SLOVENSKI STANDARD
SIST-TS CEN/TS 14425-5:2005

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Sodobna tehniļ na keramika ï Preskusne metode za ugotavljanje odpornosti monolitske keramike proti lomljenju ï 5. del: Metoda upogibnega preskusa z V-zarezo (metoda SEVNB)

Advanced technical ceramics - Test methods for determination of fracture toughness of monolitic ceramics - Part 5: Single-edge vee-notch beam (SEVNB) method

Hochleistungskeramik - Prüfverfahren zur Bestimmung der Bruchzähigkeit von monolithischer Keramik - Teil 5: Verfahren für Biegeproben mit V-Kerb (SEVNB-Verfahren)

Céramiques techniques avancées - Méthodes d'essai pour la détermination de la résistance a la fracture des céramiques monolithiques - Partie 5: Méthode du faisceau a entaille en V sur bord simple (SEVNB)

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The period of validity of this CEN/TS is limited initially to three years. After two years the members of CEN will be requested to submit their comments, particularly on the question whether the CEN/TS can be converted into a European Standard.

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Foreword

This document (CEN/TS 14425-5:2004) has been prepared by Technical Committee CEN/TC 184 "Advanced technical ceramics", the secretariat of which is held by BSI.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to announce this Technical Specification: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

CEN/TS 14425 *Advanced technical ceramics — Test methods for determination of fracture toughness of monolithic ceramics* consists of five parts:

Part 1: Guide to test method selection

Part 2: Single-edge pre-cracked beam (SEPB) method

Part 3: Chevron notched beam (CNB) (method

Part 4: Surface crack in flexure (SCF) method

Part 5: Single-edge V-notch beam (SEVNB) method

1 Scope

This part of CEN/TS 14425 describes a method for the determination of the fracture toughness of advanced technical ceramics. The procedure makes use of V-notched bars, which are loaded in 4-point bending until failure. It is applicable to ceramics with a grain size or major microstructural feature size larger than about 1 µm.

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.

EN 843-1, *Advanced technical ceramics — Monolithic ceramics — Mechanical properties at room temperature — Part 1: Determination of flexural strength*

ENV 1006, *Advanced technical ceramics — Monolithic ceramics — Guidance on the selection of test pieces for the evaluation of properties*

CEN/TS 14425-1, *Advanced technical ceramics — Test methods for determination of fracture toughness of monolithic ceramics - Part 1: Guide to test method selection*

EN ISO 7500-1, *Metallic materials - Verification of static uniaxial testing machines - Part 1: Tension/compression testing machines (ISO 7500-1:1999)*

EN ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories (ISO/IEC 17025:1999)*

ISO 3611, *Micrometer callipers for external measurement*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in CEN/TS 14425-1 apply.

4 Principle

This method of conducting a fracture toughness test is based on the preparation and fracture of bar test pieces in which a sharp-tipped notch is machined. Using the technique of a reciprocating razor blade and diamond paste, a narrow notch can be honed into a test piece using either a manual method or a simple machine. Under well-controlled conditions a notch tip radius in the range of 1 µm to 20 µm can be prepared depending on the grain size of the test material. For many materials this is a close approximation to a sharp crack, and the method has been found to give fracture toughness values very close to those of other methods such as the single-edge pre-cracked beam (SEPB) method (prCEN/TS 14425-2) or the surface crack in flexure (SCF) method (prCEN/TS 14425-4). The method has advantages of simplicity of notch production compared with using a sharp-tipped diamond saw or a diamond impregnated wire in which the tip radius is normally greater than 50 µm. The method is often easier to undertake compared with other methods of pre-cracking, and is applicable to a wider range of materials outside the scope of these other methods.

The method has been extensively researched (see Bibliography) and has been evaluated in ESIS[1)]/VAMAS[2)] round robin testing, the results of which are summarised in Annex B. This recommended practice is based upon the ESIS/VAMAS single edge V-notch beam (SEVNB) round robin testing.

The method may have some limitations for materials with grain sizes of less than 1 µm, for which the assumption that the notch approximates to a sharp crack may not be valid.

5 Apparatus

5.1 Razor blades

Standard razor blades, preferably with a support along one edge but alternatively inserted into a suitable holder.

NOTE 1 Razor blades thinner than about 0,2 mm may not be stiff enough by themselves for this task. If the razor blades are not stiff enough, it is recommended to glue or screw the blades between two steel plates leaving only about 2 mm of edge showing. It is recommended to use a razor blade with a tip angle of 30°, or smaller.

NOTE 2 Although it is possible to machine the notches entirely by hand, the use of a simple device in which the test pieces are mounted and in which a razor blade primed with diamond paste is moved in a reciprocating motion across the mounted test-pieces has a distinct advantage as this provides controlled loading and directional stability to the razor blade, and sharper notches can generally be produced. An example is shown in Annex A.

5.2 Diamond paste

Metallographic diamond paste in a viscous organic carrier and of fine grain size, typically 1 µm to 3 µm.

5.3 Lubricant

Suitable lubricating oil for lubricating the razor blade.

5.4 Test piece support

A flat plate or other suitable device for mounting test pieces during notch honing.

5.5 Flexural strength test jig

A three-point or, preferably, four-point flexural strength test jig operating in accordance with the requirements of EN 843-1. The test piece is supported on two bearing edges perpendicular to its length. The outer support bearing edges shall be parallel rollers of diameter 5,0 mm ± 0,2 mm and shall be capable of rolling outward on flat support surfaces. One of the rollers shall additionally be capable of rotating about an axis parallel to the length of the test piece such that torsional loading is minimised. The two rollers shall be positioned initially with their centres 40,0 mm ± 0,5 mm apart with their axes parallel to within 1°. The separation of the centres of the rollers in their starting positions shall be measured to the nearest 0,1 mm with a travelling microscope. The rollers shall be made from hardened steel or other hard material with a hardness greater than 40 HRC (Rockwell C-scale). The

1) ESIS = European Structural Integrity Society

2) VAMAS = Versailles Project on Advanced Materials and Standards

rollers shall have a smooth burr-free surface finish with roughness less than 0,5 µm Ra, and shall have a diameter uniform to ± 0,02 mm.

For four-point flexure, the two loading rollers are located at the quarter points, with an inner span of 20 mm ± 0,2 mm and are free to roll inwards. The rollers are free to rotate separately about an axis parallel to the length of the test piece to allow alignment. For three-point flexure, the single loading roller, which need not rotate, shall be positioned centrally between the outer support rollers. The distances between the rollers shall be measured to the nearest 0,1 mm along the length of the specimen perpendicular to the direction of loading, using a travelling microscope or other suitable device. The loading rollers in four-point flexure shall be symmetrically positioned to within ± 0,1 mm. The single loading roller in three-point flexure shall be centrally located to within ± 0,2 mm. The arrangement for loading shall ensure that equal forces are applied to the two loading rollers.

5.6 Mechanical testing machine

Mechanical testing machine capable of applying a force at a constant rate of displacement or constant loading rate to the test piece in the flexural strength test jig and of recording the force at which the test piece fractures. The force measuring device shall be in accordance with EN ISO 7500-1 and shall be accurate to better than 1 %.

5.7 Ultrasonic cleaning bath

For cleaning the test pieces after notching, an ultrasonic bath suitable for insertion of a beaker or other receptacle containing solvent.

5.8 Micrometer

A calibrated micrometer similar to one in accordance with ISO 3611, but capable of being read to a precision of 0,002 mm using a vernier or electronic readout.

5.9 Microscope

An optical microscope with calibrated magnifications over the range 50x to 500x suitable for observing the notch tip shape, and fitted with photomicrographic facilities.

5.10 Notch measuring device

A calibrated device for measuring depth of the sawn notch after fracture to an accuracy of 0,002 mm or better.

NOTE This can be achieved by use of an appropriate travelling microscope, or a conventional metallurgical microscope with calibrated stage movement, or a microscope with a calibrated micrometer eyepiece.

5.11 Drying oven

Oven capable of maintaining (120 ± 5) °C for drying test-pieces after cleaning.

5.12 Diamond slitting saw

A diamond saw or slitting machine capable of preparing a shallow notch in a set of test-pieces of depth approximately 0,5 mm and of width approximately 0,5 mm.

6 Test piece preparation

6.1 Number of test pieces

At least seven test pieces shall be prepared for notching, of which five are required for testing and two are dummy test pieces for protecting the others during notch preparation.

NOTE 1 If a machine is used for preparing the V-notches, it may not be necessary to employ the dummy test pieces to protect a test set of five test pieces.

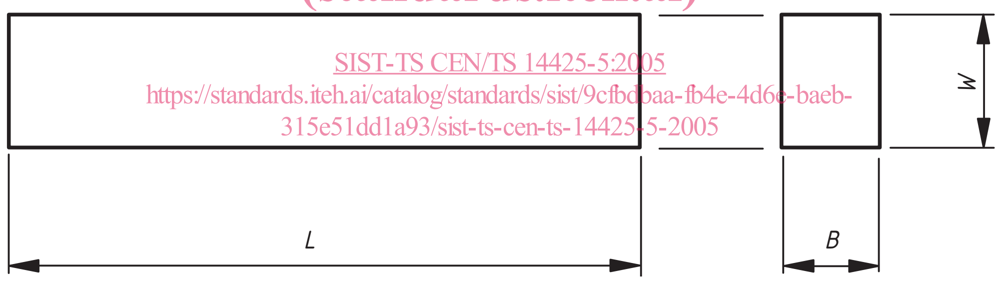
NOTE 2 Operators with no experience of preparing sharp V-notches used in this method are highly recommended first to try out the technique and equipment with surplus test pieces.

6.2 Test-piece dimensions

Select materials for the test in accordance with the guidance given in ENV 1006. Prepare bar test-pieces of rectangular cross section, preferably in accordance with the requirements for a size B test piece, as defined in EN 843-1. Figure 1 shows the shape and main dimensions of test pieces prepared in accordance with this standard.

NOTE 1 The chamfering requirements in EN 843-1 are not essential for the V-notch test and can be ignored.

NOTE 2 Size A test pieces can optionally be used.



Size B

L ≥ 45 mm

W = 4,0 mm ± 0,2 mm

B = 3,0 mm ± 0,2 mm

Size A

L ≥ 25 mm

W = 2,5 mm ± 0,2 mm

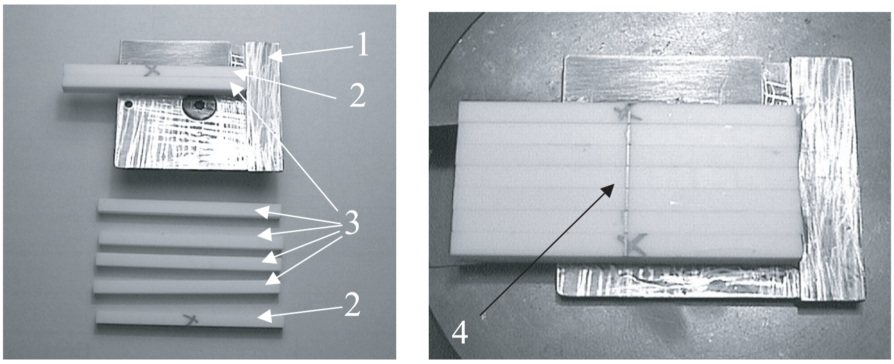
B = 2,0 mm ± 0,2 mm

Figure 1 — Test piece dimensions in accordance with EN 843-1

6.3 Preparing the V-notch by hand

Mount the test-pieces side by side on the test-piece support using an appropriate temporary adhesive, as in Figure 2. Mount test pieces and dummies as close together as possible. Ensure that the top surfaces of the test-pieces are level. Draw a pencil line across the set of test pieces at the mid-point of their length to indicate where the notch is to be prepared.

NOTE 1 It is recommended to avoid bending the test pieces while mounting on the holder.



Key

1 Mounting plate

2 Dummy test pieces

3 Test pieces for testing

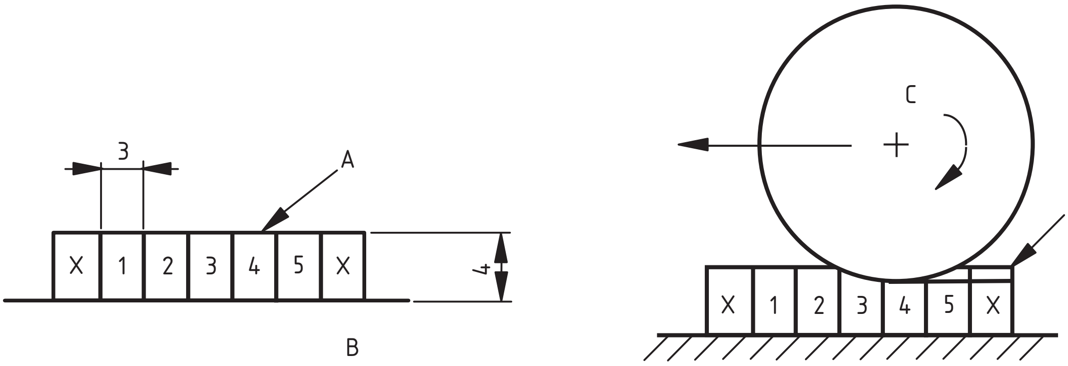
4 Pencil line as a guide for introducing a diamond sawn starter notch

Figure 2 — Mounting procedure for the set of test pieces

Mount the holder on a diamond saw. Saw a starter notch along the pencil line of width approximately 0,5 mm. The notch should have the same depth of about 0,5 mm over its entire length. Figure 3 shows a schematic arrangement for sawing. After sawing, clean the holder, test pieces and especially the notch.

NOTE 2 The width of the diamond saw blade should be about the same as, or only a little larger than, the width of the razor blade to be used for notch honing. Otherwise the razor blade might skate over the surface of the pre-sawn notch and it might be difficult to start polishing the V-notch. V-shaping the saw blade can help if available saw blades are significantly thicker than the razor blades.

Dimensions in millimetres



(a) (b)

Key

A = Tensile surface

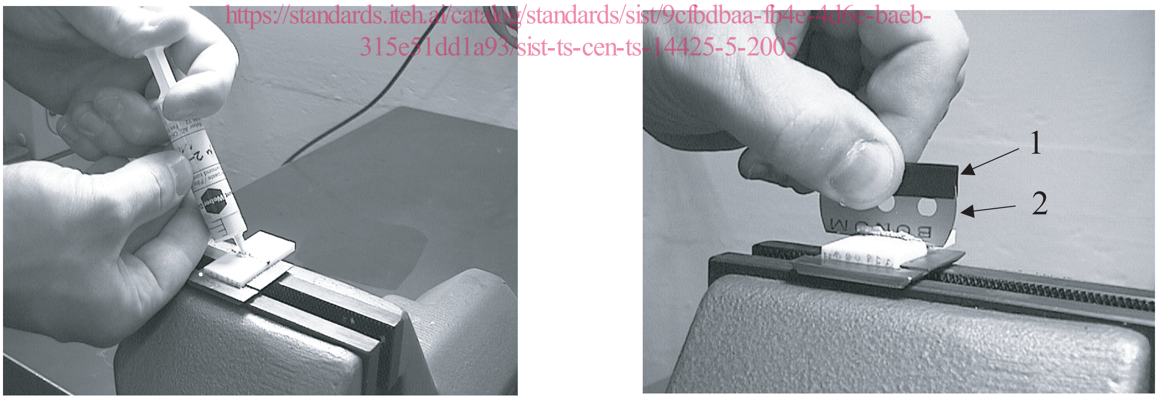
B = Holder

C = Diamond saw blade

D = Sawn notch

X = Dummy test pieces

Figure 3 — Schematic diagrams of (a) test-pieces arranged on the test piece support, and (b) machining a starter notch with a thin diamond saw blade



(a) (b)

Key

1 Heavy protection tape

2 Razor blade

Figure 4 — Applying diamond paste from a syringe to the sawn notch (a) and (b) reciprocating a razor blade in the sawn notch

Fix the test piece holder in a vice or other suitable clamp. Fill the starter notch with the fine diamond paste as shown in Figure 4(a).