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Advanced technical ceramic - Ceramic composites - Methods of test for reinforcement - Part 6: Determination of tensile properties of filament at high temperature

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Normcommissie 342 032 "Technische keramiek"

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Advanced technical ceramic - Ceramic composites - Methods of test for reinforcements - Part 6: Determination of tensile properties of filaments at high temperature

Céramiques techniques avancées - Céramiques composites - Méthodes d'essai pour renforts - Partie 6 : Détermination des propriétés en traction du filament à haute température

Hochleistungskeramik - Keramische Verbundwerkstoffe - Teil 6: Bestimmung der Zugeigenschaften von Fasern bei hoher Temperatur

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EUROPÄISCHES KOMITEE FÜR NORMUNG

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Ref. No. prEN 1007-6:2007: E

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Foreword

This document (prEN 1007-6:2007) 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 Unique Acceptance Procedure.

This document will supersede ENV 1007-6:2002.

1 Scope

This European Standard specifies the conditions for measurement of tensile properties of single filament of ceramic fibres at high temperature in air or inert atmosphere (vacuum or controlled atmosphere). The method applies to continuous ceramic filaments taken from tows, yarns, staple fibre, braids and knitting, that have strain to fracture less or equal to 5 % and show linear elastic behaviour to fracture.

The method does not apply to testing for homogeneity of strength properties of fibres, nor does it assess the effects of volume under stress. Statistical aspects of fibre failure are not included.

Two methods are proposed depending on the temperature of the filament end:

— Hot end method: this method allows determination of tensile strength, of Young's modulus and of the stress strain curve.

NOTE 1 Current experience with this technique is limited to 1 300 °C, because of the application temperature of ceramic glue.

— Cold end method.

NOTE 2 This method is limited to 1 700 °C in air and 2 000 °C in inert atmosphere because of the limits of furnaces.

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 1007-3, *Advanced technical ceramics — Ceramic composites — Methods of test for reinforcement — Part 3: Determination of filament diameter and cross-section area*

EN 1007-4, *Advanced technical ceramics — Ceramic composites — Methods of test for reinforcement — Part 4: Determination of tensile properties of filaments at ambient temperature*

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 (ISO 7500-1:2004)*

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

EN 60584-1, *Thermocouples — Part 1: Reference tables (IEC 60584-1:1995)*

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

3 Terms and definitions

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

3.1
test temperature
T
temperature of the filament at the centre of the gauge length

3.2 Lengths

3.2.1
gauge length
L_o
initial distance between two reference points on the filament, where the temperature variation is within 20 °C at test temperature

3.2.2
test specimen length
L_f
initial distance between the gripped ends of the filament

3.2.3
uniformly heated length
L_h
length of the heated zone at the test temperature, where the temperature variation is within 20 °C (see Figure A.2)

3.2.4
gradient zone length
L_d
length of each part of the test specimen where the temperature decreases from the temperature at the end of the uniformly heated length to room temperature (see Figure A.2)

3.2.5
room temperature zone length
Lc
length of each part of the test specimen where the temperature is equal to room temperature

3.3
initial cross-section area
A_o
initial cross-section area of the filament within the gauge length determined at room temperature

3.4
maximum tensile force
Fm
highest recorded tensile force on the test specimen when tested to failure

3.5
tensile stress
σ
tensile force supported by the test specimen divided by the initial cross-section area

3.6
tensile strength
σ_m
ratio of the maximum tensile force to the initial cross-section area

3.7
longitudinal deformation
ΔL
increase of the gauge length during the tensile test

3.8 Compliance

3.8.1
total compliance
C_t
reciprocal of the slope in the linear part of the force/displacement curve

3.8.2
load train compliance
C_l
ratio of the force displacement excluding any test specimen contribution to the corresponding force during the tensile test

3.8.3
gradient zone compliance
C_d
ratio of the test specimen elongation in the temperature gradient zone length L_d to the corresponding force during the tensile test

3.8.4
cold zone compliance
C_c
ratio of the test specimen elongation at room temperature Lc to the corresponding force during the tensile test

3.8.5
hot zone compliance
C_h
ratio of the test specimen elongation in the uniformly heated length L_h to the corresponding force during the tensile test

3.9
strain
ε
ratio of the longitudinal deformation to the gauge length

3.10
fracture strain
ε_m
strain at failure of the test specimen

3.11
elastic modulus
E
slope of the linear part of the tensile stress-strain curve

4 Principle

A ceramic filament is heated to the test temperature and loaded in tension. The test is performed at constant force/displacement rate up to failure. Force and cross-head displacement are measured and recorded simultaneously. When required, the elongation is derived from the cross-head displacement using a compliance correction. The test duration is limited to reduce time dependent effects.

Subjecting the whole length of a fibre to temperatures well above 1 000 °C makes it difficult to fix the ends of the specimen into appropriate temperature proof extensions. In high temperature cold-end tests this problem is avoided by keeping the junction at the ends of the test specimen at room temperature, allowing organic resins to be used like in the room temperature tests (EN 1007-4).

Two methods can thus be used:

— one consists of heating the filament over its total length (hot end method);

— one consists of heating only the central part of the filament (cold end method).

5 Apparatus

5.1 Test machine

The machine shall be equipped with a system for measuring the force applied to the test specimen. The system shall conform to grade 1 according to EN ISO 7500-1.

The machine shall be equipped with a system for measuring the force displacement. The accuracy of the measurement shall be better than 1 µm.

5.2 Load train

The grips shall align the specimen with the direction of the force. Slippage of the filament in the grips shall be prevented. The load train performance including the alignment system and the force transmitting system shall not change because of heating.

5.3 Adhesive

Use a suitable adhesive for affixing the filament to the ends of the grip, such as epoxy resin, cement or sealing wax.

5.4 Test chamber

5.4.1 General

When testing under inert conditions, a gastight chamber allows proper control of the test environment 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.

5.4.2 Gas atmosphere

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

5.4.3 Vacuum chamber

The level of vacuum shall not induce chemical and/or physical instabilities of the filament material.

5.5 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.

5.6 Temperature measurement

Thermocouples shall comply with EN 60584-1 and EN 60584-2.

Alternatively, pyrometers or thermocouples which are not covered by EN 60584-1 and EN 60584-2, but those which are appropriately calibrated, can be used.

5.7 Data recording system

Calibrated recorders may be used to record force-displacement curves.

The use of a digital data recording system combined with an analogue recorder is recommended.

5.8 Travelling microscope or other suitable measuring device

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