# SLOVENSKI STANDARD
# SIST ENV 1159-1:2000

**01-december-2000**

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**Advanced technical ceramics - Ceramic compounds - Thermophysical properties - Part 1: Determination of thermal expansion**

Advanced technical ceramics - Ceramic compounds - Thermophysical properties - Part 1: Determination of thermal expansion

Hochleistungskeramik - Keramische Verbundwerkstoffe - Thermophysikalische Eigenschaften - Teil 1: Bestimmung der thermischen Ausdehnung



Céramiques techniques avancées - Céramiques composites - Propriétés thermophysiques - Partie 1: Détermination de la dilatation thermique



**Ta slovenski standard je istoveten z:** **ENV 1159-1:1993**

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**SIST ENV 1159-1:2000** **en**

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**ENV 1159-1**

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Descriptors: Composite materials, reinforcing materials, ceramics, thermodynamic properties, determination, thermal expansion

English version

# Advanced technical ceramics - Ceramic composites - Thermophysical properties - Part 1:Determination of thermal expansion

Céramiques techniques avancées - Céramiques composites - Propriétés thermophysiques Partie 1: Détermination de la dilatation thermique

Hochleistungskeramik - Keramische Verbundwerkstoffe - Thermophysikalische Eigenschaften - Teil 1: Bestimmung der thermischen Ausdehnung



This European Prestandard (ENV) was approved by CEN on 1992-09-30 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 an European Standard (EN).

CEN members are required to announce the existance 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, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

**CEN**

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

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**Contents list**



**Annexes**

**Foreword**

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

ENV 1159 consists of three parts:

Part 1: Determination of thermal expansion
Part 2: Determination of thermal diffusivity
Part 3: Determination of specific heat capacity

CEN/TC 184 approved this European Prestandard by resolution 2-92 during its sixth meeting held in Alkmaar, Netherlands on 92-09-30.

According to the CEN/CENELEC Internal Regulations, the following countries are bound to announce this European prestandard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom.

Advanced technical ceramics - Ceramic composites - Thermophysical properties - Part 1: Determination of thermal expansion

## 1 Scope

This Part of ENV 1159 describes methods for the determination of the linear thermal expansion characteristics of ceramic matrix composite materials up to 2300 K, and is applicable to 1D, 2D and nD materials.

The method describes general principles of construction calibration and operation of the equipment.

## 2 Normative references

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

EN 821-1 : Advanced technical ceramics - Monolithic ceramics - Thermophysical properties : Part 1 : Determination of thermal expansion 1)



EN 45001 : General criteria for the operation of testing laboratories

HD 446.1 SI : Thermocouples : Part 1 : Reference tables



ISO 31-4 : Quantities and units - Part 4: Heat

ISO 3611 : Micrometer callipers for external measurement

ISO 6906 : Vernier callipers reading to 0,02 mm

## 3 Definitions

For the purpose of this prestandard the following definitions apply:

**3.1 Linear thermal expansion:** Positive or negative change in one dimension that occurs when a material is subjected to a change in temperature.

**3.2 Linear thermal expansion coefficient at temperature T:** The derivative of the length L with respect to temperature at the temperature T, divided by the length at temperature T.

$$\alpha_T = \frac{1}{L} \left(\frac{dL}{dT}\right)_{(T)}$$

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1) In preparation

**3.3 Mean linear thermal expansion coefficient between temperatures $T_1$ and $T_2$:** Linear thermal expansion between temperatures $T_1$ and $T_2$ divided by the temperature increment $T_1$ to $T_2$ and the length at temperature $T_1$.

$$\alpha(T_1, T_2) = \frac{L(T_2) - L(T_1)}{L(T_1)} \cdot \frac{1}{T_2 - T_1}$$

**3.4 Representative volume element (R.V.E,):** The minimum volume which is representative of the material considered.

## 4 Principle

### 4.1 General

A test piece is heated and subsequently cooled, either at a specified uniform rate or using defined temperature increments. Its change of length and its temperature are measured continuously or at regular frequent intervals during the imposed temperature cycle.

One of two methods may be used to determine the linear thermal expansion coefficient, either by direct measurement or by a differential method.



### 4.2 Direct measurement

In this method the variation in length of the test piece is measured directly. It is necessary to know the change in dimensions of the test piece support system by previous calibration.



The test piece is placed in a specimen holder and is made to contact a displacement transducer by using a push rod made of the same material as the holder. This assembly is put in a furnace. The differential expansion between the test piece and the test piece holder is measured during the increase and the decrease in temperature.

The apparatus is shown in figure 1.

### 4.3 Differential method

This method consists of measuring the changes in length between a reference piece (see 6.2) and the test piece. It is not therefore necessary to know the change in dimensions of the test piece support system.

The apparatus is shown in figure 2.

## 5 Apparatus

### 5.1 Construction materials

The test piece holder and the push rod shall be made from thermomechanically stable materials of the same type, which shall be chemically inert and thermally compatible with the test piece material under the environmental conditions of the test.

NOTE : For temperatures above 1400 °C, it is necessary to employ a vacuum or inert gas atmosphere, with a non-oxide material appropriate for the test environment, such as a grade of dense graphite.

### 5.2 Heating and cooling device

Furnace, capable of working in a controlled atmosphere when required, and of controlling the temperature of the test piece to within 1 % of its mean temperature, expressed in K.

### 5.3 Temperature measurement

Thermocouples, in accordance with HD 446.1, subject to the upper temperature requirements and environmental consideration, except for tungsten-rhenium couples which may be used at higher temperatures, but are not covered by HD 446.1 and should be individually calibrated. For temperature in excess of 2000 K, infrared detectors or any suitable device may be used.



### 5.4 Test piece mounting

The device used shall allow free axial movement of the test piece and of the reference piece in case of differential measurement. The mechanical environment shall minimize stresses. For vertical measurement apparatus, the test pieces shall be free standing and mechanically stable on the end-plate. For measuring apparatus which is horizontal or inclined to the horizontal, the sideways movement or twist of the test piece shall be restricted, without any restriction of axial movement, by a suitable arrangement.

### 5.5 System for measuring and recording the thermal expansion

System, capable of measuring displacements to an accuracy better than 0,1 µm. The system shall allow recording of the test piece temperature and the displacement simultaneously. The system for measuring of displacements shall be periodically calibrated in accordance with annex A for direct measurement or annex B for differential measurement.

### 5.6 Test piece measurement

Device for measuring the test piece dimensions, with an accuracy better than 0,05 mm (e.g. micrometer in accordance with ISO 3611 or callipers in accordance with ISO 6906).

## 6 Specimens

### 6.1 Test pieces

The dimensions of the test pieces depend on the type of apparatus used. For differential measurements, the test piece and the reference piece (see 6.2) shall have the same length $L_0$ (see table 1).

The test piece shall be cut in such a way that the axis of desired measurement is related to the principal fibre orientations in accordance with agreement between parties to the measurement.

The end-faces of the length of the test piece shall be plane, parallel to each other and perpendicular to the long axis.

### 6.2 Reference pieces

Reference materials shall be chosen so that their properties are as close as possible to the properties of the material to be tested. The reference piece shall have a volume of the same order and if possible shall have the same dimensions as the test piece (see table 1).



For measurement at high temperature (over 2000 K) under inert atmosphere, reference materials generally used are either tungsten or highly purified graphite. Reference materials shall be procured from a certified laboratory.



NOTE : NIST in USA is one laboratory which supplies reference materials. Highly purified 'POCO' graphite is largely used as a reference for measurement at high temperature.

### 6.3 Dimensions

**Table 1 : Recommended test piece dimensions**

Dimensions in millimeters

| | Material with small R.V.E. (see 3.4) such as 1D or 2D | Material with large R.V.E. (see 3.4) such as nD | Tolerances |
|---|---|---|---|
| L(o), total length | 30 | 70 | ± 0,2 |
| B, width | 7 | | |
| h, thickness | depending on material and equipment | depending on material and equipment | depending on material and equipment |
| diameter | - | 30 | - |
| Parallelism of end faces | ± 0,01 | ± 0,01 | - |

NOTE 1 : A test piece volume of a minimum of 5 R.V.E. is recommenced (see 3.4)

NOTE 2 : The shape and dimensions of the test piece depend on the structure of reinforcement. In the case of material such as 3D, a large test piece is often necessary when the representative volume element is important.