SLOVENSKI STANDARD
SIST ENV 1892:2000

01-december-2000

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

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

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

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81.060.30 Sodobna keramika Advanced ceramics

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English version

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CEN

European Committee for Standardization
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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 organizations of the following countries are bound to annouce 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 ENV 1892 specifies the conditions for determination of tensile 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 standard 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.

2 Normative references

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

ENV 1893	Advanced technical ceramics - Mechanical properties of ceramic composites at high temperature in air at atmospheric pressure - Determination of tensile properties
EN 60584-2	Thermocouples - Part 2 : Tolerances
EN 10002-2	Metallic materials - Tensile testing - Part 2 : Verification of the force measuring system of the tensile testing machines
HD 446-1S1	Thermocouples - Part 1 : Reference tables
HTMTC[1)]	Code of practice - Code of practice for the measurement of misalignement induced bending in uniaxially loaded tension compression test pieces
ISO 3611	Micrometer callipers for external measurement

3 Principle

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

The test duration is limited to reduce creep effects.

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

NOTE : When constant loading rate is used in the non linear region of the tensile curve, only the tensile strength can be obtained from the test. In this region constant crosshead displacement rate or constant deformation rate is recommended to obtain the complete curve.

4 Definitions and symbols

For the purposes of this pre-standard, the following definitions and symbols apply :

4.1 test temperature, T

Temperature of the test piece at the center 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 temperature is within 50 °C of the test temperature.

4.5 initial cross section area, S_o

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

4.6 longitudinal deformation, A

Increase in the gauge length between reference points under a tensile force. Its value corresponding to the maximum tensile force shall be denoted A_m.

4.7 tensile strain, ϵ

Relative change in the gauge length defined as the ratio A/L_o. Its value corresponding to the maximum force shall be denoted ϵ_m.

4.8 tensile stress, σ

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

4.9 maximum tensile force, F_m

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

4.10 tensile strength, σ_m

Ratio of the maximum tensile 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 :

$$EP(\sigma_1,\sigma_2) = \frac{(\sigma_2 - \sigma_1)}{(\epsilon_2 - \epsilon_1)} \qquad (1)$$

where :

$(\epsilon_1, \sigma_1$ and $(\epsilon_2, \sigma_2$ lie near the lower and the 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 linearity starts near 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 alignment system and the force transmitting system, shall not change because of heating.

The attachment fixtures shall align the test specimen axis with the applied force direction.

NOTE 1 : This point should be verified and documented, according to, for example the procedure described in the HTMTC code of practice.

The grip design shall prevent the test specimen from slipping.

There exist two types of gripping systems :

NOTE 2 : The choice of gripping system will depend on material, on test specimen design and on alignment requirements.

- hot grips where the grips are in the hot zone of the furnace ;

NOTE 3 : This technique is limited in temperature because of the nature and strength of the materials which can be used for grips.

- cooled grips where the grips are outside the hot zone.

NOTE 4 : In this technique, a temperature gradient exists between the centre which is at the prescribed temperature and the ends which are at the same temperature as the grips.

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 the 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 variation of temperature 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 gauge length is recommended. The linearity tolerances shall be lower than 0,05 % of the extensometer range used.

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

5.5.1 Mechanical extensometer

In this case, the gauge length is the 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 with HD 446-1S1 and EN 60584-2.

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

5.7 Data recording system

A calibrated recorder may be used to record force-deformation curve. 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 :

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

The volume in the gauge length shall be representative for the material.

The total length L depends on furnace and gripping system.

NOTE : Generally, total length is greater than 150 mm.

6.1 Test specimens commonly used with a hot gripping system

Several type of test specimens can be used.

Type 1 is represented in figure 1 below and recommended dimensions are given in table 1.

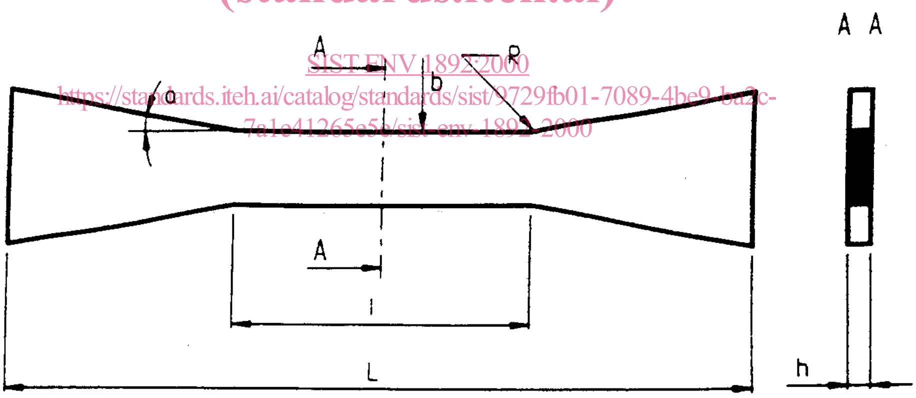

Figure 1

Table 1

		2D and xD	Tolerance
l	Calibrated length	30 mm to 80 mm	± 0,5 mm
h	Thickness	> 2 mm	± 0,2 mm
α	Angle	10° to 30°	-
b	Width of the calibrated length	8 mm to 20 mm	± 0,2 mm
R	Radius	> 30 mm	± 2 mm
	Parallelism of machined parts	0,05 mm	-