



# SLOVENSKI STANDARD

## SIST ENV 12789:2000

01-december-2000

---

### Advanced technical ceramics - Mechanical properties of ceramic composites at high temperature under air at atmospheric pressure - Determination of flexural strength

Advanced technical ceramics - Mechanical properties of ceramic composites at high temperature under air at atmospheric pressure - Determination of flexural strength

Hochleistungskeramik - Mechanische Eigenschaften von keramischen Verbundwerkstoffen bei hoher Temperatur au Luft bei Atmosphärendruck - Bestimmung der Beigefestigkeit

Céramiques techniques avancées - Propriétés mécaniques des céramiques composites a haute température sous air a pression atmosphérique - Détermination de la résistance en flexion

**Ta slovenski standard je istoveten z: ENV 12789:1998**

---

#### **ICS:**

81.060.30      Sodobna keramika      Advanced ceramics

**SIST ENV 12789:2000**      en

**iTeh STANDARD PREVIEW**  
**(standards.iteh.ai)**

SIST ENV 12789:2000

<https://standards.iteh.ai/catalog/standards/sist/527daf64-2a1d-4f7f-b2ee-18d74996d4f0/sist-env-12789-2000>

EUROPEAN PRESTANDARD  
PRÉNORME EUROPÉENNE  
EUROPÄISCHE VORNORM

**ENV 12789**

April 1998

ICS 81.060.99

Descriptors: composite materials, reinforcing materials, technical ceramics, mechanical properties, high temperature tests, test atmospheres, atmospheric pressure, determination, flexural strength

English version

**Advanced technical ceramics - Mechanical properties of ceramic composites at high temperature under air at atmospheric pressure - Determination of flexural strength**

Céramiques techniques avancées - Propriétés mécaniques des céramiques composites à haute température sous air à pression atmosphérique - Détermination de la résistance en flexion

This European Prestandard (ENV) was approved by CEN on 27 June 1997 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

## Contents

<b>Foreword</b> .....	<b>3</b>
<b>1 SCOPE</b> .....	<b>3</b>
<b>2 NORMATIVE REFERENCES</b> .....	<b>3</b>
<b>3 PRINCIPLE</b> .....	<b>4</b>
<b>4 DEFINITIONS AND SYMBOLS</b> .....	<b>4</b>
4.1 TEST TEMPERATURE, $T$ .....	4
4.2 MAXIMUM FLEXURAL FORCE, $F_M$ .....	4
4.3 FLEXURAL STRESS, $\sigma$ .....	4
4.4 FLEXURAL STRENGTH, $\sigma_{F,M}$ .....	4
<b>5 APPARATUS</b> .....	<b>4</b>
5.1 TEST MACHINE.....	4
5.2 TEST JIG .....	5
5.3 SET-UP FOR HEATING.....	5
5.4 TEMPERATURE MEASUREMENT.....	5
5.5 DATA RECORDING SYSTEM .....	5
5.6 MICROMETERS .....	5
<b>6 TEST SPECIMENS</b> .....	<b>6</b>
<b>7 TEST SPECIMEN PREPARATION</b> .....	<b>6</b>
7.1 MACHINING AND PREPARATION .....	6
7.2 NUMBER OF TEST SPECIMENS .....	7
<b>8 TEST PROCEDURES</b> .....	<b>7</b>
8.1 TEST SET-UP : TEMPERATURE CONSIDERATIONS.....	7
8.2 TEST SET-UP : OTHER CONSIDERATIONS .....	8
8.3 TESTING TECHNIQUE.....	8
8.4 TEST VALIDITY .....	9
<b>9 CALCULATION OF RESULTS</b> .....	<b>9</b>
9.1 TEST SPECIMEN ORIGIN.....	9
9.2 FLEXURAL STRENGTH.....	9
<b>10 TEST REPORT</b> .....	<b>10</b>

## 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 ENV 12789 specifies the conditions for determination of the flexural strength of ceramic matrix composite materials with continuous fibre reinforcement under three-point or four-point bending for temperatures up to 1 700 °C in air at atmospheric pressure.

This prestandard 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.

NOTE 1 : In most cases, ceramic matrix composites to be used at high temperature in air are coated with an antioxidation coating.

NOTE 2 : The purpose of this prestandard is to determine the flexural strength of a material under an oxidizing environment but not to measure material oxidation.

SIST ENV 12789:2000

<https://standards.iteh.ai/catalog/standards/sist/527daf64-2a1d-4f7f-b2ee-f8d74996d4f0/sist-env-12789-2000>

## 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 prestandard only when incorporated in it by amendment or revision. For undated references the latest edition of publication referred to applies.

ENV 843-5	Advanced technical ceramics - Monolithic ceramics - Mechanical tests at room temperature - Part 5 : Statistical analysis
EN 10002-2	Metallic materials - Tensile testing - Part 2 : Verification of the force measuring system of the tensile testing machines
EN 60584-1	Thermocouples - Part 1 : Reference tables
EN 60584-2	Thermocouples - Part 2 : Tolerances
ISO 3611	Micrometer callipers for external measurement

### 3 Principle

A test specimen of specified dimensions is heated to the testing temperature. It is subsequently flexion loaded to fracture in such a way that failure occurs in tension or in compression along one principal axis of reinforcement.

The test is performed at constant crosshead displacement rate.

The test duration is limited to reduce any time dependent effects (creep, etc.).

### 4 Definitions and symbols

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

#### 4.1 test temperature, $T$

Temperature at the centre of the test piece

#### 4.2 maximum flexural force, $F_m$

Highest recorded force in a flexural test on the test specimen when tested to failure.

#### 4.3 flexural stress, $\sigma$

The nominal stress on the outer surface of the test specimen, calculated at mid-span.

NOTE : This stress is conventionally calculated according to the simple beam theory, whose basic assumptions may not be met by ceramic matrix composite materials.

#### 4.4 flexural strength, $\sigma_{f,m}$

Maximum flexural stress applied to a test specimen that fractures during a flexural test

Two flexural strengths can be distinguished :

- **apparent flexural strength,  $\sigma_{f,m,a}$** , when the apparent dimensions are used.
- **effective flexural strength,  $\sigma_{f,m,e}$** , when the dimensions are corrected by a factor, to account for the presence of the antioxidative protection.

### 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.

## 5.2 Test jig

The test jig is composed of two parts, linked to the fixed and mobile parts of the machine. It has two outer support rollers and one (three-point bending) or two (four-point bending) inner support rollers.

The material of the jig and that of the rollers shall not react with that of the specimen, nor with the environment.

The cylindrical rollers shall have a diameter of 4 mm to 10 mm. Their length shall be at least equal to the width of the specimen. They shall be made of a material with a hardness at least equal to that of the specimen. The axes of the rollers shall be parallel to within 0,01 mm/mm.

The outer rollers (three and four-point bending) and inner rollers (four-point bending) shall be free to rotate (see figure 1).

Either two or three rollers, for three-point or four-point bending respectively, shall be free to pivot around an axis parallel to the longitudinal direction of the test specimen, in order to adapt to the non-parallelism of the upper and lower faces of unmachined test specimens( see figure 1).

The rolling and pivoting ability of the rollers shall not be affected by heating. The distance between rollers shall be in accordance to clause 6.

The inner roller(s) shall be centred with respect to the outer rollers to within 0,2 mm. In the case of four-point bending a levelling system shall be used to ensure symmetrical loading of the test specimen.

The performance shall not change because of heating.

<https://standards.iteh.ai/catalog/standards/sist/527daf64-2a1d-4f7f-b2ee-18d74996d4f0/sist-env-12789-2000>

## 5.3 Set-up for heating

The set-up for heating shall be constructed in such a way that the variation of temperature of the test specimen which is between the outer support rollers is less than 50 °C at test temperature.

## 5.4 Temperature measurement

Thermocouples shall comply to 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.

## 5.5 Data recording system

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

## 5.6 Micrometers

Micrometers used for the measurement of the dimensions of the test specimen shall be in accordance with ISO 3611.

## 6 Test specimens

Recommended specimen dimensions are given in table 1. These dimensions have been successfully used and take due account of the following factors:

The amount of material under load shall be representative of the nature of the material and of the reinforcement structure. This sets minimum limits to the span and to the width and thickness of the specimen. In the case of flexural, as opposed to tensile testing, also the distribution of the longitudinal reinforcement through the thickness has to be considered. When this distribution is not symmetrical with respect to the neutral plane, care shall be taken to insure that it is similar between specimens.

The thickness and the distance between the inner and outer roller(s) shall be chosen so as to avoid shear failure. This is achieved by setting a minimum limit to the ratio between the moment arm and the specimen thickness. A value of 10 is commonly used and translates into a minimum  $L/h$  ratio of 20 in three-point bending, and a minimum  $(L-L_i)/h$  ratio of 20 in four-point bending with  $L_i=L/3$ .

Other factors affecting the size and dimensions of the specimens are the type of the heating and of the loading system.

**Table 1 : Recommended test specimen and span dimensions**

iTech STANDARD PREVIEW  
(standards.iteh.ai)

Dimensions in millimeters

	1D 2D & xD	Tolerance
$L_t$ , total length	$L + 10$	$+ 1$
b, width	10	$\pm 0,2$
h, thickness	2,5	$\pm 0,2$
Inner span four-point bending, $L_i$	25	$\pm 0,1$
Outer span four-point bending, L	75	$\pm 0,1$
three-point bending, L	50	$\pm 0,1$

NOTE : If it is necessary to define test specimens of different dimensions, the conditions of clause 6 should be taken into account.

## 7 Test specimen preparation

### 7.1 Machining and preparation

During cutting out, care shall be taken to align the longitudinal test specimen axis with one of the principal axes of reinforcement.

Specimens may be tested with either machined or non-machined top and bottom surfaces. In some cases machining is not recommended because it may cause breakage of the fibers near the top and bottom surfaces as well as damage to the antioxidation coating if present. When machining these surfaces, care shall be taken to maintain a reinforcement geometry across the thickness of the specimen, which is representative of the material in the as-processed condition. In particular, it shall be assured that the symmetry of an originally symmetric reinforcement geometry is preserved in the specimen cross section after machining.



Machining parameters which avoid damage to the material shall be established and documented. These parameters shall be adhered to during test specimen preparation.

NOTE : When specimens are machined from a plate which has been protected against oxidation, the cut surfaces of the specimen are unprotected. These surfaces should be protected to prevent oxidation.

## 7.2 Number of test specimens

At least five valid test results, as specified in paragraph 8.4 are required per loading condition. For specimens with a non-symmetric reinforcement geometry with respect to the neutral plane, tests in two orientations for which the tensile and compressive face are interchanged may be necessary.

If a statistical evaluation of the flexural strength is required, the number of test specimens shall be in accordance with ENV 843-5.

## 8 Test procedures

### 8.1 Test set-up : Temperature considerations

The following determination shall be carried out under conditions representative of the tests, and shall be repeated every time there is a change in material, in specimen geometry, in loading attachments, etc.. In establishing them, time shall be allowed for temperature stabilisation.

Prior to testing, the temperature gradient within the outer span shall be established over the temperature range of interest. This shall be done by measuring the specimen temperature at a minimum of three locations, which shall be the points over the supports and at the centre. The temperature variation within the outer span shall meet the requirements of paragraph 5.3.

During a series of tests, the test temperature can be determined either directly by measurement on the specimen itself, or indirectly from the temperature indicated by the temperature control device. In the latter case, the relationship between the control temperature and test specimen temperature at the centre of the length shall be established beforehand on a dummy test specimen over the range of temperature of interest. The dummy specimen shall be made of the same material as the specimen to be tested.

NOTE: The relationship between the temperature indicated by the temperature control system and the test temperature is usually established simultaneously with the temperature gradient

Temperature may be measured by any means complying with paragraph 5.4. If thermocouples are used to measure the temperature at different locations of the specimen, they shall be embedded (and sealed if necessary) into a dummy specimen to a depth approximately equal to half the specimen dimension in the direction of insertion.