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Fine ceramics (advanced ceramics, advanced technical ceramics) — Ceramic composites — Determination of the degree of misalignment in uniaxial mechanical tests

National foreword

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Fine ceramics (advanced ceramics, advanced technical ceramics) — Ceramic composites — Determination of the degree of misalignment in uniaxial mechanical tests

Céramiques techniques — Céramiques composites — Détermination du degré de non-alignement lors des essais mécaniques uniaxiaux

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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The committee responsible for this document is ISO/TC 206, *Fine ceramics*.

Fine ceramics (advanced ceramics, advanced technical ceramics) — Ceramic composites — Determination of the degree of misalignment in uniaxial mechanical tests

1 Scope

This International Standard describes a procedure

— to verify the degree of misalignment of the load train of the test machines using a reference test specimen uniformly loaded in tension or in compression, and

— to give indications in order to correct defects such as torsion and bending.

This International Standard is not intended to provide a quantitative and acceptable limit before the testing of ceramic matrix composites with a fibre reinforcement: unidirectional (1D), bidirectional (2D), and tridirectional (xD, with $2 < x \leq 3$) loaded along one principal axis of reinforcement. This limit depends on the sensitivity of each type of composite to the misalignment defect.

NOTE 1 This limit is to be defined between the testing establishment and the customer.

NOTE 2 Monolithic ceramics are very sensitive to misalignment defects while CMCs (ceramic matrix composite) in general are moderately sensitive to them.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3611, *Geometrical product specifications (GPS) — Dimensional measuring equipment: Micrometers for external measurements — Design and metrological characteristics*

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/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

CEN/TR 13233:2007, *Advanced technical ceramics — Notations and symbols* (to be replaced by future ISO NP 19634)

3 Terms and definitions

For the purposes of this document, the terms and definitions given in CEN/TR 13233:2007 (to be replaced by future ISO NP 19634) and the following apply.

3.1 General

3.1.1
calibrated length
l
part of the reference test specimen which has a uniform and minimum cross-section area

3.1.2
width
b
width of the reference test specimen in the calibrated length

3.1.3
thickness
h
thickness of the reference test specimen in the calibrated length

3.2 Type of defects

3.2.1
C-type magnitude
θ
angle between the loading axis of each of the two grips

Note 1 to entry: See Figure 1.

3.2.2
S-type magnitude
d
distance between the loading axis when they are parallel

Note 1 to entry: See Figure 2.

3.2.3
torsion defect magnitude
ϕ
angle between the gripping planes

Note 1 to entry: See Figure 3.

4 Principle

A rectangular cross section of a reference test specimen (Clause 7) equipped with 10 strain gauges is loaded in tension or in compression, up to a load corresponding to 10 % of the nominal load capacity of the load cell used for the tests of CMCs. The stress corresponding to this value shall not exceed 50 % of the elasticity limit of the material used for the reference test specimen. The readings obtained from the strain gauges bonded on the calibrated length of the reference test specimen allow the determination of the degree of misalignment.

The positioning of strain gauges is such that it indicates the magnitude of defects. These magnitudes allow the correction, in a practical manner, of the different types of defects:

— bending defects, either C (Figure 1) or S (Figure 2);

— torsion (Figure 3).

The indications for correction are obtained by comparing the experimental readings of the strain gauges to values from charts established from numerical simulations.

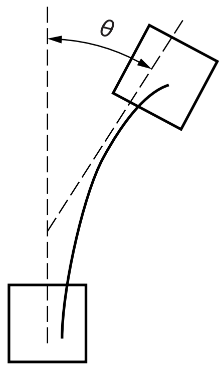


Figure 1 — C defect magnitude

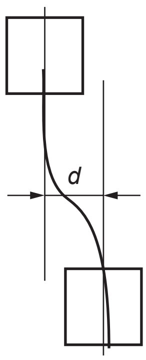
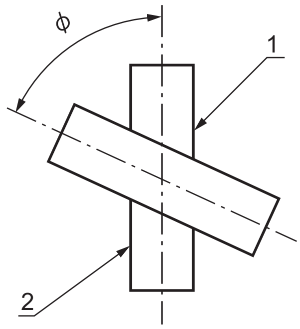


Figure 2 — S defect magnitude



Key

1 lower grip

2 upper grip

Figure 3 — Torsion defect magnitude

5 Apparatus

5.1 Test machine

The configuration of the test machine, including the load train and load cell, shall be identical to the test machine used for the tests on the CMCs and shall be in accordance with ISO 7500-1.

5.2 Load train

The load train configuration shall ensure that the load indicated by the load cell and the load experienced by the test specimen are the same.

The grip design shall prevent the test specimen from slipping. The choice of gripping system will depend on material, on test specimen design, and on alignment requirements.

5.3 Strain gauges

The principle of this method requires the use of strain gauges with an active surface equal to or smaller than $4 \times 2{,}5\ mm^2$.

Furthermore, the distance between the edge of the test reference specimen and the longitudinal axis of the strain gauge shall be such as to avoid edge effects. A minimum distance of 2 mm is required.

Care shall be taken to ensure that the strain gauge readings are not influenced by the surface preparation and the adhesive used.

5.4 Data recording system

A calibrated recorder can be used to record load/strain curves. The use of a data recording system combined with an analogue recorder is recommended.

All strain measuring equipment and data acquisition systems shall be calibrated as appropriate. Typically they shall have an accuracy to within ±0,5 % of indicated reading or ±3 microstrain, whichever is greater, and a resolution of 1 microstrain.

5.5 Micrometers

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

6 Reference test specimens

The degree of misalignment of the load train of the test machine is verified by performing tests at room temperature with the following reference test specimen:

— dimensions: see Figure 4 and Table 1;

— material: steel ISO reference;

— location of the strain gauges: see Figure 4.

If another reference test specimen is used, it is necessary to establish a new series of charts.

Plan parallelism of the faces: ±0,02 mm.

Dimensions of the strain gauges, in millimetres: 

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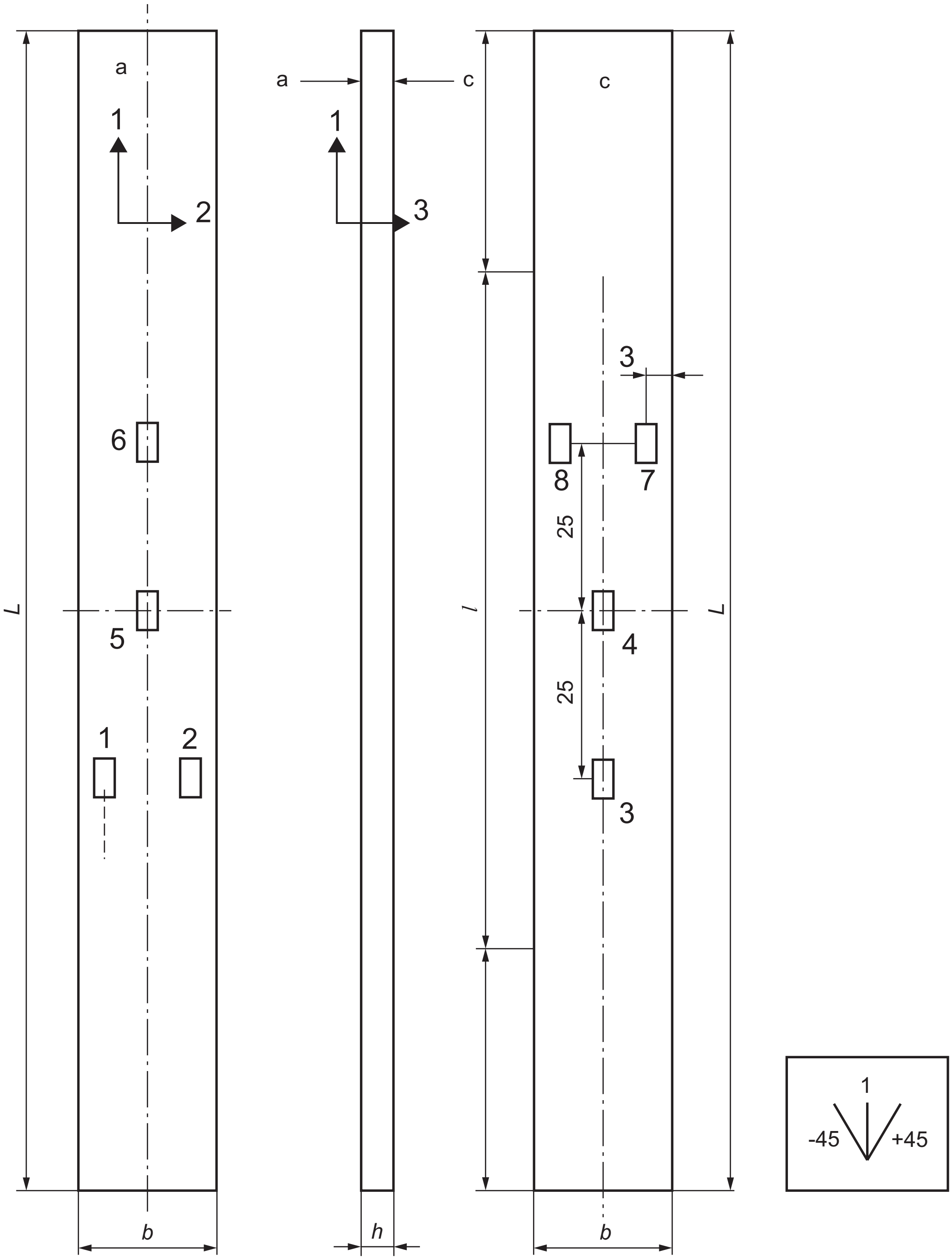
Dimensions in millimetres



NOTE 1 Gauge n° 5 is a rosette allowing measurements of strains parallel to 1 and to ±45°.

NOTE 2 Keys a and c indicate each surface.

Figure 4 — Dimensions of the reference test specimen and location of the strain gauges

7 Reference test specimen preparation

7.1 Adhesion of strain gauges

It is essential to protect strain gauges and adhesives from effects due to moisture and other degrading contaminants. Therefore, it is recommended that after installation of the strain gauges, a layer of protective coating material such as strain-gauge-grade silicone rubber is applied.

7.2 Reference test specimen validity

Periodically check the response of the strain gauges by comparing Young's modulus of the steel, the reference test specimen is made from, determined for each location of the strain gauges, to the value of Young's modulus determined during the first utilization of the reference test specimen by the same method.

The difference between these two values shall not exceed 5 %. This value shall be indicated more accurately when more experimental results are made available.

It is recommended to do this verification once a year.

8 Test procedure

8.1 General

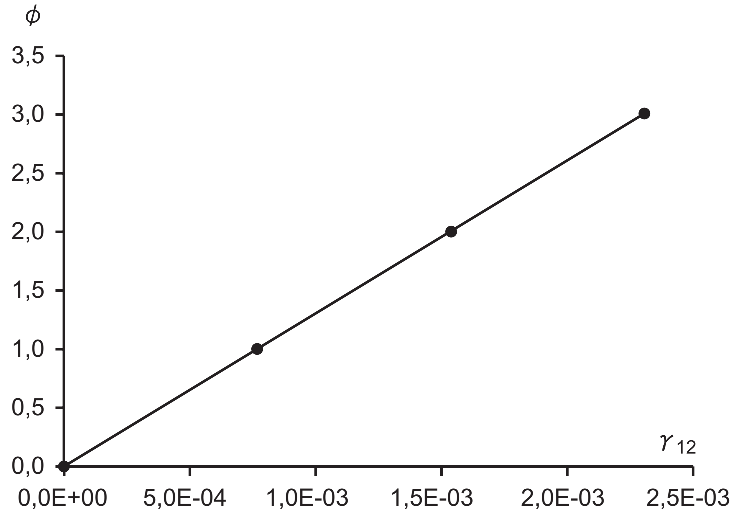
The procedure consists of the following sequence.

8.2 Correction of the torsion defect

The reference test specimen is gripped while keeping the uniaxial load at 0 by using a specific mounting tool that secures a strict parallelism between the loading axis and the longitudinal axis of the reference test specimen. To check it, compare responses given by gauges 1 and 2.

Record the reading of strain gauges at position 5 and calculate the distortion ($\varepsilon_{+45} - \varepsilon_{-45}$). This value allows the determination of the torsion defect using chart 1 (see Figure 5). If this value is higher than the authorized limit, a correction of the angle ϕ between the two grips shall be done.

The above procedure is repeated until the value of the angle ϕ is less than or equal to the authorized limit.



NOTE ϕ is in degrees and strains are dimensionless: $\phi = 1\,287{,}6\ \gamma_{12}$.

Figure 5 — Chart 1 — Torsion defect

8.3 Correction of the C defect

Load the reference test specimen to stretch the load train.

Record the longitudinal readings of the strain gauges located at position 4 ($\varepsilon_{1,4}$) and 5 ($\varepsilon_{1,5}$): see specimen drawing in Figure 4 given by strain gauges n° 4 and n° 5, respectively, and see dimensions in Table 1.

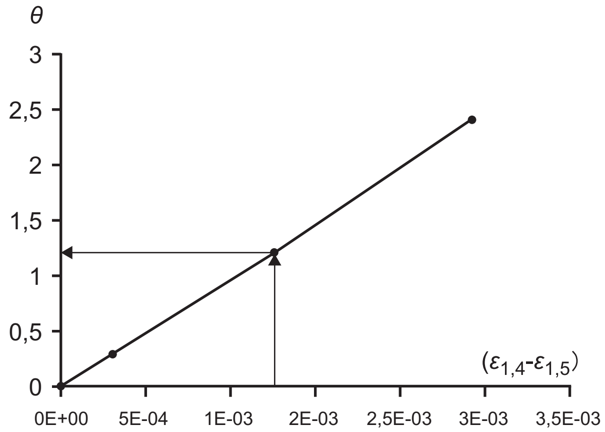
Calculate the value of ($\varepsilon_{1,4} - \varepsilon_{1,5}$) and determine the C defect using chart 2 (see Figure 6). If this value is higher than the authorized limit, a correction of the angle θ between the loading axis of each of the two grips shall be done.

The above procedure is repeated until the value of the angle θ is less or equal to the authorized limit.

Then unload the reference test specimen.

Table 1 — Specimen dimensions

	Dimensions mm	**Tolerances** mm
length with strain gauges, *l*	100	±0,1
thickness, *t*	4	±0,1
width, *b*	18	±0,1
a *L* = 200 mm is recommended.		



NOTE θ is in degrees and strains are dimensionless: $\theta = 790\ (\varepsilon_{1,4} - \varepsilon_{1,5})$.

Figure 6 — Chart 2 — C defect

8.4 Correction of the S defect

Load the reference test specimen to stretch the load train.

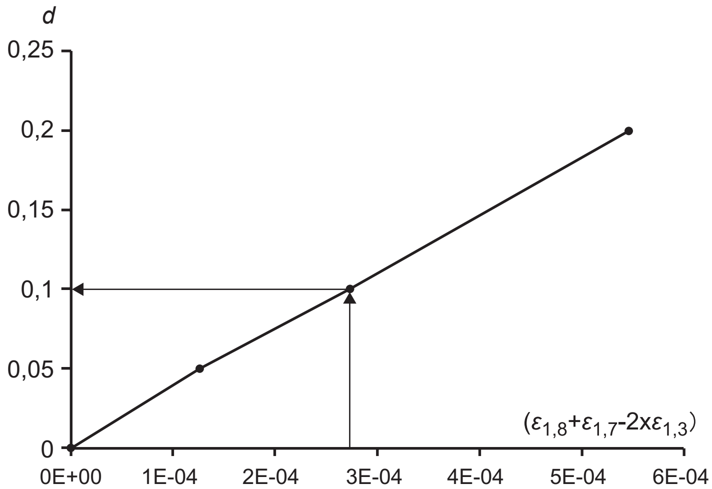
Record the longitudinal deformations of the strain gauges located at positions 1, 2, 3, 6, 7, and 8 ($\varepsilon_{1,1}$, $\varepsilon_{1,2}$, $\varepsilon_{1,3}$, $\varepsilon_{1,6}$, $\varepsilon_{1,7}$, and $\varepsilon_{1,8}$ respectively); see specimen drawing in Figure 4 and dimensions in Table 1.

Calculate the value of ($\varepsilon_{1,8} + \varepsilon_{1,7} - 2 \times \varepsilon_{1,3}$) and of ($\varepsilon_{1,1} + \varepsilon_{1,2} - 2 \times \varepsilon_{1,6}$). The higher of these two values is then used to determine the S defect from chart 3 (see Figure 7). If this value is higher than the authorized limit, a correction of the distance d between the loading axes when they are parallel shall be done.

The above procedure is repeated until the value of the distance d is less than or equal to the authorized limit.

Then unload the reference test specimen.

Dimensions in millimetres



NOTE Strains are dimensionless: $d = 371{,}43\ (\varepsilon_{1,8} + \varepsilon_{1,7} - 2 \times \varepsilon_{1,3})$.

Figure 7 — Chart 3 — S defect

8.5 Final verification before starting a series of measurements on CMCs

Load the reference test specimen up to 50 % of its elastic limit. Record simultaneously all the longitudinal deformations given by strain gauges located at positions 1 to 8 ($\varepsilon_{1,1}$, $\varepsilon_{1,2}$, $\varepsilon_{1,3}$, $\varepsilon_{1,4}$, $\varepsilon_{1,5}$, $\varepsilon_{1,6}$, $\varepsilon_{1,7}$, and $\varepsilon_{1,8}$, respectively).

Apply the procedures described in 8.3 and 8.4 for the calculation and correction of the C and S defects, respectively.

Then use the values of deformations in order to determine the percent bending strain (PBS). PBS is the bending strain times 100 divided by the axial strain.

Unload the reference test specimen.

Remove it from the grips.

Rotate the test specimen 180° around the longitudinal axis and replace it in the grips.

Repeat the final verification procedure.

9 Test report

The test report shall be in accordance with the reporting provisions of ISO/IEC 17025 and shall contain at least the following information:

a) the name and address of the testing establishment;

b) date of test;

c) on each page, a unique report identification and page number;

d) customer name and address;

e) a reference to this International Standard, i.e. determined in accordance with ISO 17161;

f) an authorizing signature;

g) any deviation from the method described, with appropriate validation, i.e. demonstrated to be acceptable to the parties involved;

h) a description of the equipment used;

i) reference test specimen used, if different from the recommended one;

j) test specimen drawing;

k) the dimensions of all strain gauges used, expressed in millimetres;

l) maximum values of torsion defect, C defect, and S defect, after final verification;

m) number of tests carried out and the number of valid results obtained;

n) details of any aspect of the experimental procedure which might influence the results;

o) comments on the test or test results.

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[2] Reynaud P., Tallaron C., Cosculluela A., Cambas C., Gomez P., Delamaide J.L. et al. ICCM 12, Juillet, 1999, *Measurement of bending in specimens of CMC uniaxially loaded in tension-compression,* Paris

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