
**Fine ceramics (advanced ceramics,
advanced technical ceramics) —
Test method for flexural strength
of monolithic ceramics at room
temperature**

*Céramiques techniques — Méthode d'essai de résistance en flexion des
céramiques monolithiques à température ambiante*

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Reference number
ISO 14704:2016(E)

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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.

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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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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*.

This third edition cancels and replaces the second edition (ISO 14704:2008), which has been technically revised.

Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for flexural strength of monolithic ceramics at room temperature

1 Scope

This International Standard specifies a test method for determining the flexural strength of monolithic fine ceramics, and whisker- or particulate-reinforced ceramic composites, at room temperature and applies to materials with grain size less than 200 μm . This test method may be used for materials development, quality control, characterization and design data-generation purposes.

NOTE Since fracture is due to tensile stress, flexural strength data can be used to calculate a uniaxial tensile strength considering the effect of the tested volume and Weibull-statistics. So, flexural strength is often used in substitute for uniaxial tensile strength.

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 — Calibration and verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Calibration and verification of the force-measuring system*

3 Terms and definitions

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

3.1

flexural strength

maximum nominal stress at fracture of a specified elastic beam loaded in bending

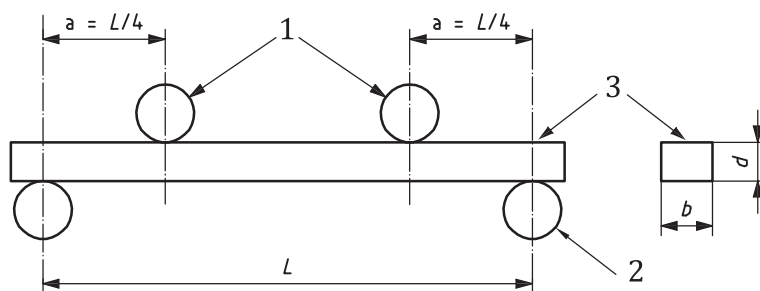
3.2

four-point flexure

configuration of flexural strength testing where a test piece is loaded equally by two bearings symmetrically located between two support bearings

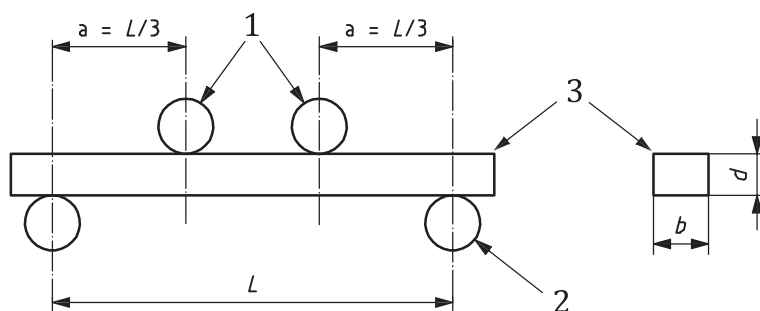
Note 1 to entry: See [Figure 1](#), a) and b).

Note 2 to entry: The bearings may be cylindrical rollers or cylindrical bearings.



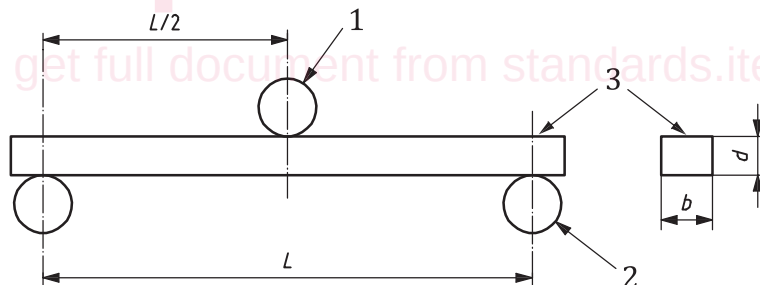
$$L = 40 \text{ mm} \pm 0,1 \text{ mm}$$

a) Four-point-1/4 point flexure



$$L = 30 \text{ mm} \pm 0,1 \text{ mm}$$

b) Four-point-1/3 point flexure



$$L = 30 \text{ mm} \pm 0,1 \text{ mm} \text{ or } 40 \text{ mm} \pm 0,1 \text{ mm}$$

c) Three-point flexure

Key

- 1 loading bearings
- 2 support bearing
- 3 test piece

Figure 1 — Flexural test configurations

3.3

four-point-1/4 point flexure

specific configuration of four-point flexural strength testing where the inner bearings are situated one-quarter of the support span away from the two outer bearings

Note 1 to entry: See [Figure 1 a\)](#).

3.4**four-point-1/3 point flexure**

specific configuration of four-point flexural strength testing where the inner bearings are situated one-third of the support span away from the two outer bearings

Note 1 to entry: See [Figure 1 b](#)).

3.5**semi-articulating fixture**

test fixture designed to apply uniform and even loading to test pieces that have flat and parallel surfaces

3.6**fully articulating fixture**

test fixture designed to apply uniform and even loading to test pieces that may have uneven, non-parallel or twisted surfaces

3.7**three-point flexure**

configuration of flexural strength testing where a test piece is loaded at a location midway between two support bearings

Note 1 to entry: See [Figure 1 c](#)).

Note 2 to entry: *Four-point flexure* ([3.2](#)) is usually preferred, since a large amount of material is exposed to the maximum stress (see [Annex A](#) for more information).

4 Principle

A beam test piece with a rectangular cross-section is loaded in flexure until fracture. The load at fracture, the test fixture and test piece dimensions are used to compute the flexural strength which is often used in substitute for uniaxial tensile strength of a ceramic. The material is assumed to be isotropic and linearly elastic.

5 Apparatus**5.1 Testing machine**

The testing machine shall be capable of applying a force to the loading roller (three-point flexure) or equally to the loading rollers (four-point flexure) in order to stress the test piece. The machine shall be capable of applying the force at a constant loading or displacement rate. The test machine shall be equipped for recording the peak load applied to the test piece. The accuracy of the test machine shall be in accordance with ISO 7500-1, Class 1, with an accuracy of 1 % of indicated load at fracture.

5.2 Test fixture**5.2.1 General**

Three- or four-point flexure configurations shall be used, as illustrated in [Figure 1](#). The four-point-1/4 point configuration is recommended. The fixture shall have bearings that are free to roll, as described in [5.2.2](#), in order to eliminate frictional constraints when the test piece surfaces expand or contract during loading. In addition, the fixture shall be designed so that parts “articulate” or tilt to ensure uniform loading to the test piece. The articulation is designed so that parts of the fixture can rotate, as shown in [Figure B.1](#), to ensure even loading on the left and right bearings. An articulation is also needed to ensure that all the bearings evenly contact the test piece surfaces and apply uniform load. Semi-articulated fixtures have some articulating or tilting capabilities and may be used with test pieces that have flat and parallel surfaces, such as on as-machined test pieces. A semi-articulating fixture has pairs of upper and lower bearings that articulate to match the test piece surfaces, as shown in [Figures B.2](#) and [B.3](#). Fully articulated fixtures have more moving parts and are necessary for test pieces that do not have flat and

parallel surfaces. They allow independent articulation of the bearings. Fully articulated fixtures often are necessary for as-fired, heat-treated or oxidized test pieces, since uneven loading can cause twisting and severe errors. A fully articulating fixture may also be used with machined test pieces.

5.2.2 Bearings

Test pieces shall be loaded and supported by bearings. The bearings may be cylindrical rollers or cylindrical bearings. The bearings shall be made of a steel which has a hardness of no less than HRC 40 for test piece strengths up to 1 400 MPa, or no less than HRC 46 for test piece strengths up to 2 000 MPa. Alternatively, the bearing may be made of a ceramic or hardmetal with an elastic modulus between 200 GPa and 500 GPa and a flexural strength greater than 275 MPa. The bearing length shall be greater than or equal to 12 mm. The bearing diameter shall be approximately 1,5 times the test piece thickness (d). Diameters between 4,5 mm and 5 mm are recommended. The bearings shall have a smooth surface and shall have a diameter that is uniform to $\pm 0,015$ mm. The bearings shall be free to roll in order to eliminate friction. In four-point flexure, the two inner bearings shall be free to roll inwards, and the two outer bearings shall be free to roll outwards. In three-point flexure, the two outer bearings shall be free to roll outwards, and the inner (middle) bearing shall not roll.

NOTE 1 Friction can cause errors in the stress calculations. The rolling can be accomplished by several designs. The bearing can be mounted in roller bearing or cylindrical bearing assemblies. It is also acceptable, and simpler, for the bearings to be free to roll on the fixture surface, as shown in [Figure 2](#).

The bearing diameter is specified on the basis of competing requirements. The bearings should not be so large as to cause excessive change in the moment arm as a test piece deflects, as this can create errors from contact-point tangency shift. On the other hand, the bearings should not be so small as to create excessive wedging stresses in the test piece or create contact stresses that damage the fixture.

NOTE 2 The bearing hardness and stiffness requirements and guidelines are intended to ensure that test pieces with strengths up to 1 400 MPa (or 2 000 MPa), and elastic moduli as high as 500 GPa, can be tested without damaging the fixture. Higher-strength or stiffer ceramic test pieces can require harder bearings. For example, if the bearing elastic modulus is greater than 500 GPa, then it is advisable to lengthen the bearings and the fixture support width to more than 12 mm to distribute the forces over a longer bearing length.

5.2.3 Four-point fixture: semi-articulating

[Figure B.2 a\)](#) shows the actions of the bearings in this fixture. The two inner bearings shall be parallel to each other to within 0,015 mm over their length (≥ 12 mm in accordance with [5.2.2](#)). The two outer bearings shall be parallel to each other to within 0,015 mm over their length. Either the two inner or the two outer bearings shall be capable of articulating (tilting) together as a pair to match the test piece surface. All four bearings shall rest uniformly and evenly across the test piece surface. The fixture shall apply equal load to all four bearings. All four bearings shall be free to roll.

5.2.4 Four-point fixture: fully articulating

[Figure B.2 b\)](#) shows the actions of the bearings in this fixture. One bearing need not articulate (tilt). The other three bearings shall articulate (tilt) independently to follow the test piece surface. All four bearings shall rest uniformly and evenly across the test piece surface. The fixture shall apply equal load to all four bearings. All four bearings shall be free to roll.

5.2.5 Three-point fixture: semi-articulating

[Figure B.3 a\)](#) shows the actions of the bearings in this fixture. The two outer bearings shall be parallel to each other to within 0,015 mm over their length (≥ 12 mm in accordance with [5.2.2](#)). The two outer bearings shall articulate together to follow the test piece surface, or the middle bearing shall articulate to follow the test piece surface. All three bearings shall rest uniformly and evenly across the test piece surface. The fixture shall be designed to apply equal load to the two outer bearings. The two support (outer) bearings shall be free to roll outwards. The middle bearing shall be fixed and not free to roll.

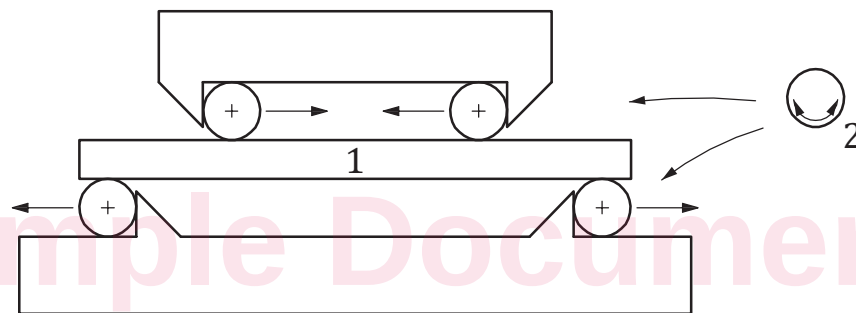
5.2.6 Three-point fixture: fully articulating

Figure B.3 b) and c) show the actions of the bearings in this fixture. Any two of the bearings shall be capable of articulating (tilting) independently to rest uniformly and evenly across the test piece surface. The fixture shall be designed to apply equal load to the two outer bearings. The two support (outer) bearings shall be free to roll outwards. The middle bearing shall not roll.

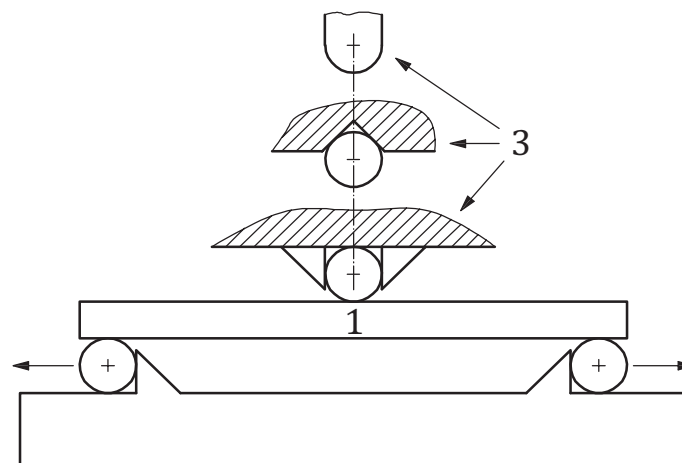
5.2.7 Positioning of bearings

The bearings shall be positioned so that the spans are accurate to within $\pm 0,1$ mm. The middle bearing for the three-point fixture shall be positioned midway between the outer bearings to within $\pm 0,1$ mm. The inner bearings for the four-point fixture shall be centered over the outer bearings to within $\pm 0,1$ mm.

NOTE The positions of the bearings can be defined either by the use of captive bearings, or by appropriate stops against which the bearings are held at the commencement of a test. The spans can be measured to the nearest 0,1 mm using a traveling microscope or other suitable device. The spans can also be verified by measurement of the distances between bearing stops and adding (outer span) or subtracting (inner span) the radii of the bearing cylinders.



a) Four-point flexure



b) Three-point flexure

Key

- 1 test piece
- 2 alternative rolling bearings
- 3 alternative loading bearing arrangements

NOTE 1 For a), the four bearings shall be free to roll.

NOTE 2 For b), the two outer bearings are free to roll outwards, but the middle bearing shall be non-rolling.

Figure 2 — Schematic representation of fixtures showing the rolling action of the bearing