SLOVENSKI STANDARD
oSIST prEN ISO 24370:2023

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Fina keramika (sodobna keramika, sodobna tehnična keramika) - Preskusne metode za ugotavljanje odpornosti monolitske keramike proti lomljenju pri sobni temperaturi z metodo upogibnega preskusa z zarezo (metoda CNB) (ISO 24370:2005)

Fine ceramics (advanced ceramics, advanced technical ceramics) - Test method for fracture toughness of monolithic ceramics at room temperature by chevron-notched beam (CNB) method (ISO 24370:2005)

Hochleistungskeramik - Prüfverfahren zur Bestimmung der Bruchzähigkeit monolithischer Keramik an Biegeproben mit Chevron-Kerb (CNB-Verfahren) (ISO 24370:2005)

Céramiques techniques - Méthode d'essai de ténacité à la rupture des céramiques monolithiques à température ambiante sur éprouvette entaillée en chevron (ISO 24370:2005)

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81.060.30	Sodobna keramika	Advanced ceramics

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INTERNATIONAL STANDARD

ISO 24370

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Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for fracture toughness of monolithic ceramics at room temperature by chevron-notched beam (CNB) method

Céramiques techniques — Méthode d'essai de ténacité à la rupture des céramiques monolithiques à température ambiante sur éprouvette entaillée en chevron

Reference number
ISO 24370:2005(E)

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Contents

Page

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 24370 was prepared by Technical Committee ISO/TC 206, *Fine ceramics*.

Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for fracture toughness of monolithic ceramics at room temperature by chevron-notched beam (CNB) method

1 Scope

This International Standard specifies a test method for determining the fracture toughness of monolithic ceramic materials at room temperature by the chevron-notched beam (CNB) method.

This International Standard is applicable to monolithic ceramics and whisker- or particulate-reinforced ceramics that are regarded as macroscopically homogeneous. It is not applicable to continuous-fibre reinforced ceramic composites.

This International Standard is usually applicable to ceramic materials with a fracture toughness less than about 12 MPa($m^{1/2}$). The test method is applicable to materials with a flat crack-growth resistance curve and may be applicable to materials with a rising crack-growth resistance curve (R-curve).

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 7500-1:2004, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of the force-measuring system*

ISO 14704:2000, *Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for flexural strength of monolithic ceramics at room temperature*

3 Terms and definitions

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

3.1
stress intensity factor
K_I
magnitude of the elastic stress field singularity at the tip of a crack subjected to opening mode (mode I) displacement

NOTE It is a function of applied force and test specimen size, geometry and crack length.

3.2
fracture toughness
generic term for measures of the resistance of extension of a crack

3.3
fracture toughness value
$K_{I,CNB}$
value of crack-extension resistance, i.e. fracture toughness, as measured by the CNB method

NOTE The measured stress intensity factor corresponds to a crack-extension resistance of a stably-extending crack in a chevron-notched beam specimen. The measurement is performed to the operational procedure herein and satisfies all the validity requirements.

NOTE The definition, interpretation and measurement of $K_{I,CNB}$ assume a flat crack-growth resistance curve.

3.4
critical stress intensity factor
K_{Ic}
critical value of K_I at which fracture occurs

4 Symbols

l_0	chevron tip dimension, CNB method (Figure 2)
l_1	chevron dimension, CNB method, [$l_1 = (l_{11} + l_{12})/2$]
l_{11}	chevron dimension, CNB method (Figure 2)
l_{12}	chevron dimension, CNB method (Figure 2)
B	test specimen thickness (Figure 2)
K_I	stress intensity factor, Mode I
K_{Ic}	critical stress intensity factor, Mode I
$K_{I,CNB}$	fracture toughness value, chevron-notched beam method
S_o	flexure fixture outer span
S_i	flexure fixture inner span
L	test specimen length
F_{max}	maximum force applied to the test specimen by the test machine and thereby recorded (Figure 5)
F_{Tare}	force applied to the test specimen by the upper fixture
F	total force applied to the test specimen ($F_{max} + F_{Tare}$). This value is used in calculation of $K_{I,CNB}$
T	notch thickness or kerf resulting from cutting of the chevron notch (Figure 2)
W	test specimen width (Figure 2)
Y^*_{min}	minimum value of the stress intensity factor coefficient Y^*

5 Principle

This International Standard is intended to be used for material development, material comparison, quality assurance, characterization, reliability analysis and design data generation. The chevron-notched beam (CNB) method measures the fracture toughness value $K_{I,CNB}$ by fracturing a flexural specimen, that has a chevron notch (Figures 1 and 2). The specimen is fractured by four-point flexure. Force versus displacement, and backface strain or time are recorded in order to detect unstable fracture. The fracture toughness value $K_{I,CNB}$ is calculated from the fracture load and the minimum stress intensity factor coefficient. Background information concerning this test method may be found in References [1] and [2]. An international interlaboratory comparison study (round robin) project on the chevron-notched method is described in Reference [3], and a comparison of this method to other standardized methods is given in References [2] and [4].

NOTE Ceramics generally exhibit stable crack extension from a chevron notch if the notch is sufficiently narrow (< 0,30 mm), and the other notch dimensions are within the specified tolerances. If stable crack extension is not obtained, then the fracture toughness cannot be directly measured.

6 Apparatus

6.1 Test machine

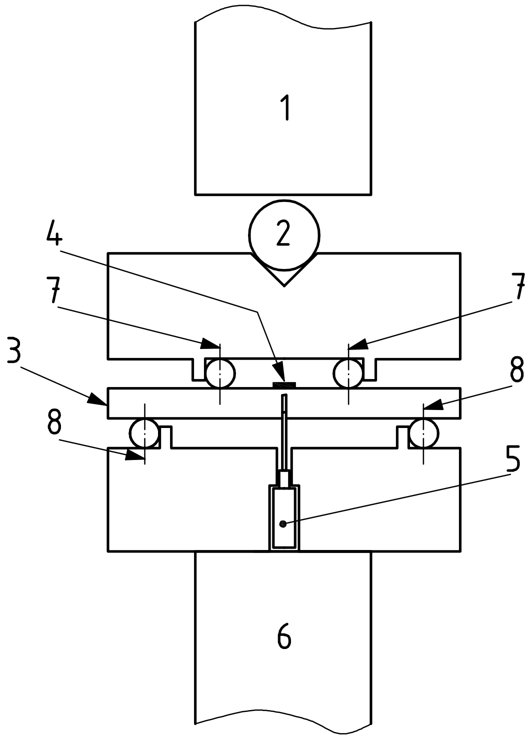
A suitable testing machine capable of applying a uniform cross-head speed shall be used. The testing machine shall be in accordance with ISO 7500-1:2004 Class 1, with an accuracy of 1 % of the indicated force at fracture.

6.2 Flexure fixtures

A schematic diagramme of a typical flexure fixture and test specimen is shown in Figure 1. Flexure fixtures shall meet the requirements of ISO 14704. The fixtures should be semi-articulating. Test specimens shall be contacted by smooth cylindrical bearings with a diameter between 4,50 mm and 5,00 mm. The diameter should be uniform to ± 0,015 mm.

The bearings shall be free to roll in order to minimize friction, and the two inner bearings shall be free to roll inward, and the two outer bearings shall be free to roll outward. The inner span, S_i, should measure 20 mm ± 0,5 mm and the outer span, S_o, should measure 40 mm ± 0,5 mm. Alternatively, the inner and outer span may measure 10 mm and 30 mm, respectively.

When specific test environments other than the laboratory air are employed, an adequate chamber to hold the environment around the test fixture is required. For gaseous environments such as dry nitrogen, a polyethylene bag can be used. For liquid environments such as silicone oil or water, the specimen can be coated and placed in the fixture or the fixture and test specimen can be immersed in a chamber containing the liquid.



Key

1 push rod
2 ball
3 test specimen
4 strain gauge
5 displacement transducer
6 support rod
7 flexure fixture inner span, S_i
8 flexure fixture outer span, S_o

Figure 1 — Schematic example of four-point flexure of a chevron-notched test specimen

6.3 Micrometer

A micrometer such as shown in ISO 3611[11] but with a resolution of 0,002 mm shall be used to measure the test specimen dimensions. The micrometer shall have flat anvil faces such as shown in ISO 3611[11]. The micrometer shall not have a ball tip or sharp tip since these might damage the specimen. Alternative dimension-measuring instruments may be used provided that they have a resolution of 0,002 mm or finer.

6.4 Optical microscope

A travelling microscope or an optical microscope equipped with a calibrated filar eyepiece should be used to measure chevron notch dimensions l_0, l_{11}, l_{12} and T. Magnifications of 10 × to 50 × are usually required. The dimensional measurement performance of the measurement system shall be calibrated with a reference standard.

6.5 Stability detection equipment

The stability of the test is detected by monitoring the test specimen centre-point displacement, load-point displacement, actuator displacement, cross-head displacement or backface strain. Alternatively, force can be recorded as a function of time. Examples of force as a function of strain, actuator stroke and time are shown in Figure 3.

Both backface strain and extensometers placed within or near the flexure fixture are excellent for detecting the stability of the test [5] [6] [7]. Test system extensometers that are placed remotely relative to the test specimen are less sensitive to the local events in the test specimen and may not detect stable extension. Monitoring force as a function of time is a less effective method of detecting stable crack extension. This is particularly the case for materials with a low fracture toughness [e.g. $< 3{,}0$ MPa($m^{1/2}$)] and high elastic modulus (e.g. 400 GPa). Reference [2] discusses experience with various monitoring methods.

If an extensometer contacting the test specimen is used, the force of the extensometer on the specimen should be less than 0,2 N.

7 Test specimens

7.1 Geometry, size, preparation and edge chamfering

7.1.1 Recommended geometry

Rectangular beams with dimensions shown in Figure 2 should be used. Cross-sectional tolerances should be $\pm$ 0,20 mm.

The parallelism tolerance on opposite longitudinal faces should be 0,015 mm. The test specimen illustrated in Figure 2 resulted in excellent correlation to other standardized test methods for a wide variety of ceramics [2], and has been used in the development of a reference material [4]. The stress intensity factor coefficient is based on the straight-through-crack-assumption model and correlates well with finite element analysis (FEA) models for the range allowed [2].