

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

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 quasistatically

3.5
dynamic elastic moduli
elastic moduli determined non-quasistatically, i.e. under adiabatic conditions, such as in the resonant, ultrasonic pulse or impulse excitation methods

4 Method A: Static bending 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 may be calculated according to thin beam equations.

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.