



BSI Standards Publication

Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for compressive behaviour of continuous fibre-reinforced composites at room temperature (ISO 20504:2006)

National foreword

This British Standard is the UK implementation of EN ISO 20504:2016. It is identical to ISO 20504:2006. It supersedes BS EN 658-2:2002 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee RPI/13, Advanced technical ceramics.

A list of organizations represented on this committee can be obtained on request to its secretary.

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English Version

Fine ceramics (advanced ceramics, advanced technical ceramics) - Test method for compressive behaviour of continuous fibre-reinforced composites at room temperature (ISO 20504:2006)

Céramiques techniques - Méthode d'essai de résistance à la compression des composites renforcés de fibres continues à température ambiante (ISO 20504:2006)

Hochleistungskeramik - Bestimmung der Eigenschaften unter Druck von endlosfaserverstärkten Verbundwerkstoffen bei Raumtemperatur (ISO 20504:2006)

This European Standard was approved by CEN on 25 March 2016.

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European foreword

The text of ISO 20504:2006 has been prepared by Technical Committee ISO/TC 206 “Fine ceramics” of the International Organization for Standardization (ISO) and has been taken over as EN ISO 20504:2016 by Technical Committee CEN/TC 184 “Advanced technical ceramics” the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2016, and conflicting national standards shall be withdrawn at the latest by October 2016.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 658-2:2002.

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Endorsement notice

The text of ISO 20504:2006 has been approved by CEN as EN ISO 20504:2016 without any modification.

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 20504 was prepared by Technical Committee ISO/TC 206, *Fine ceramics*.

Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for compressive behaviour of continuous fibre-reinforced composites at room temperature

1 Scope

This International Standard 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 $2 < x \leq 3$), tested along one principal axis of reinforcement. This method may also be applied 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 referenced documents are indispensable for the application 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 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 3611, *Micrometer callipers for external measurements*

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

ISO 14126, *Fibre-reinforced plastic composites — Determination of compressive properties in the in-plane direction*

ASTM E1012, *Standard Practice for Verification of Test Frame and Specimen Alignment Under Tensile and Compressive Axial Force Application*

3 Terms and definitions

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

3.1

gauge section

part of the test specimen which has uniform and minimum cross-sectional area

3.2

gauge section length

l

length of the gauge section

3.3
initial gauge length

L_0
initial distance between reference points on the test specimen in the gauge section before initiation of the test

3.4
final gauge length

L_f
final distance between reference points on the test specimen in the gauge section at the completion of the test

3.5
initial cross-sectional area

A_0
initial area of the gauge section's cross-section

3.6
longitudinal deformation

ΔL
change (contraction) of the initial gauge due to the application of a uniaxial compressive force

NOTE The longitudinal deformation corresponding to the maximum force should be denoted as $\Delta L_{c,m}$.

3.7
compressive strain

ε
relative change in the gauge length defined as the ratio $\Delta L/L_0$

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

3.8
compressive force

F_c
uniaxial compressive force applied to a test specimen

3.9
maximum compressive force

$F_{c,m}$
greatest uniaxial compressive force applied to a test specimen when tested to failure

3.10
compressive stress

σ
compressive force supported by the test specimen at any time in the test divided by the initial cross-sectional area such that $\sigma = F_c/A_0$

3.11
compressive strength

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

3.12
proportionality ratio or pseudo-elastic modulus

E_p
slope of the linear region of the stress-strain curve, if any

NOTE 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 as:

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

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 Figures A.1 and A.2).

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

3.13 elastic modulus

E

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

See Figure A.2.

3.14 axial strain

average of the longitudinal strain measured at the surface of the test specimen at specified locations

See Annex B.

3.15 bending strain

difference between the longitudinal strain at a given longitudinal location on the test specimen surface and the axial strain at the same location

See Annex B.

3.16 buckling force

critical axially applied force at which an initially straight column assumes a curved shape

3.17 critical buckling stress

critical axial compressive stress at which an initially straight column assumes a curved shape

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.

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

For cross-head 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 Annex B. The maximum percent bending shall not exceed 5 % at an average axial strain of 500×10^{-6} .

There are two alternative means of force application:

- a) 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.

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

NOTE 2 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 may occur, it is recommended to use antibuckling devices similar to those described in ISO 14126. These devices should not introduce parasitic stresses (i.e. stresses other than the uniform, axial stress) during loading of the test specimen.

- b) 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.

Alignment shall be verified and documented in accordance with, for example, the procedure described in Annex B.

5.3 Strain measurement

5.3.1 General

For continuous measurement of the longitudinal deformation as a function of the applied force, either strain gauges or a suitable extensometer may be used. Use an extensometer that meets the requirements of at least class 1 in ISO 9513. Measurement of longitudinal deformation over a length as long as possible within the gauge section length of the test specimen is recommended.

5.3.2 Strain gauges

Strain gauges are used for the verification of the alignment on the test specimen. They may also be used to determine longitudinal deformation during testing. In both cases, the length of the strain gauges shall be such that the readings are not affected by local features on the surface of the specimen, such as fibre crossovers. Unless it can be shown that strain gauge readings are not unduly influenced by localized strain events, such as fibre crossovers, strain gauges should be not less than 9 mm to 12 mm in length for the longitudinal direction and not less than 6 mm in length for the transverse direction. The strain gauges, surface preparation and bonding agents/adhesives should be chosen to provide adequate performance on the subject materials.