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Fine ceramics (advanced ceramics, advanced technical ceramics) — Mechanical properties of monolithic ceramics at room temperature — Determination of compressive strength

Céramiques techniques — Propriétés mécaniques des céramiques monolithiques à température ambiante — Détermination de la résistance en compression

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

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

Fine ceramics (advanced ceramics, advanced technical ceramics) — Mechanical properties of monolithic ceramics at room temperature — Determination of compressive strength

1 Scope

This International Standard specifies a method for the determination of nominal compressive strength of advanced monolithic technical ceramic materials at room temperature.

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*

EN 623-4, *Advanced technical ceramics — Monolithic ceramics — General and textural properties — Part 4: Surface roughness*

EN 843-5, *Advanced technical ceramics — Mechanical properties of monolithic ceramics at room temperature — Part 5: Statistical analysis*

3 Terms and definitions

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

3.1
nominal compressive strength
$\sigma_{c,m}$
maximum nominal stress supported by the material at the instant of failure when loaded in linear elastic compression

4 Significance and use

Advanced technical ceramics are used for applications in which their corrosion resistance, their high temperature stability, their potential for light-weight constructions, and their high nominal compressive strength can be utilized in an ideal manner. For application of ceramic components, it shall be considered that they are loaded mainly with compressive stresses since this type of loading is considerably less critical than probably appearing tensile stresses.

This International Standard describes the background for a directed material development, quality control, and for component-optimised applications. It ensures the determination of comparable nominal compressive strength data.

The result obtained from a compression strength test is determined by a large number of factors associated with the microstructure of the material, the surface finishing procedure applied for the preparation of the test pieces, the size and shape of the test piece, the rate of load application, and the relative humidity of the ambient atmosphere. Furthermore, the result obtained from a strength test is influenced by possible existing misfit of ram and test piece cross section as well as of elastic constants. These factors are minimized by a sophisticated test assembly in ASTM C 1424-04 [1]. With respect to an applicable and reproducible procedure of the measurement, it is consciously abstained from the adoption of this test assembly. The test assembly defined in this International Standard represents an alternative to the above mentioned ASTM C 1424-04 [1] that is approved and feasible in industrial practice.

As a consequence of the brittle nature of ceramics, there is usually a considerably range of results obtained from a number of nominal identical test pieces. The factors (mentioned above) combined mean that caution in the interpretation of test results is required. For many purposes, and as described in this International Standard, the results of strength test can be described in terms of a mean value and a standard deviation. Further statistical evaluation of results is required for design data acquisition, and can be desirable for other purposes (see EN 843-5).

This method places closely defined restrictions on the size and shape of the test pieces and on the function of the test apparatus in order to minimize the errors that can arise as a consequence of the test method.

5 Apparatus

5.1 Test machine

A test machine shall be used that conforms to the safety requirements defined in ISO 7500-1 and ISO 7500-1 Amendment 1. The test jig shall be surrounded by an adequate shatter protection device.

The test machine shall be capable of applying the force at a constant loading or displacement rate. The machine shall be equipped to continuously record the force applied to the test piece including the maximum force applied to the test piece. The accuracy of the test machine shall be in accordance with ISO 7500-1, grade 1.

5.2 Test jig

The test jig shall be capable to perform compression tests and ensure to meet the requirements described below.

In Figure 1 an example of a test jig is shown and in Figure 2 a schematic representation of the test jig including a compression platen with calotte for self-alignment.

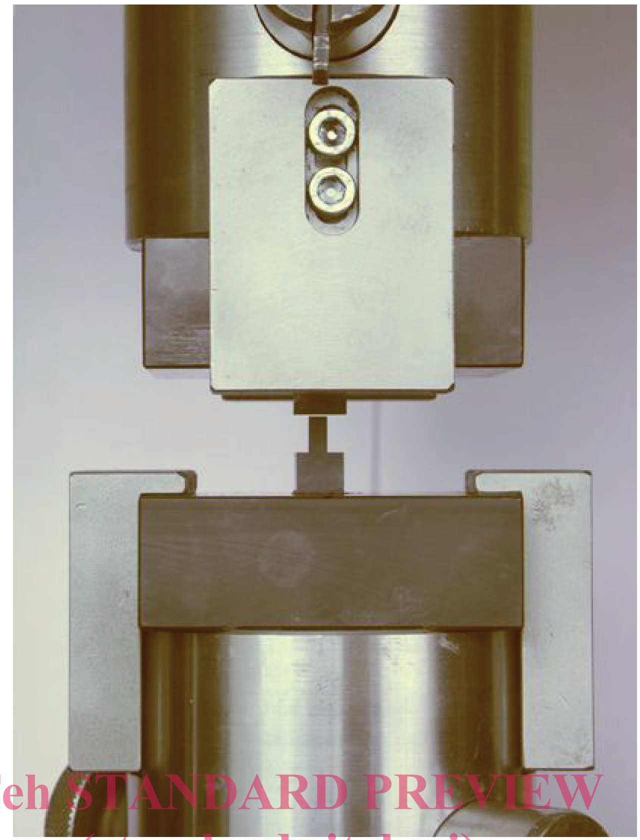
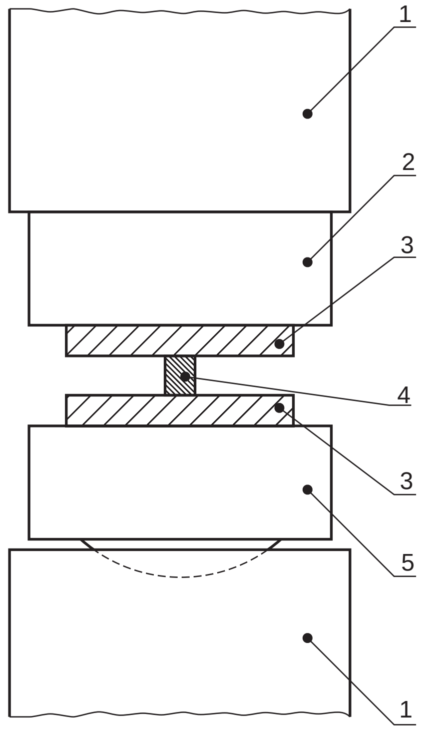


Figure 1 — Example of a test jig



Key

1 load ram

2 compression platen

3 loading block

4 compressive test piece

5 compression platen with calotte

Figure 2 — Schematic representation of the test jig including a compression platen with calotte for self-alignment

The two compression platens shall be aligned axially to the load line of the test machine. The loading surfaces of the upper and lower compression platens shall be parallel to each other within 0,01 mm per 10 mm and perpendicular to the load line of the test machine.

For a better alignment, one of the compression platens should have a calotte for self-alignment.

Hardness and Young's modulus of the loading blocks and compression platens shall be larger than or equal to the hardness and Young's modulus (≥400 GPa, e.g. silicon carbide or cemented carbide) of the test piece.

Loading blocks positioned between compression platens and the test piece as shown in Figures 1 and 2 shall be used to minimize mismatches between compression platens and test piece and to protect the compression platens against damage. Loading blocks could be made from the same material as the test pieces.

The surface of the compression platen that is in contact with the loading block shall be larger than the surface of the loading block that is in contact with the compression platen. The cross section of the contact surface of the loading blocks shall be at least five times greater than the cross sections of the contact surfaces (end faces) of the test piece. The loading blocks shall have a thickness large enough to resist the test without fracture and shall be used only once.

The compression platens shall be checked for damage after each compression test. Damaged compression platens shall be replaced or refinished to remove the volume damaged.

The lower loading block shall be placed centred on the lower compression platen and the test piece shall be placed centred on the lower loading block. Subsequently, the upper loading block shall be placed centred on the upper end face of the test piece and the upper compression platen shall be moved towards the upper loading block until force closure. Optical markers or other suitable devices shall be used for central alignment of test piece and loading blocks.

5.3 Length measuring equipment

A micrometer conforming to ISO 3611 and with a resolution ≤0,1 % of the dimension to be measured, or an alternative calibrated device measuring to this resolution, shall be used for the measurement of test piece dimensions.

6 Test pieces

6.1 Dimensions and tolerances

A test piece with a square cross section with side lengths of (4 ± 0,1) mm or with a cylindrical cross section with a diameter of (4,5 ± 0,1) mm shall be used. The test piece shall have a height of (8 ± 0,2) mm with end faces parallel to 0,2 % relative to the side length or the diameter of the test piece. The long edges of the squared test piece shall be chamfered at approximately 45° to a width of (0,25 ± 0,05) mm.

Other shapes or dimensions of test pieces can be used according to agreement between the parties and shall be stated in the test report.

6.2 Surface finish

6.2.1 General

This International Standard permits any relevant surface finish described in the following four categories:

— I: as-fired;

— II: machined,;

— III: lapping/polishing;

— IV: agreed procedure.

Categories II or III are recommended when there is no other specified method for the test. The aim of procedures according to categories II and III is to minimize the damage created in the test pieces due to the preparation method in order to examine strength more representative of the material than the machining. The recommended procedures cannot be standardized in the conventional sense because of variation between grinding machines and the different behaviours during grinding of different types of material. The procedures described should thus be considered as guidelines. Furthermore, since there are no methods for exact measurement of the surface finish parameters of ceramic materials, special attention should be paid to the quality of the machining.

6.2.2 Surface finish I: as-fired

The test pieces to be tested in the as-fired (ex-kiln) condition with surface preparation only on the sample end-face (in order to avoid edge stresses) provided shall have dimensions according to 6.1. The long edge chamfer of square test pieces shall be applied before firing. Test pieces which are outside these limits shall be rejected.

