



SLOVENSKI STANDARD SIST ENV 1007-5:2000

01-december-2000

Advanced technical ceramics - Ceramic composites - Methods of test for reinforcements - Part 5: Determination of distribution of tensile strength and of tensile strain to failure of filaments within a multifilament tow at ambient temperature

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Hochleistungskeramik - Keramische Verbundwerkstoffe Verfahren zur Prüfung von Verstärkungen - Teil 5: Bestimmung der Verteilung von Zugfestigkeit und Zugdehnung von Fasern im Faserbündel bei Raumtemperatur

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Céramiques techniques avancées - Céramiques composites - Méthodes d'essais pour les renforts - Partie 5: Détermination des distributions des résistances en traction et des déformations de traction a rupture des filaments dans un fil a température ambiante

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ICS:

81.060.30 Sodobna keramika Advanced ceramics

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EUROPEAN PRESTANDARD
PRÉNORME EUROPÉENNE
EUROPÄISCHE VORNORM

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ICS 81.060.99

Descriptors: ceramics, technical ceramics, reinforcing materials, tests, environmental tests, tensile tests, determination, mechanical properties, tensile strength, tensile stress, break strength

English version

Advanced technical ceramics - Ceramic composites - Methods
of test for reinforcements - Part 5: Determination of distribution
of tensile strength and of tensile strain to failure of filaments
within a multifilament tow at ambient temperature

Céramiques techniques avancées - Céramiques
Composites - Méthodes d'essais pour les renforts - Partie
5: Détermination des distributions des résistances en
traction et des déformations de traction à rupture des
filaments dans un fil à température ambiante

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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
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Foreword

This European Prestandard has been prepared by Technical Committee CEN/TC 184 "Advanced technical ceramics", the secretariat of which is held by BSI.

ENV 1007 has five parts :

- Part 1 : Determination of size contents
- Part 2 : Determination of linear density
- Part 3 : Determination of filament diameter
- Part 4 : Determination of tensile properties of filament at ambient temperature
- Part 5 : Determination of distribution of tensile strength and of tensile strain to failure of filaments within a multifilament tow at ambient temperature

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 part of ENV 1007 specifies the conditions for the determination of the distribution of strength and rupture strain of ceramic filaments within a multifilament tow at room temperature by performing a single tensile test on a multifilament tow.

This part of European prestandard applies to tows of continuous ceramic filaments which are assumed to act freely and independently under loading, and behave linearly elastic up to failure.

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 in the publications 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.

- | | |
|------------|---|
| EN 10002-2 | Metallic materials - Tensile testing - Part 2 : Verification of the force measuring system of the tensile testing machine |
| ISO 10119 | Determination of the density of carbon fibres |
| ENV 1007-2 | Advanced technical ceramics - Ceramic composites - Methods of test for reinforcements - Part 2 : Determination of linear density |
| ENV 1007-4 | Advanced technical ceramics - Ceramic composites - Methods of test for reinforcements - Part 4 : Determination of tensile properties of filament at ambient temperature |
| ENV 843-5 | Advanced technical ceramics - Monolithic ceramics - Mechanical tests at room temperature - Statistical analysis |

3 Principle

A multifilament tow is loaded in tension at a constant displacement rate up to rupture of all the filaments in the tow. The force and displacement are measured and recorded. From the force-displacement curve the two-parameter Weibull distribution of the rupture strain and of the strength of the filaments is obtained by sampling the non-linear parts of the curve at discrete intervals j , which correspond to an increasing number of failed filaments in the tow.

The linear part of the force-displacement curve may be used to determine Young's modulus of the filament.

4 Significance and use

Because measurement of the displacement directly on the tow is difficult, it is usually obtained indirectly via a compliance measurement which includes contributions of the loading train, of the grips, of the tabbing materials, etc.. These contributions have to be corrected for in the analysis. When it is possible to measure the tow elongation directly (by using a suitable extensometer system) this correction is not needed. The calculation of the results in clause 10 also applies in this case by setting the load train compliance equal to zero.

The evaluation method is based on an analysis of the non linear increasing and decreasing parts of the force-displacement curve, which are caused by progressive filament failure during the test. The occurrence of these stages is promoted by a higher stiffness of the loading and gripping system. When the force-displacement curve does not show these non linear parts the evaluation method of this prestandard cannot be applied.

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The distribution of filament rupture strain does not depend on the number of filaments in the tow and is hence not affected by the number of filaments which are broken before the test. The determination of the filament strength distribution and of the elastic modulus requires knowledge of the initial cross sectional area of the tow. Because the number of unbroken filaments within the tow prior to the test is usually unknown, the values for the filament strength and for the elastic modulus necessarily represent lower bounds to these quantities. Also, the variation in filament diameter, which affects the strength values, is not accounted for.

Because of the difference in the evaluation, the values of the Weibull modulus for the filament rupture strain and for the filament strength are slightly different.

The Weibull parameters determined by this test method and extrapolated to the respective gauge length cannot be compared directly with those obtained from tensile tests on monofilaments according to ENV 1007-4 because of the large difference in test conditions.

5 Definitions and symbols

For the purposes of this European prestandard, the following definitions and symbols apply:

5.1 gauge length, L_0

Initial distance between two reference points on the tow.

NOTE : Usually the gauge length is taken as the distance between the gripped ends of the tow.

5.2 initial cross section area, A_0

Cross section area of the tow.

5.3 tow elongation, ΔL

Increase of the gauge length between the two reference points during the tensile test.

5.4 compliance

5.4.1 total compliance, C_t

Ratio of the measured displacement to the corresponding force during the tensile test.

5.4.2 load train compliance, C_l

Ratio of the load train elongation, excluding the specimen contribution, to the corresponding force during the tensile test.

5.5 strain, ε

Ratio of the tow elongation ΔL to the gauge length L_0 .

5.6 filament rupture strain, $\varepsilon_{r,j}$

The strain at step j in the non linear parts of the force-displacement curve.

5.7 filament strength, $\sigma_{r,j}$

Ratio of the tensile force to the cross section area of all unbroken filaments at step j in the non linear parts of the force-displacement curve.

5.8 average filament strength, $\bar{\sigma}_r$

Statistical average strength of the filaments in the tow for each test determined from the Weibull strength distribution parameters of the filaments.

5.9 Mean filament strength, $\overline{\sigma}_r$

Arithmetic mean of the average strengths.

6 Apparatus

6.1 Tensile testing equipment

The test machine shall be equipped with a system for measuring the force applied to the specimen and the displacement, or directly the tow elongation. The machine shall conform to grade 1 or better in EN 10002-2. The grips shall align the specimen with the direction of the force. Slipping of the specimen in the grips shall be prevented.

NOTE : The use of a displacement transducer placed at the ends of the grips (see figure 1) should limit the contribution of different parts of the load train to the measured displacement, and hence should increase the accuracy.

① displacement transducer
② grip
③ test specimen

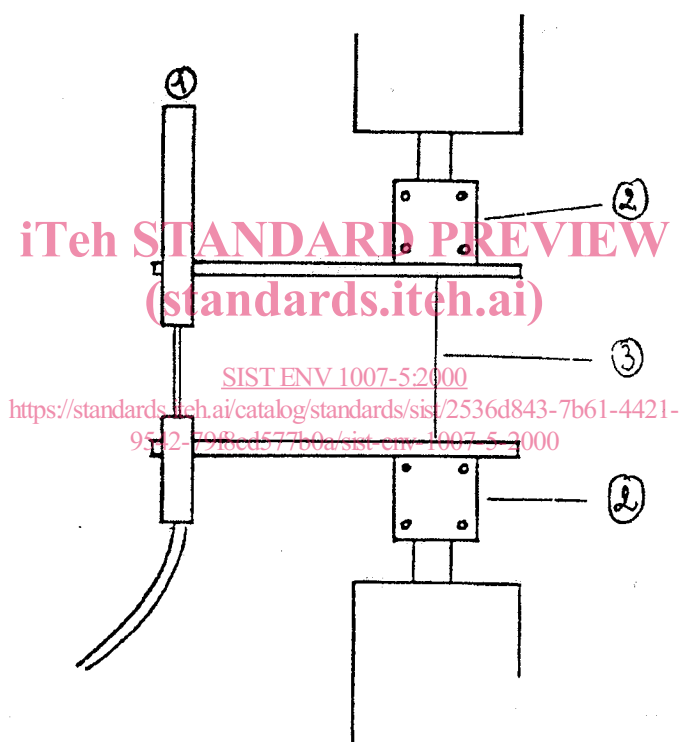


Figure 1

6.2 Data recording

A calibrated recorder shall be used to record force-displacement curves. The use of a digital data recording system combined with an analogue recorder is recommended.

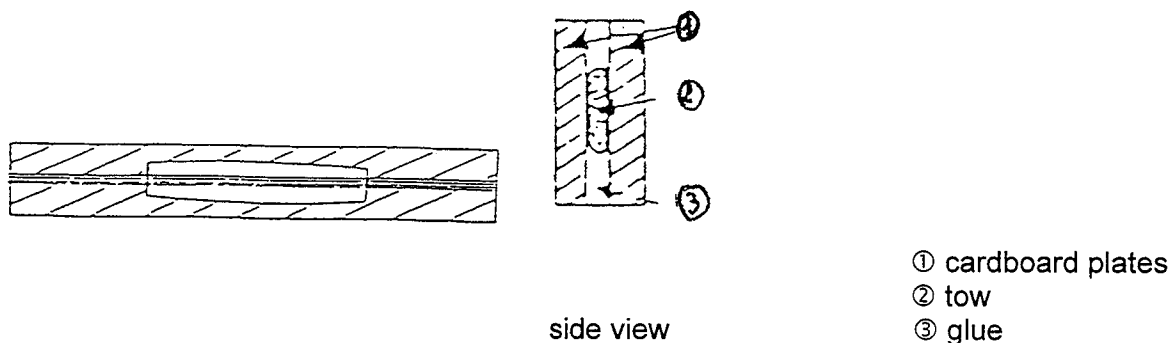
7 Test specimen

Specimens with a gauge length of 200 mm shall be used to establish the filament strength and filament rupture strain distributions. Specimens with gauge lengths of 100 mm and 300 mm shall be used to determine the load train compliance. Examples of two types of test specimen are given below.

7.1 Window type specimen

A window type specimen is shown in figure 2. A stretched tow is fixed between two identical sheets of material each containing a central window. When the displacement is not measured directly on the tow, the height of the window defines the gauge length.

NOTE : This type of specimen has the advantage of easy handling.



gripped end ← gauge length → gripped end

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 Figure 2

7.2 Cylindrical end type specimen

A cylindrical end type specimen is shown in figure 3. Both ends of a stretched tow are fixed in small diameter cylindrical tubes. When the displacement is not measured directly on the tow, the distance between the inner ends of the tubes with the tow in a stretched condition defines the gauge length.

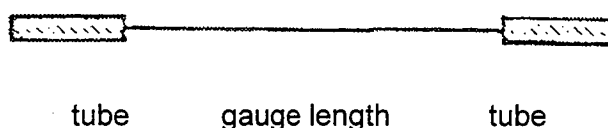


Figure 3

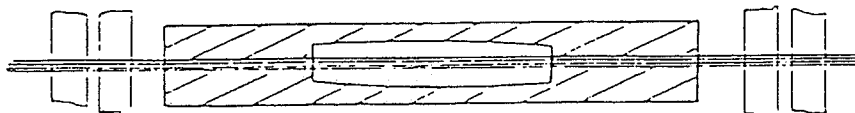
8 Test specimen preparation

Extreme care shall be taken during specimen preparation to ensure that the procedure is repeatable from specimen to specimen. When a glue is used, the same type and the same bonding length shall be used for the preparation of all test specimens of a given series. Specimens shall be handled with care to avoid breaking filaments.

NOTE : High repeatability in specimen preparation is required in order to allow a correct determination of the load train compliance.

8.1 Window type specimen

An untwisted multifilament tow is glued between two identical plates made of cardboard or another suitable material. The filaments shall be stretched. To achieve this, both ends of the two plates are well soaked by the glue, then the tow is placed on the centreline of one of the plates under a small axial prestress. The ends of the tow extending beyond the plate are fixed by adhesive tapes onto a support (see figure 4) and the parts of the tow in the gripping area are soaked with glue. The second plate is then pressed face to face to the first one.



adhesive tapes gripped end ← gauge length L_0 → gripped end adhesive tapes

Figure 4

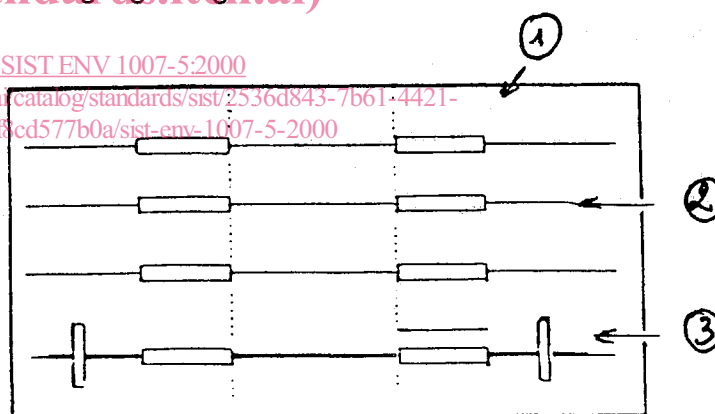
8.2 Cylindrical end type specimen

The specimens are prepared on a support provided with alignment grooves in which the cylindrical tubes are placed. The untwisted multifilament tow is introduced into the tubes, stretched and glued (see figure 5). The diameter of the cylindrical tubes shall be as small as possible, compatible with the size of the tow.

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① support
② groove for alignment
③ adhesive tapes

Figure 5

8.3 Number of test specimens

For the establishment of the distribution of filament strength and filament rupture strain, three valid tests, as specified in 9.7, of specimens with a 200 mm gauge length are needed. When the elongation of the tow is not measured directly, additionally three valid tests at the other two gauge lengths of 100 mm and 300 mm, as specified in 9.7, are required for the establishment of the load train compliance.

9 Test procedure

9.1 Determination of the initial cross section area

For the purpose of determining the filament strength distribution, as well as the elastic modulus on the specimens with a 200 mm gauge length, the initial cross section area of the multifilament tow is calculated from the linear density determined according to ENV 1007-2, and from the density determined in ISO 10119. Alternatively the initial cross section area can be determined by measuring the number and the average diameter of the filaments in the tow, for instance through image analysis.

9.2 Determination of the gauge length

The gauge length shall be measured with an accuracy of $\pm 0,5$ mm.

9.3 Gripping

The specimen shall be placed in the test equipment in such a way that axial alignment is as accurate as possible. During gripping, care shall be taken not to load the specimen in tension. When the displacement is not measured directly on the tow, the specimen shall be inserted in the grips in such a way that the distance between the grips is equal to or less than the gauge length (see figure 6).

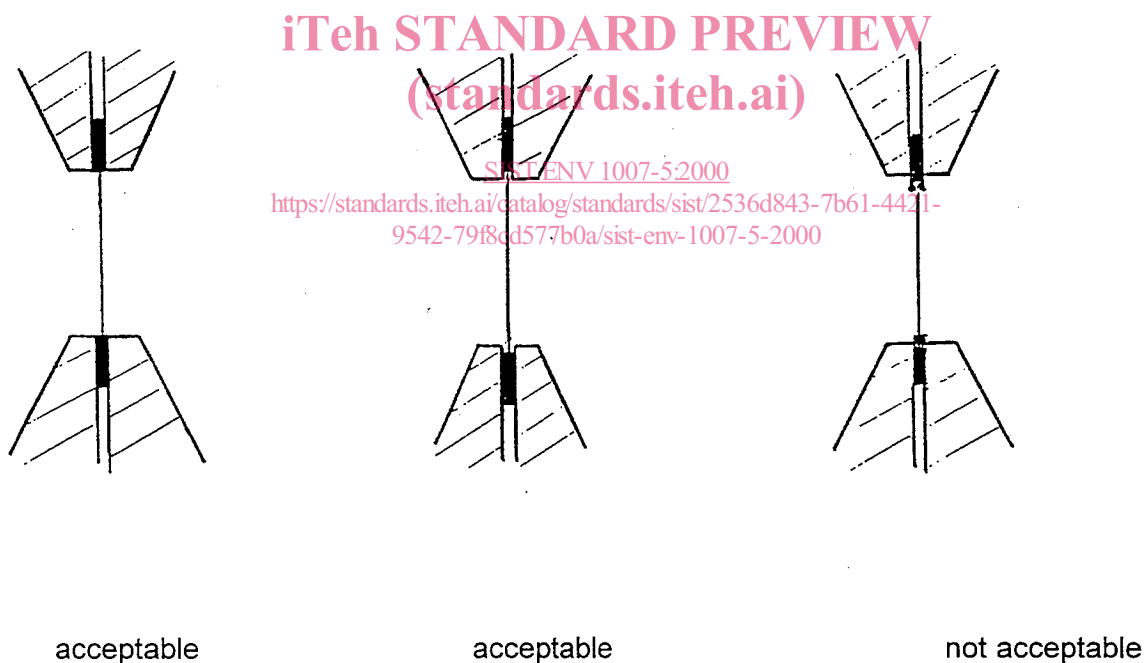


Figure 6