SLOVENSKI PREDSTANDARD

oSIST prEN 15157:2005

junij 2005

Sodobna tehnična keramika - Keramični kompoziti - Mehanske lastnosti pri visoki temperaturi v zraku v pogojih atmosferskega tlaka - Določanje lastnosti utrujanja pri konstantni amplitudi

Advanced technical ceramics - Ceramic composites. Mechanical properties at high temperature in air at atmospheric pressure - Determination of fatigue properties at constant amplitude

ICS 81.060.30

Referenčna številka
oSIST prEN 15157:2005(en)

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

DRAFT
prEN 15157

February 2005

ICS

English version

Advanced technical ceramics - Ceramic composites. Mechanical properties at high temperature in air at atmospheric pressure - Determination of fatigue properties at constant amplitude

Céramiques techniques avancées - Composites céramiques. Propriétés mécaniques à haute température dans l'air à pression atmosphérique - Détermination des propriétés de fatigue à amplitude constante

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 184.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

This draft European Standard was established by CEN in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

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.

Warning : This document is not a European Standard. It is distributed for review and comments. It is subject to change without notice and shall not be referred to as a European Standard.

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

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

Ref. No. prEN 15157:2005: E

Contents

Page

Foreword

This document (prEN 15157:2005) has been prepared by Technical Committee CEN/TC 184 "Advanced technical ceramics", the secretariat of which is held by BSI.

This document is currently submitted to the CEN Enquiry.

1 Scope

This European pre-standard specifies the conditions for the determination of constant-amplitude of load or strain in uniaxial tension/tension or in uniaxial tension/compression cyclic fatigue properties of ceramic matrix composite materials (CMC) with fibre reinforcement for temperature up to 1 700 °C in air at atmospheric pressure.

This standard applies to all ceramic matrix composites with a fibre reinforcement, unidirectional (1D), bi-directional (2D), and tri-directional (xD, with 2 < x ≤ 3).

The purpose of this pre-standard is to determine the behaviour of CMC when subjected to mechanical fatigue and oxidation simultaneously. Contrary to the tests for the determination of fatigue properties at high temperature in inert atmosphere, in the tests conducted at high temperature and in oxidative atmosphere, there is an accumulation of damage due to the influence of purely mechanical fatigue and due to the chemical effects of the material's oxidation.

2 Normative references

The following referenced documents are indispensable for the application 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 13233,1998, *Advanced Technical Ceramics – Ceramic composites – Notations and symbols.*

ENV 1892, *Advanced technical ceramics - Mechanical properties of ceramic composites at high temperature under inert atmosphere - Determination of tensile properties.*

ENV 1893, *Advanced technical ceramics - Mechanical properties of ceramic composites at high temperature in air at atmospheric pressure - Determination of tensile properties.*

EN 658-1, *Advanced technical ceramics - Mechanical properties of ceramic composites at room temperature - Determination of tensile strength.*

EN 60584-2, *Thermocouples - Part 2: Tolerances.*

EN ISO 7500-1, Metallic materials - Verification of static uniaxial testing machines – Part 1: Tension/compression testing machines - Verification and calibration of the force- measuring system.

EN 12291, *Advanced technical ceramics - Mechanical properties of ceramic composites at high temperature in air at atmospheric pressure - Determination of compressive properties.*

EN 10002-4, *Metallic materials - Tensile test - Part 4: Verification of extensometers used in uniaxial testing.*

HD 446.1S1, *Thermocouples - Part 1: Reference tables.*

WI 136, *A guide for the determination of the degree of misalignment in uniaxial mechanical tests.*

ISO 3611, *Micrometer callipers for external measurement.*

3 Principle

A test specimen of specified dimensions is heated to the testing temperature and tested in cyclic fatigue as follows:

- Method A: The test specimen is cycled between two constant stress levels at a specified frequency;
- Method B: The test specimen is cycled between two constant strain levels at a specified frequency.

The total number of cycles is recorded. If strain is not determined, only the life time duration or the residual mechanical properties can be determined. If strain is determined, a number of stress-strain cycles are recorded at specified intervals to determine damage parameters, in addition to the life time duration and residual mechanical properties.

NOTE Residual properties can be determined on the test specimens which have not failed during the test, using the methods described in the appropriate European Standards.

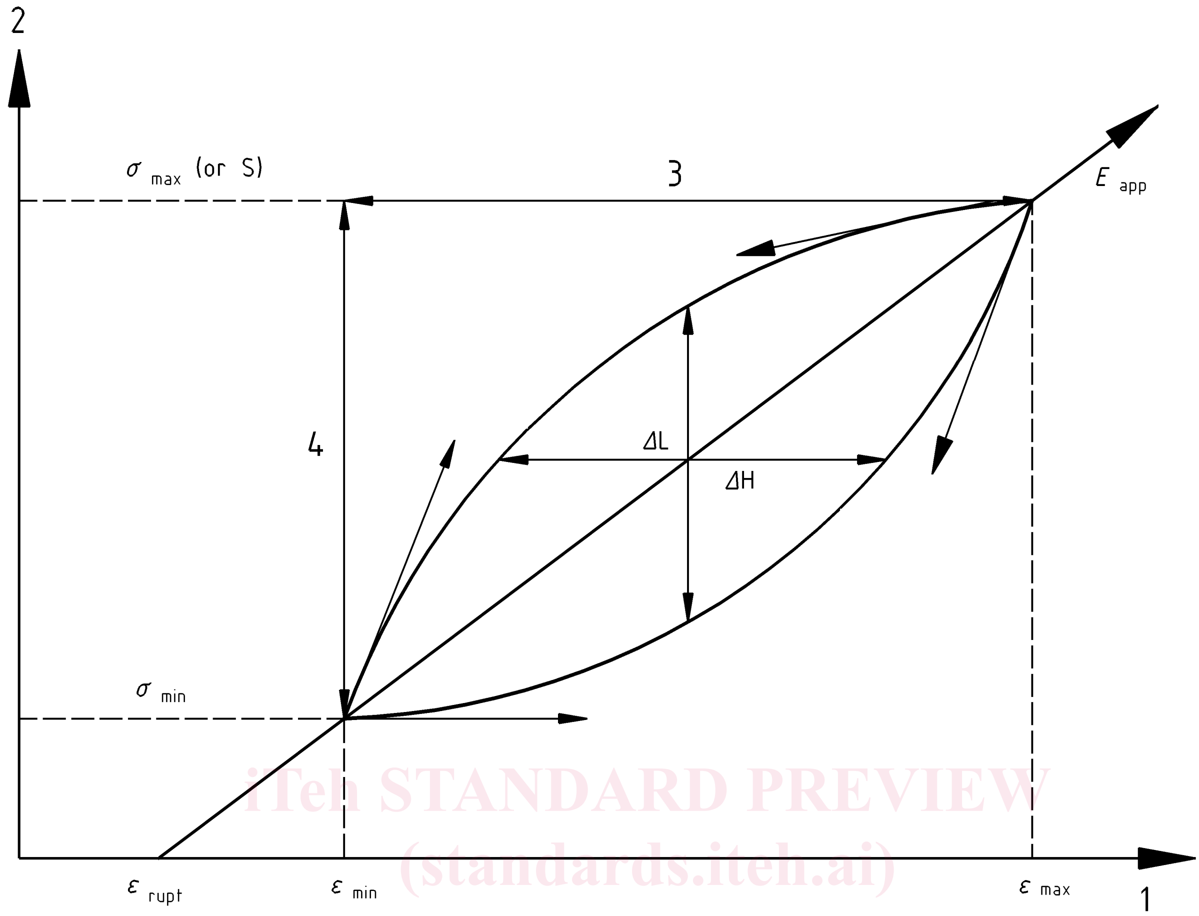
4 Significance and use

This test method allows to characterise the cyclic fatigue behaviour at constant amplitude of CMC's subjected to long duration loading. The simplest way to determine the fatigue properties of a material is to establish life-time diagrams. In these diagrams, the time to failure (or the cyclic fatigue life) is plotted versus stress (or strain) amplitude.

The complete life-time diagram requires a great number of test specimens, which is expensive and time consuming. Hence, it can be sufficient to know the cyclic-fatigue under specified stress (or strain) conditions, or to measure the fatigue limit. In any case, the typical fatigue test is defined by cyclic loading, constant amplitude, environment, temperature and frequency.

To better characterise the mechanical behaviour during a fatigue test, it is possible to determine several mechanical parameters from stress-strain curves. These parameters can then be plotted versus time or versus number of cycles. This displays the damage evolution during the cyclic loading. The following parameters can be considered (see Figure 1):

- the residual strain at zero load;
- the secant elastic modulus, or the relative damage parameters;
- the area of the stress-strain hysterisis loop, or the internal friction;
- the maximum strain, the minimum strain, or the difference between them for a selected cycle;
- some specific tangent elastic moduli, for example at the top or at the bottom of the stress-strain loop.



Key

1 Strain (ε)

2 Stress (σ)

3 Width (L)

4 Height (H)

Figure 1 — Parameters that can be considered to assess the cyclic fatigue behaviour

5 Definitions and symbols

For the purposes of this European Standard, the following terms and definitions given in EN 13233 and the following definitions and symbols apply.

5.1
test temperature, T
temperature of the test specimen at the centre of the gauge length

5.2
calibrated length, l
the part of the test specimen which has uniform and minimum cross section area

5.3
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 30 °C at test temperature

5.4
controlled temperature zone
the part of the calibrated length including the gauge length where temperature is within 50 °C of the test temperature

5.5
initial cross section area, S_o
initial cross section area of the test specimen within the calibrated length, at test temperature

Two initial cross section areas of the test specimen can be defined:

— apparent cross section area: this is the total area of the cross section $S_{o\ app}$;

— effective cross section area: this is the total area corrected by a factor, to account for the presence of a coating, $S_{o\ eff}$.

5.6
longitudinal deformation, A
change in the gauge length between reference points under a uniaxial force

5.7
strain, ε
relative change in the gauge length defined as the ratio A/L_o

5.8
stress, σ
the force supported by the test specimen at any time in the test, divided by the initial cross section area

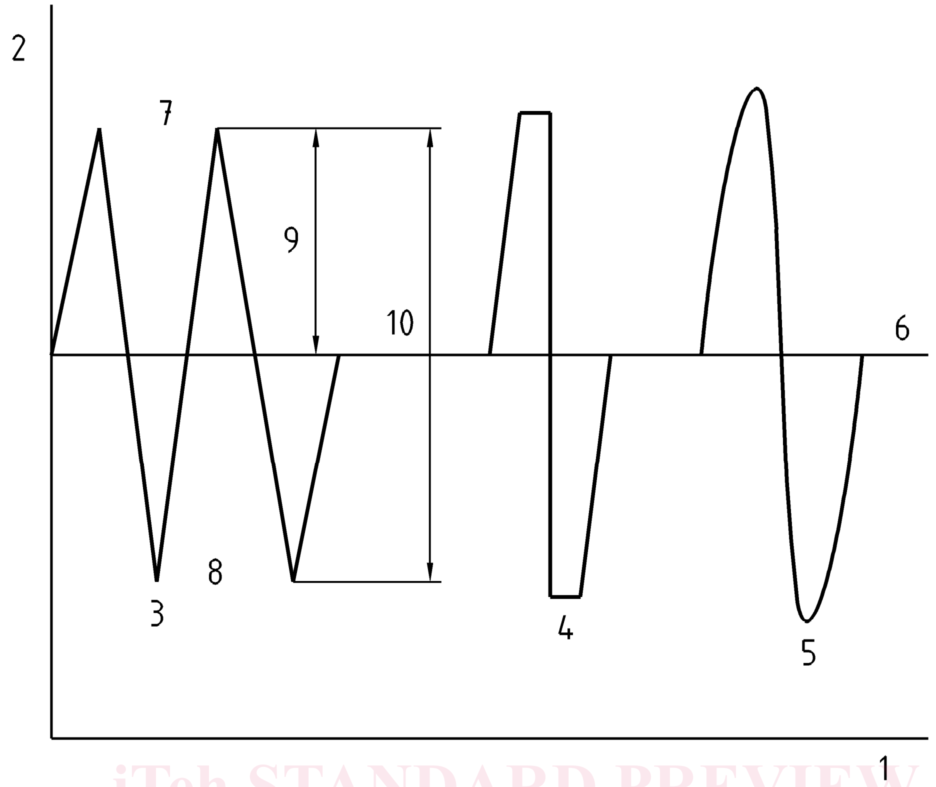
Two stresses can be distinguished:

— apparent stress, σ_{app}, when the apparent cross section area (or total cross section area) is used;

— effective stress, σ_{eff}, when the effective cross section area is used.

Stress can be either in tension or in compression.

5.9
constant amplitude loading
in cyclic fatigue loading, a constant wave form loading in which the peak loads and the valley loads are kept constant during the test (see Figure 2) for nomenclature relevant to cyclic fatigue testing



Key

1 Time
2 Control parameter (test mode)
3 Triangular form
4 Trapezoidal form
5 Sinusoidal form
6 Mean
7 Peak (maximum)
8 Valley (minimum)
9 Amplitude
10 Range

Figure 2 — Cyclic fatigue nomenclature and wave forms

5.10 cyclic fatigue phenomena

5.10.1
load ratio, R
in cyclic fatigue loading, the algebraic ratio of the two loading parameters of a cycle; the most widely used ratios are:

R = (minimum load / maximum load) or R = (valley load / peak load)

5.10.2 stress cyclic fatigue

5.10.2.1
maximum stress, σ_{max}
the maximum applied stress during cyclic fatigue

5.10.2.2
minimum stress, σ_{min}
the minimum applied stress during cyclic fatigue

5.10.2.3
mean stress, σ_m
the average applied stress during cyclic fatigue such that:

$$\sigma_m = (\sigma_{max} + \sigma_{min}) / 2$$

5.10.2.4
stress amplitude, σ_a
the difference between the maximum stress and the minimum stress, such that:

$$\sigma_a = (\sigma_{max} - \sigma_{min}) / 2 = \sigma_{max} - \sigma_m = \sigma_m - \sigma_{min}$$

5.10.3 strain cyclic fatigue

5.10.3.1
maximum strain, ε_{max}
the maximum applied strain during cyclic fatigue

5.10.3.2
minimum strain, ε_{min}
the minimum applied strain during cyclic fatigue

5.10.3.3
mean strain, ε_m
the average applied strain during cyclic fatigue such that:

$$\varepsilon_m = (\varepsilon_{max} + \varepsilon_{min}) / 2$$

5.10.3.4
strain amplitude, ε_a
the difference between the maximum stress and the minimum stress, such that:

$$\varepsilon_a = (\varepsilon_{max} - \varepsilon_{min}) / 2 = \varepsilon_{max} - \varepsilon_m = \varepsilon_m - \varepsilon_{min}$$

5.10.4 fatigue parameters

5.10.4.1
number of cycles, N
the total number of loading cycles which is applied to the test specimen during the test

5.10.4.2
cyclic fatigue life, N_f
the total number of loading cycles which is applied to the test specimen up to failure

5.10.4.3
time to failure, t_f
time duration required to obtain the number of cycles N_f

5.10.5
definition of the stress-strain curve parameters
see Figure 1 in paragraph 4