SLOVENSKI STANDARD
SIST ENV 13235:2000

01-december-2000

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

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

Hochleistungskeramik - Mechanische Eigenschaften von keramischen Verbundwerkstoffen bei hoher Temperatur in inerter Atmosphäre - Bestimmung des Kreichverhaltens

Ta slovenski standard je istoveten z: ENV 13235:1998

ICS:

81.060.30	Sodobna keramika	Advanced ceramics

SIST ENV 13235:2000 en

EUROPEAN PRESTANDARD
PRÉNORME EUROPÉENNE
EUROPÄISCHE VORNORM

ENV 13235

November 1998

ICS 81.060.99

Descriptors: composite materials, reinforcing materials, ceramics, technical ceramics, mechanical properties, high temperature tests, determination, creep properties

English version

Advanced technical ceramics - Mechnical properties of ceramic composites at high temperature under inert atmosphere - Determination of creep behaviour

Hochleistungskeramik - Mechanische Eigenschaften von keramischen Verbundwerkstoffen bei hoher Temperatur in inerter Atmosphäre - Bestimmung des Kreichverhaltens

This European Prestandard (ENV) was approved by CEN on 10 August 1998 as a prospective standard for provisional application.

The period of validity of this ENV 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 ENV can be converted into a European Standard.

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

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

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

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

Ref. No. ENV 13235:1998 E

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 announce this European Prestandard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European prestandard specifies the conditions for the determination of the tensile creep deformation and failure behaviour of ceramic matrix composite materials with continuous fibre reinforcement for temperatures up to 2 000 °C under vacuum or in a gas atmosphere which is inert to the material under test. The purpose of these test conditions is to prevent changes to the material as a result of chemical reaction with the test environment.

This pre-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 prestandard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at 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 1892	Advanced technical ceramics - Mechanical properties of ceramic composites at high temperature under inert atmosphere: Determination of tensile properties
EN 60584-1	Thermocouples - Part 1 : Reference tables
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
ISO 3611	Micrometer callipers for external measurement
WI 136	Code of practice: Code of practice for the measurement of misalignment induced bending in uniaxially loaded tension compression test pieces.

3 Principle

A test specimen of specified dimensions is heated to the test temperature, and loaded in tension until a specified level of force. This force is maintained at a constant level for a specified time or until rupture. The variation in gauge length is recorded in relation to time.

4 Definitions and symbols

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

4.1 creep

The total time-dependent increase of gauge length starting from the time when the constant specified level of force is reached.

4.2 test temperature, T

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

4.3 calibrated length, l

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

4.4 gauge length, L_0

Initial distance between reference points on the test specimen in the calibrated length at test temperature, at moment when loading is completed.

4.5 controlled temperature zone

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

4.6 initial cross section area, A_0

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

4.7 applied tensile force

The constant force applied to the test specimen during the test.

4.8 applied tensile stress

The applied tensile force divided by the initial cross section area.

4.9 longitudinal deformation, ΔL

Change in the gauge length caused by creep.

4.10 tensile creep strain, ε_{cr}

Relative change in the gauge length at time *t*, caused by creep. The value corresponding to rupture is noted $\varepsilon_{cr,m}$

4.11 creep rupture time, $t_{cr,m}$

The time elapsed from the moment when loading is completed until the moment of rupture.

4.12 creep strain rate, $\dot{\varepsilon}_{cr}$

Change in creep strain per unit time at time *t*.

4.13 creep types

4.13.1 Primary creep

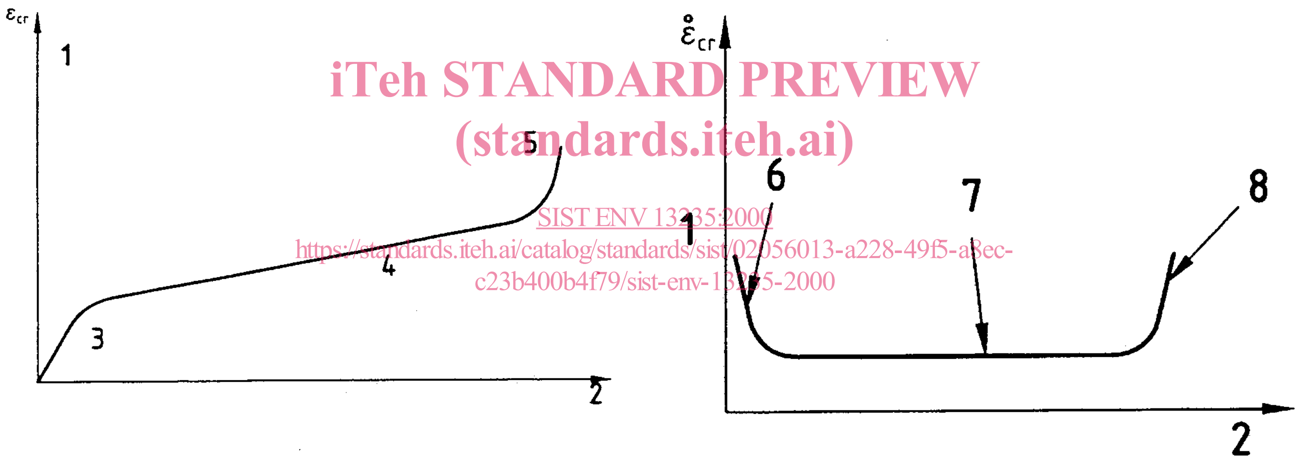
The part of the creep strain versus time curve which presents a decreasing creep strain rate (see figures 1a and 1b)

4.13.2 Secondary creep

The part of the creep strain versus time curve which presents a constant creep strain rate (see figure 1a and 1b)

4.13.3 Tertiary creep

The part of the creep strain versus time curve which presents an increasing creep strain rate (see figures 1a and 1b)



1 Creep strain cr
2 Time t
3 Primary creep
4 Secondary creep
5 Tertiary creep

6 Primary creep
7 Secondary creep
8 Tertiary creep

Figure 1a : Creep strain versus time (a)

Figure 1b : Creep strain rate versus time (b)

Figure 1

5 Significance and use

Several mechanisms may be responsible for time-dependent deformation of fibre-reinforced ceramic matrix composites at high temperature. These may be creep of the fibre and/or the matrix, or may be caused by the composite nature of the material (matrix microcracking, fibre-matrix interface sliding). Creep is characterised the total time-dependent increase of the gauge length, starting from the time when the specified force level is reached, whatever the mechanism responsible.

During the loading phase, the loading rate up to the specified force level can have a dramatic effect on the subsequent accumulation of creep strain. This is particularly the case when the fibres and the matrix have very different creep strengths. Upon fast application of the force, the load is distributed between the fibres and the matrix according to their elastic modulus and their volume fraction. With increasing time, the load redistributes between the fibres and the matrix whereby the constituent with the higher resistance against creep deformation takes up more load at the expense of the constituent with the lower creep resistance.

When the force is applied at a lower rate, such a load redistribution between the fibres and the matrix can already occur during the loading phase. For the same applied force, this results in a lower load in the weaker constituent. When the matrix has the lower creep resistance, fast loading may hence cause matrix cracking, which in turn exposes the bridging fibres to a higher load, and causes them, as well as the composite to creep at a higher rate. By applying the force at a sufficiently low rate, matrix microcracking may be avoided, and the creep life of the composite may increase considerably.

It is therefore necessary to select the loading rate for which the phenomenon is negligible.

6 Apparatus

6.1 Test installations

Two different types of installation can be used :

6.1.1 Universal test machine

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

6.1.2 Creep testing rig

When a creep testing rig is used, the force application system shall be calibrated. The testing rig shall be equipped with a system to allow smooth loading of the specimen(s). In the case where multiple specimens are tested test rig, precautions shall be taken to avoid shock loading the other specimens when one of the specimens fails. Whichever system is used, care shall be taken to ensure that the force applied to the specimen remains constant to within ± 1 % even when the environmental conditions (temperature, pressure) fluctuate.

6.2 Load train

The gripping system shall align the test specimen axis with that of the applied force. The alignment shall be verified and documented.

NOTE 1: WI 136 referenced in section 2 is a suitable procedure for alignment verification.

The choice of a hot or cold gripping system depends on the material to be tested, on the geometry of specimen and on the heating system, and it affects the alignment performance as well as the axial temperature distribution on the specimen.

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. This can be achieved in two ways. The most straightforward consists of mounting the load cell inside the test chamber. When this is not possible, a pre-calibration of the response of pressure variation in the test chamber on the load cell signal shall be made. Pressure variation during testing shall not induce variations of the load experienced by the specimen larger than those indicated in 6.1.

The load train performance including the alignment and the force transmission shall not change because of heating.

6.3 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 during the test is less than 1 % of the scale of the load cell being used.

6.3.1 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.

6.3.2 Vacuum chamber

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

6.4 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. The variation of test temperature with time for the entire duration of the test shall be within ± 5 °C for temperatures below 1 000 °C and within ± 10 °C for temperatures above and including 1 000 °C.

6.5 Extensometer

The extensometer used shall be capable of continuous and stable recording of the longitudianl deformation at test temperature for the entire duration of the creep test.

The use of an extensometer with the greatest gauge length is recommended. As the total strains may be very small, the accuracy of the extensometer shall be of 0,001 % of the gauge length.

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