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# Fine ceramics (advanced ceramics, advanced technical ceramics) — Mechanical properties of ceramic composites at room temperature — Determination of compressive properties

*Céramiques techniques — Propriétés mécaniques des composites à matrice céramiques à température ambiante — Méthode de détermination des propriétés en compression*

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# Foreword

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This document was prepared by Technical Committee ISO/TC 206, *Fine ceramics*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 184, *Advanced technical ceramics,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 20504:2019), of which it constitutes a minor revision. The changes are as follows:

— notation of 3.3 and 3.4 harmonized and replaced throughout the document;

— duplicated text removed from the definition in 3.6;

— minor editorial changes.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.


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# Fine ceramics (advanced ceramics, advanced technical ceramics) — Mechanical properties of ceramic composites at room temperature — Determination of compressive properties

## 1 Scope

This document describes procedures for determination of the compressive behaviour of ceramic matrix composite materials with continuous fibre reinforcement at room temperature. This method applies to all ceramic matrix composites with a continuous fibre reinforcement, uni-directional (1D), bi-directional (2D) and tri-directional ($x$D, with $2 < x < 3$), tested along one principal axis of reinforcement or off axis conditions. This method also applies to carbon-fibre-reinforced carbon matrix composites (also known as carbon/carbon or C/C). Two cases of testing are distinguished: compression between platens and compression using grips.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. 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 — Calibration and verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Calibration and verification of the force-measuring system*

ISO 9513, *Metallic materials — Calibration of extensometer systems used in uniaxial testing*

ISO 14744, *Welding — Acceptance inspection of electron beam welding machines*

ISO 17161, *Fine ceramics (advanced ceramics, advanced technical ceramics) — Ceramic composites — Determination of the degree of misalignment in uniaxial mechanical tests*

## 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

**3.1**
**calibrated length**
part of the test specimen which has uniform and minimum cross-sectional area

**3.2**
**initial gauge length**
$L_0$
initial distance between reference points on the test specimen in the calibrated length before initiation of the test

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**3.3**
**initial cross-sectional area**
$S_o$
initial area of specimen cross-section in the calibration length

**3.4**
**longitudinal deformation**
$A$
decrease of the initial gauge length under compressive force

Note 1 to entry: The longitudinal deformation corresponding to the maximum force is denoted as $A_{c,m}$.

**3.5**
**compressive strain**
$\varepsilon$
relative decrease of the gauge length defined as the ratio $A/L_o$

Note 1 to entry: The compressive strain corresponding to the maximum force is denoted as $\varepsilon_{c,m}$.

**3.6**
**compressive force**
$F_c$
uniaxial force carried by the test specimen at any time during the test

**3.7**
**maximum compressive force**
$F_{c,m}$
greatest uniaxial compressive force applied to the test specimen when tested to failure

**3.8**
**compressive stress**
$\sigma$
compressive force supported by the test specimen at any time in the test divided by the initial cross-sectional area such that $\sigma = F_c/S_o$

**3.9**
**compressive strength**
$S_{c,m}$
greatest compressive stress applied to a test specimen when tested to failure

**3.10**
**proportionality ratio**
**pseudo-elastic modulus**
$E_p$
slope of the linear region of the stress-strain curve, if any

Note 1 to entry: Examination of the stress-strain curves for ceramic matrix composites allows definition of the following cases:

— Material with a linear region in the stress-strain curve.

For ceramic matrix composites that have a mechanical behaviour characterised by a linear region, the proportionality ratio $E_p$ is defined using Formula (1).

$$E_p(\sigma_1, \sigma_2) = \frac{\sigma_2 - \sigma_1}{\varepsilon_2 - \varepsilon_1} \quad (1)$$

where ($\varepsilon_1$, $\sigma_1$) and ($\varepsilon_2$, $\sigma_2$) lie near the lower and the upper limits of the linear region of the stress-strain curve (see Annex A, Figures A.1 and A.2).

— Material with nonlinear region in the stress-strain curve. In this case only, stress-strain couples can be determined at specified stresses or specified strains.


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**3.11**
**elastic modulus**
*E*
proportionality ratio or pseudo-elastic modulus, in the special case where the linearity starts near the origin

Note 1 to entry: See Figure A.2.

# 4 Principle

A test specimen of specified dimensions is loaded in compression. The compression test is usually performed at a constant cross-head displacement rate or at a constant deformation rate.

Constant force rate is only allowed in the case of linear stress-strain behaviour up to failure.

For crosshead displacement tests, a constant rate is recommended when the test is conducted to failure.

The force and longitudinal deformation are measured and recorded simultaneously.

# 5 Apparatus

## 5.1 Test machine

The machine shall be equipped with a system for measuring the force applied to the test specimen that shall conform to grade 1 or better in accordance with ISO 7500-1.

## 5.2 Load train

The load train is composed of movable and fixed cross-heads, the loading rods and the grips or platens. Load train couplers may additionally be used to connect the grips or platens to the loading rods.

The load train shall align the test specimen axis with the direction of force application without introducing bending or torsion in the test specimen. The misalignment of the test specimen shall be verified and documented in accordance with the procedure described in ISO 17161. The maximum percent bending strain (PBS) shall not exceed 5 % at an average axial strain of $500 \times 10^{-6}$.

There are two alternative means of force application:

1) Compression platens are connected to the force transducer and the moving cross-head. The parallelism of these platens shall be better than 0,01 mm in the loading area and the faces of the platens shall be perpendicular to the force application direction.

   The use of platens is not recommended for compression testing of 1D and 2D materials with small thicknesses because of buckling.

   NOTE A compliant interlayer material (composed only of paper or cardboard) between the test specimen and platens can be used for testing macroscopically inhomogeneous materials to ensure uniform contact pressure.

   When the dimensions of the test specimen are such that buckling can occur, it is recommended that antibuckling devices are used similar to those described in ISO 14126. These devices should not introduce parasitic stresses during loading of the test specimen.

2) Grips are used to clamp and load the test specimen. The grip design shall prevent the test specimen from slipping and the grips shall align the test specimen axis with that of the applied force.

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