SLOVENSKI STANDARD
SIST ENV 12290:2000

01-december-2000

Advanced technical ceramics - Mechanical properties of ceramic composites at high temperature under inert atmosphere - Determination of compression properties

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Hochleistungskeramik - Mechanische Eigenschaften von keramischen Verbundwerkstoffen bei hoher Temperatur in inerter Atmosphäre - Bestimmung der Eigenschaften unter Druck

Céramiques techniques avancées - Propriétés mécaniques des céramiques composites a haute température en atmosphere neutre - Détermination des caractéristiques en compression

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English version

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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart,36 B-1050 Brussels

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Contents

Foreword

This European Prestandard has been prepared by Technical Committee CEN/TC 184 "Advanced technical ceramics", the secretariat of which is held by BSI.

According to the CEN/CENELEC Internal Regulations, the national standards organisations of the following countries are bound to announce this European Prestandard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Prestandard ENV 12290 specifies the conditions for determination of compression properties of ceramic matrix composite materials with continuous fibre reinforcement for temperatures up to 2 000 °C under vacuum or a gas atmosphere which is inert to the material under test.

NOTE : The use of these environments is aimed at avoiding changes of the material to be tested due to chemical reaction with its environment during the test.

This Prestandard applies to all ceramic matrix composites with a continuous fibre reinforcement, unidirectional (1D), bidirectional (2D), and tridirectional (xD, with $2 < x \leq 3$), loaded along one principal axis of reinforcement.

Two cases are distinguished :

a) compression between platens ;
b) compression using grips.

2 Normative references

This European Prestandard 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 European Prestandard only when incorporated in it by amendment or revision. For undated references the latest edition of publication referred to applies.

HTMTC[1)]	Code of practice - Code of practice for the measurement of misalignement induced bending in uniaxially loaded tension compression test pieces
HD 446-1S1	Thermocouples - Part 1 : Reference tables
EN 10002-2	Metallic materials - Tensile testing - Part 2 : Verification of the force measuring system of the tensile testing machines
EN 10002-4	Metallic materials - Tensile testing - Part 4 : Verification of extensometers used in uniaxial testing
EN 60584-2	Thermocouples - Part 2 : Tolerances
ENV 12291	Advanced technical ceramics - Mechanical properties of ceramic composites at high temperature in air at atmospheric pressure - Determination of compression properties
ISO 3611	Micrometer callipers for external measurement

1) Published by JRC institute for Advanced Materials, ISBN 92-826-9681-2, EUR 16138EN.

3 Principle

A test specimen of specified dimensions is heated to the testing temperature, and loaded in compression. The test is performed at constant crosshead displacement rate, or constant deformation rate. Force and longitudinal deformation are measured and recorded simultaneously.

The test duration is limited to reduce creep effects.

NOTE 1 : Constant loading rate is only allowed in the case of linear stress-strain behaviour up to failure.

NOTE 2 : In order to protect fixture, it is recommended to use constant crosshead displacement rate when the test is carried out until rupture.

4 Definitions and symbols

For the purposes of this Prestandard, the following definitions and symbols apply :

4.1 test temperature, *T*

Temperature of the test piece at the centre of the gauge length.

4.2 calibrated length, *l*

The part of the test specimen which has uniform and minimum cross section area.

4.3 gauge length, L_o

Initial distance between reference points on the test specimen in the calibrated length. The temperature variation in the gauge length shall be within 20 °C at test temperature.

4.4 controlled temperature zone

The part of the calibrated length including the gauge length where the temperature is in a range of 50 °C of the test temperature.

4.5 initial cross section area, A_o

Initial cross section area of the test specimen within the calibrated length, at test temperature.

4.6 longitudinal deformation, ΔL

Decrease in the gauge length between reference points under a compression force. Its value corresponding to the maximum force shall be denoted $\Delta L_{c,m}$.

4.7 compression strain, ϵ

Relative change in the gauge length defined as the ratio $\Delta L/L_o$. Its value corresponding to the maximum force shall be denoted as $\epsilon_{c,m}$.

4.8 compression stress, σ

The compression force supported by the test specimen at any time in the test divided by the initial cross section area.

4.9 maximum compression force, F_m

Highest recorded compression force in a compression test on the test specimen when tested to failure.

4.10 compression strength, $\sigma_{c,m}$

Ratio of the maximum compression force to the initial cross section area.

4.11 proportionality ratio or pseudo-elastic modulus, *Ep*

The slope of the linear section of the stress-strain curve, if any. Examination of the stress-strain curves for ceramic matrix composites allows definition of the following cases :

a) Material with a linear section in the stress-strain curve

For ceramic matrix composites that have a mechanical behaviour characterised by a linear section, the proportionality ratio is defined as :

$$Ep(\sigma_1, \sigma_2) = \frac{\sigma_2 - \sigma_1}{\epsilon_2 - \epsilon_1} \quad (1)$$

where :

(ϵ_1, σ_2) and (ϵ_2, σ_2) lie near the lower and upper limits of the linear section of the stress-strain curve.

The proportionality ratio or pseudo-elastic modulus is termed the elastic modulus, *E*, in the single case where the material has a linear behaviour from the origin.

b) Material with no-linear section in the stress-strain curve.

In this case only stress-strain couples can be fixed.

5 Apparatus

5.1 Test machine

The machine shall be equiped with a system for measuring the force applied to the test specimen which shall conform to grade 1 or better according to EN 10002-2. This shall prevail during actual test conditions (gas pressure, temperature).

5.2 Load train

The load train configuration shall ensure that the load indicated by the load cell and the load experienced by the test specimen are the same.

The load train performance including the alignement system and the force transmitting system shall not change because of heating.

There are two alternative means of load application :

a) Compression platens are connected to the load cell and on the moving crosshead. The parallelism of these platens shall be better than 0,01 mm, in the loading area, at room temperature and they shall be perpendicular to the load direction.

NOTE 1 : The use of platens is not recommended for compression testing of 1D and 2D materials with low thicknesses because of buckling.

NOTE 2 : A compliant interlayer material between the test specimen and platens can be used for testing macroscopically inhomogeneous materials to ensure even contact pressure. This material should be chemically compatible with both test specimen and platen materials.

b) Grips are used to clamp and load the test specimen.

The grip design shall prevent the test specimen from slipping. The grips must align the test specimen axis with that of the applied force.

NOTE : This point should be verified and documented according to, for example, the procedure described in the HTMTC code of practice.

The grips or the platens can be either in the hot zone of the furnace or outside.

NOTE : When grips or platens are outside the furnace, a temperature gradient exists between the centre of the specimen which is at the prescribed temperature and the ends which are at the same temperature as the grips or platens.

5.3 Test chamber

Gastight chamber which allows proper control of the test specimen environment in the vicinity of the test specimen during the test. The installation shall be such that the variation of load due to the variation of pressure is less than 1 % of the scale of the load cell being used.

5.3.1 Gas atmosphere

The gas atmosphere shall be chosen depending on the material to be tested and on test temperature. The level of pressure shall be chosen depending, on the material to be tested, on temperature, on the type of gas, and on the type of extensometry.

5.3.2 Vacuum chamber

The level of vacuum shall not induce chemical and/or physical instabilities of the test specimen material, and of extensometer rods, when applicable.

5.4 Set-up for heating

The set-up for heating shall be constructed in such a way that the temperature gradient within the gauge length is less than 20 °C at test temperature.

5.5 Extensometer

Extensometry shall be capable of continuously recording the longitudinal deformation at test temperature.

The use of an extensometer with the greatest possible gauge length is recommended. The linearity tolerance shall be lower or equal than 0,15 % of the extensometer range used.

The extensometer shall comply with class 1 or better, according to EN 10002-4.

Besides other types, two commonly used types of extensometer are :

5.5.1 Mechanical extensometer

In this case, the gauge length is the initial longitudinal distance between the two locations where the extensometer rods contact the test specimen.

The rods may be exposed to temperatures higher than the test specimen temperature. Temperature and/or environment induced structural changes in the rod material shall not affect the accuracy of deformation measurement. The material used for the rods shall be compatible with the test specimen material.

Care should be taken to correct for changes in calibration of the extensometer which may occur as a result of operating under conditions different from calibration.

NOTE : Rod pressure onto the test specimen should be the minimum necessary to prevent slipping of the extensometer rods.

5.5.2 Electro-optical extensometer

Electro optical measurements in transmission require reference marks on the test specimen. For this purpose rods or flags are attached to the surface perpendicularly to its axis. The gauge length is the distance between the two reference marks. The material used for marks (and adhesive if used) shall be compatible with the test specimen material and the test temperature and shall not modify the stress field in the specimen.

NOTE : The use of integral flags as parts of the test specimen geometry is not recommended because of stress concentration induced by such features.

5.6 Temperature measurement

Thermocouples shall comply to HD 446-1S1 and EN 60584-2.

Alternatively, when thermocouples which are not covered by HD 446-1S1 and EN 60584-2 or pyrometers are used, the calibration data shall be added to the test report.

5.7 Data recording system

A calibrated recorder may be used to record the force-deformation curve. However, the use of a digital data recording system combined with an analogue recorder is recommended.

5.8 Micrometers

Micrometers used for the measurement of the dimensions of the test specimen shall be in accordance with ISO 3611.

6 Test specimens

The choice of specimen geometry depends on several factors, such as :

- the nature of the material and of the reinforcement structure ;
- the type of heating system ;
- the type of loading system.

The volume in the gauge length shall be representative of the material and calibrated length shall be chosen such as to avoid buckling failure.

6.1 Compression between platens

Type 1 is commonly used and is represented on figure 1 below.

Recommended dimensions are given in table 1.

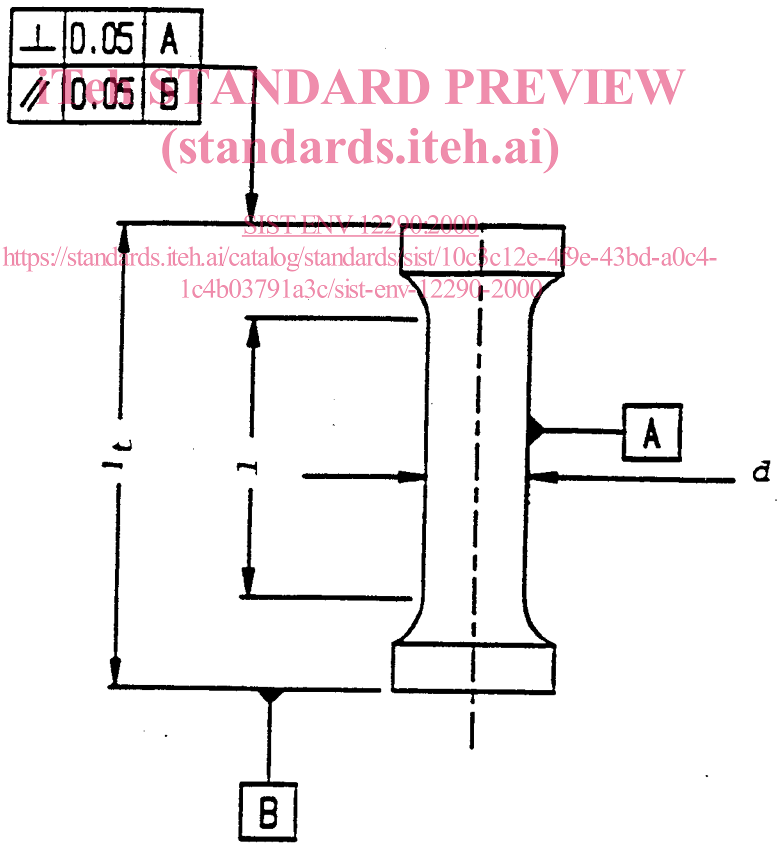

Figure 1