SLOVENSKI STANDARD
SIST ENV 1007-6:2007
01-januar-2007

Sodobna tehniļ na keramika - Keramiļ ni kompoziti - Preskusne metode za ojaļ itve - 6. del: Doloļ anje nateznih lastnosti vlaken pri visoki temperaturi

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

Hochleistungskeramik - Keramische Verbundwerkstoffe - Verfahren zur Prüfung der Faserverstärkungen - Teil 6: Bestimmung der Zugeigenschaften von Fasern bei hoher Temperatur

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

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ICS:

81.060.30	Sodobna keramika	Advanced ceramics

SIST ENV 1007-6:2007 **en**

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English version

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

This European Prestandard (ENV) was approved by CEN on 13 July 2001 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.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
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Foreword

This European Prestandard (ENV 1007-6:2002) 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, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Prestandard 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, which 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 to 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.

NOTE Current experience with this technique is limited to 1300 °C, because of the application temperature of ceramic glue.

This method allows determination of tensile strength, of Young's modulus and of the stress strain curve.

— Cold end method.

NOTE This method is limited to 1700 °C in air and 2000 °C in inert atmosphere because of the limits of furnaces.

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 the publication referred to applies.

ENV 843-5, *Advanced technical ceramics – Monolithic ceramics – Mechanical tests at room temperature – Part 5 : Statistical analysis.*

ENV 1007-3, *Advanced technical ceramics - Ceramic composites - Methods of test for reinforcements Part 3 : Determination of filament diameter.*

EN 1007-4, *Advanced technical ceramics - Ceramic composites - Methods of test for reinforcements Part 4 : Determination of tensile properties of filament at ambient temperature.*

EN 10002-2, *Metallic materials – Tensile testing – Part 2 : Verification of the force measuring system of the tensile testing machine.*

EN 60584-1, *Thermocouples – Part 1 : Reference tables.*

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

3 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 1000 °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) ;

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

4 Definitions and symbols

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

4.1
test temperature, T
temperature of the filament at the centre of the gauge length

4.2
Lengths

4.2.1
lauge length, L_o
initial distance between two reference points on the filament. The temperature variation in the gauge length shall be within 20 °C at test temperature

4.2.2
test specimen length, L_f
initial distance between the gripped ends of the filament

4.2.3
uniformly heated length, L_h
length of the heated zone at the test temperature, where the temperature variation is within 20 °C (see Figure 2 Appendix A)

4.2.4
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 2 Appendix A)

4.2.5
room temperature zone length, Lc
length of each part of the test specimen where the temperature is equal to room temperature

4.3
initial cross section area A_o
initial cross section area of the filament within the gauge length determined at room temperature

4.4
maximum tensile force, *Fm*
highest recorded tensile force on the test specimen when tested to failure

4.5
tensile stress, σ
the tensile force supported by the test specimen divided by the initial cross section area

4.6
tensile strength, σ_m
ratio of the maximum tensile force to the initial cross section area

4.7
longitudinal deformation, ΔL
the increase of the gauge length during the tensile test

4.8
compliance

4.8.1
total compliance, C_t
the reciprocal of the slope in the linear part of the force/displacement curve

4.8.2
load train compliance, C_l
ratio of the force displacement excluding any test specimen contribution to the corresponding force during the tensile test

4.8.3
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

4.8.4
cold zone compliance, C_c
ratio of the test specimen elongation at room temperature Lc to the corresponding force during the tensile test

4.8.5
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

4.9
strain, ε
ratio of the longitudinal deformation to the gauge length

4.10
fracture strain, ε_m
the strain at failure of the test specimen

4.11
elastic modulus, E
the slope of the linear part of the tensile stress-strain curve

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 10002-2.

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

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

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.

5.4.1 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.

5.4.2 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 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.

6 Hot end method

In high temperature hot-end tests the test specimen strain can be determined in simple analogy to the room temperature method assuming that the test specimen sees isothermal conditions along its whole length. According to this hypothesis, the gauge length L_0 is equal to the test specimen length L_f.

6.1 Test specimens

Specimens with a gauge length of 25 mm shall be used to establish the force-displacement curves.

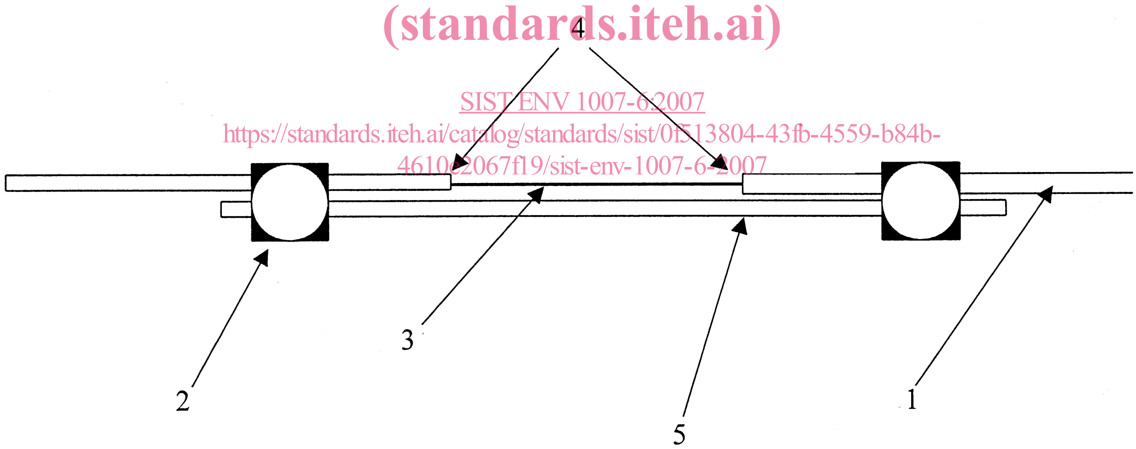
Specimens with a gauge length of 10 mm and 40 mm shall be used to determine the load train compliance C_l.

The tolerance on the gauge length is ± 1 mm.

6.2 Test specimen preparation

Extreme care shall be taken during test specimen preparation to ensure that the procedure is repeatable from test specimen to test specimen and to avoid handling damage.

NOTE As an example to prevent damage during *test* specimen manipulation and mounting, the assembly of test specimen and alumina tubes is maintained straight by an extra alumina rod, as shown in Figure 1.



key

1 alumina tubes
2 temporary screw attachment
3 test specimen
4 high temperature joints between the test specimen and the alumina tubes

Figure 1

6.3 Number of test specimens

For each test condition, five valid test results at a gauge length of 25 mm, are required.

For the determination of strain related properties, three additional tests at each gauge length of 10 mm and 40 mm are required in order to establish load-train compliance, C_L.

NOTE 1 If a statistical evaluation is required, the number of test specimens at a gauge length of 25 mm shall be in accordance with ENV 843-5.

NOTE 2 A compliance determination is not required if only strength needs to be determined.

6.4 Test Procedure

6.4.1 Test set-up : determination of the temperature profile

The following determinations shall be carried out under actual test conditions :

Prior to testing, the temperature profile inside the furnace shall be established over the temperature range of interest. This shall be done by measuring the temperature at a minimum of three locations which correspond to the ends and the centre of the maximum gauge length.

NOTE When the type of specimen assembly described in Figure 1 is used, the temperature profile may be determined inside the furnace at the end and at mid-way between the tubes positioned at the distance corresponding to the maximum gage length and without the filament mounted.

During a series of tests, the test temperature is determined indirectly from the temperature indicated by the temperature control device.

The relation between the control temperature and the test temperature is established over the range of temperature of interest.

NOTE Usually the determination of the temperature profile and the relation between control temperature and test temperature are established simultaneously.

6.4.2 Test set-up : other considerations

The dimension of the filament varies with the temperature and the variation is very difficult to measure.

6.4.2.1 Determination of the gauge length, L_0

The gauge length is measured to an accuracy of ± 0,1 mm at room temperature.

6.4.2.2 Determination of the initial cross section area, A_0

The filament diameter and thus the initial crass section area at test temperature, is measured at room temperature in accordance with ENV 1007-3.

NOTE 1 In principle, the initial cross section area is to be determined on the filament to be tested. In practice, this may be achieved by sampling the lengths to be tested from a single filament at intermittent locations and using the parts in between for diameter measurement. This assumes that for the lengths of fibres to be tested, the diameter does not vary significantly with the length.

NOTE 2 An alternative method consists of measuring the filament cross section after fracture from a transverse cross section taken from the part of the grips still containing embedded fibre. In this case, care has to be taken not to damage the fibre during preparation.

6.4.3 Testing technique

Follow the chronological steps :

6.4.3.1 Zero the load cell

6.4.3.2 Specimen mounting

Mount the specimen in the load train with its longitudinal axis coinciding with that of the test machine. Care shall be taken not to induce torsional loads or surface damage to the filament. The position of the gauge length relative to the furnace shall be identical to that previously use in 6.4.1.