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Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for fracture toughness of monolithic ceramic thin plates at room temperature

Céramiques techniques (céramiques avancées, céramiques techniques avancées) — Méthode d'essai pour déterminer la ténacité des plaques minces en céramique monolithique à température ambiante

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Foreword

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

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for fracture toughness of monolithic ceramic thin plates at room temperature

1 Scope

This document describes a test method for the determination of the fracture toughness of monolithic ceramic thin plates at room temperature by the single-edge precracked plate method or the single-edge V-notch plate method.

This document is intended for use with monolithic ceramics and whisker- or particulate-reinforced ceramics which are regarded as macroscopically homogeneous. It does not include continuous-fibre-reinforced ceramics composites. This document is applicable to ceramic thin plates with a thickness of 0,2 mm to <1,0 mm.

The single-edge V-notch plate method can be applied to monolithic ceramics with a grain size larger than about 1 μm. The use of this method is inappropriate for yttria tetragonal zirconia polycrystal material (Y-TZP), which consists of homogeneous fine submicron grains. The method might also be unsuitable for some other very tough or soft ceramics in which a sharp crack does not form at the root of the V-notch.

This document is for material development, material comparison, quality assurance, characterization, reliability and design data generation.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 1101, *Geometrical Product Specifications (GPS) — Geometrical tolerancing — Tolerances of form, orientation, location and run-out*

ISO 4287, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters*

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 15732, *Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for fracture toughness of monolithic ceramics at room temperature by single edge precracked beam (SEPB) method*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 15732 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

4 Principle

This method is to obtain the fracture toughness value from the precrack length or the V-notch depth, specimen dimensions and distance between the bending supports by measuring the fracture load of specimen according to the three- or four-point bending fracture test of a single-edge precracked plate specimen or a V-notched plate specimen. For the single-edge precracked plate method, a straight-through pop-in precrack is induced in the specimen via three-point bending a saw-notched test specimen bonded to a brass beam. For the V-notch plate method, a sharp-tipped notch is machined using the technique of a reciprocating razor blade and diamond paste.

The use of the single-edge V-notch plate method for materials with grain size less than 1 µm is not recommended, since the assumption that the notch approximates to a sharp crack is not established. Users should strive to minimize the notch-root radius in the test pieces. This document places a provisional criterion that the notch-root radius should be similar to or less than twice the average grain size of the material.

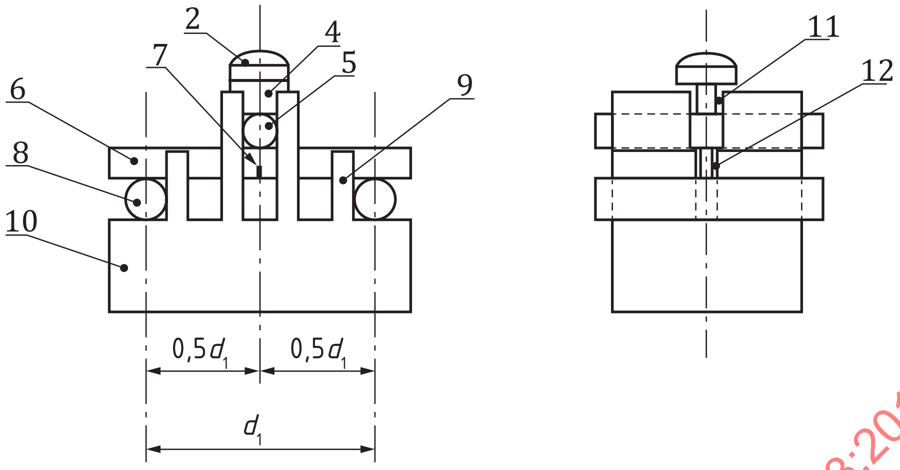
5 Apparatus

5.1 Bend testing machine.

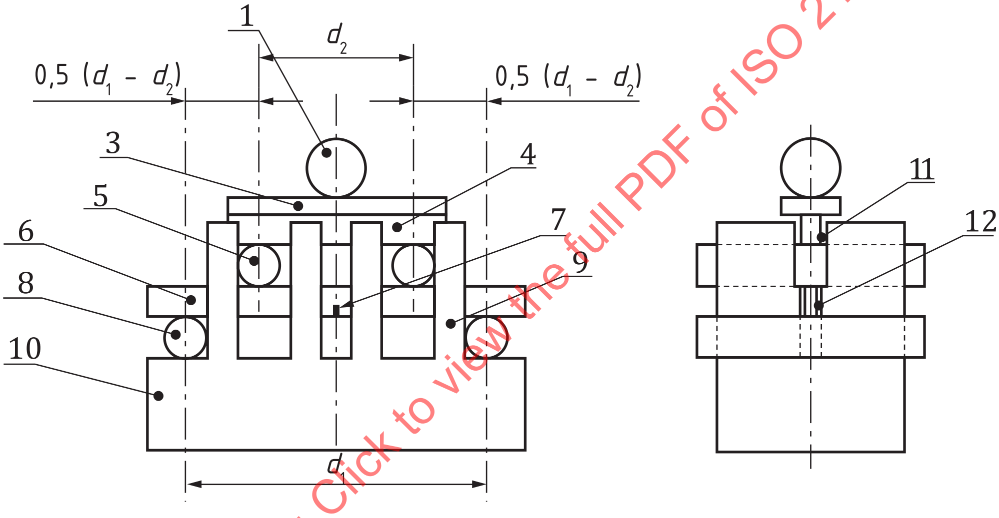
A suitable testing machine capable of applying a uniform cross-head speed shall be used. The testing machine shall be in accordance with ISO 7500-1, with an accuracy of 1 % of the indicated force at fracture.

5.2 Bend test fixture.

The general features of the bend test fixture are illustrated in Figure 1. The bend test fixture shall be symmetrical about the centre line shown. The fixture shall have a thin slit in which the test specimen can stand vertically on the supporting roller pins. The width of the slit shall be about 0,03 mm larger than the specimen thickness. The loading roller pin for the three-point bend test is placed in the positioning groove of the supporting member as shown in Figure 1 (a). The width of the positioning groove should be about 0,05 mm larger than the diameter of the roller pin. The left and right loading roller pins for the four-point bend test are placed in each positioning groove of the supporting member as shown in Figure 1 (b) and are held against the stops and pillars. For both three-point and four-point bend tests, the supporting roller pins are held against the stops and pillars. The loading member has a tooth, which is put in the longitudinal groove of the supporting member to prevent the loading roller pin from tilting so that it can push the specimen vertically. Other types of fixtures are acceptable; however, compression force shall be applied vertically on the top surface of the specimen. Materials composing the parts of the roller pins to be used shall be made of a material free from plastic deformation and risk of fracture. The diameter of loading roller pin and supporting roller pins shall be between 4,0 mm and 5,0 mm. The surface roughness of the rollers, *R*a, as defined in ISO 4287 shall be not more than 0,4 µm.



a) Three-point bend test fixture



b) Four-point bend test fixture

Key

1 loading ball
2 loading member with round head
3 loading member
4 tooth of the loading member
5 loading roller pins
6 specimen
7 precrack or V notch
8 supporting roller pins
9 stops and pillars
10 supporting member
11 longitudinal groove for the tooth of the loading member
12 slit for the specimen

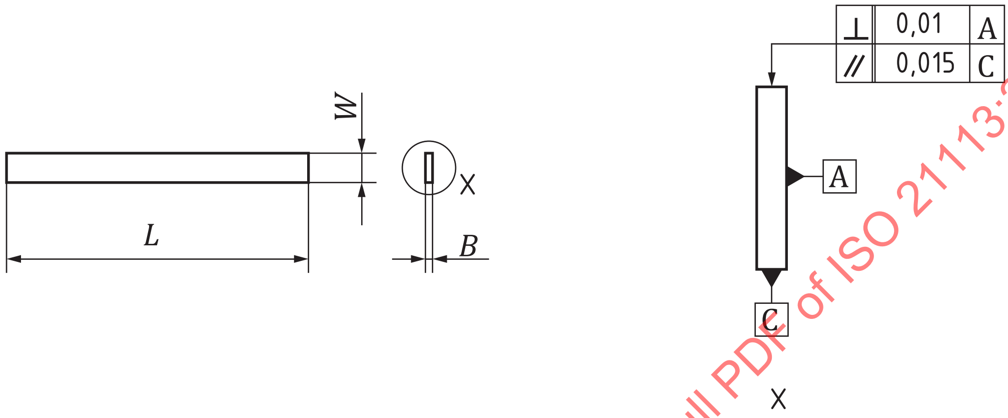
Bending mode	Specimen	Diameter of roller pins mm	Support span d_1 mm	Loading span d_2 mm
3-point bend	I	4,0 to 5,0	30 ± 0,3	—
4-point bend	I	4,0 to 5,0	30 ± 0,3	10 ± 0,2
4-point bend	II	4,0 to 5,0	40 ± 0,4	20 ± 0,2

Figure 1 — Bend test fixtures

6 Test piece dimension and preparation

6.1 Shape and dimensions of test piece

Prepare plate test pieces of rectangular cross-section. Figure 2 shows the shape and main dimensions of the test pieces. The parallelism tolerance on the opposite longitudinal side $L \times B$ face shall be 0,015 mm as defined in ISO 1101. The longitudinal side faces shall intersect with the large faces perpendicularly. The maximum variation in perpendicularity shall not exceed 0,01 mm. The variation of thickness, B_{max}–B_{min}, shall be less than 10 % of the average thickness, B_{ave}, which is determined from the thicknesses at three or more points.



Specimen	Total length *L* mm	Width *W* mm	Thickness *B* mm
I	≥36	4,0 ± 0,2	0,2 to 1,0
II	≥45	4,0 ± 0,2	0,2 to 1,0

Figure 2 — Dimensions of specimen

The longitudinal side $L \times B$ faces of as-cut thin plate usually intersect with the large face at a slightly oblique angle or have burrs and/or chippings as described in Figure 3. Both cross section and the longitudinal side $L \times B$ faces shall be observed with an optical microscope at a magnification of about 20 × or greater. The longitudinal side faces shall be polished until they form a right angle to the large surfaces.

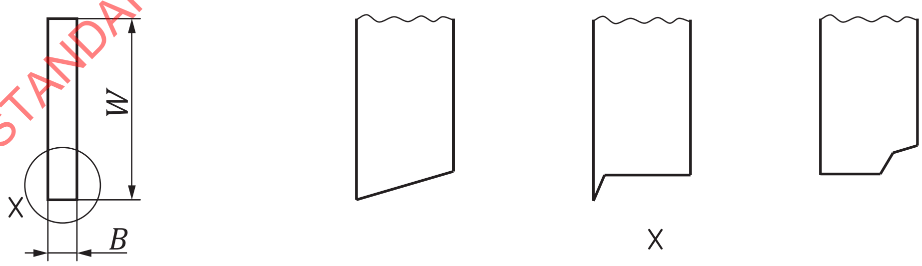


Figure 3 — Guidelines for the unacceptable cross sections of specimen

It is recommended that the cut specimen width is slightly larger than 4,0 mm taking into account the reserving space for polishing. It is also recommended that the length, L, of the test piece is kept constant, for example 40 mm ± 0,2 mm, unless special requests exist. Otherwise, different brass beams with stops need to be made for the ease of centring of the notch and precrack in the fixture every time the length of the test piece is changed.

6.2 Test piece preparation

Machining aspects unique to the precracked method and V-notched method shall be used as specified in Annexes A and B, respectively.

6.3 Number of test piece

At least eight test pieces shall be prepared for a flexural-strength test, of which five are required for valid results.

7 Test methods

7.1 Three or four-point bending fracture test

7.1.1 Insert the test piece into the slit of the test jig slowly, with the precracked or V-notched face on the outer-support rollers as shown in Figure 1. Ensure that the precrack is on the centre of supporting roller pins to within ± 0,1 mm. Set the loading roller pin(s) on the specimen and hold the pin(s) until the loading member is placed on it, otherwise the loading roller pin(s) will drop off. When the loading member is positioned, turn the loading member so that the tooth fits in the longitudinal groove of the support member. If the tooth of the loading member is out of the longitudinal groove, the loading member and loading roller will tilt slightly, and compressive force will be applied obliquely to the test specimen.

7.1.2 Apply a compressive load to the loading member at a cross-head speed of 0,5 mm/min until the specimen fractures, and measure the maximum load, P_f, to an accuracy of 1 %.

7.2 Measurement of thickness and width of test piece

The measurement of the thickness and width of the specimen shall be carried out using a micrometer or other device accurate to the nearest 0,01 mm.

7.3 Measurement of precrack length

For the single-edge precracked plate method, measure the precrack length of the test piece after fracture as specified in Annex C.

8 Evaluation of validity of measured value

A valid test shall meet the requirements specified in Annexes B and C.

9 Calculation

Calculate the fracture toughness value, K_{Ipp} or $K_{\mathrm{Ic,SEVNP}}$, from the measured values for each specimen according to Formulae (1) to (4). Obtain the average value of fracture toughness of five or more specimens conforming to the specification given in Clause 8 and round off to one decimal place.

$$K_{\mathrm{Ipp}}\ or\ K_{\mathrm{Ic,SEVNP}} = \frac{P_{\mathrm{f}} \times d_1}{B \times W^{3/2}} \left[\frac{3}{2} \alpha^{1/2} \times Y(\alpha) \right] \tag{1}$$

where, in the case of three-point bend specimen I,

$$Y(\alpha) = 1{,}964 - 2{,}837\,\alpha + 13{,}711\,\alpha^2 - 23{,}250\,\alpha^3 + 24{,}129\,\alpha^4 \tag{2}$$

In the case of four-point bend specimen I and II,

$$K_{\mathrm{Ipp}}\ or\ K_{\mathrm{Ic,SEVNP}} = \frac{P_{\mathrm{f}} \times (d_1 - d_2)}{B \times W^{3/2}} \left[\frac{3}{2} \frac{\alpha^{1/2}}{(1-\alpha)^{3/2}} \times Y(\alpha) \right] \tag{3}$$

$$Y(\alpha) = 1{,}987\,7 - 1{,}326\,\alpha - \frac{(3{,}49 - 0{,}68\,\alpha + 1{,}35\,\alpha^2)\alpha(1-\alpha)}{(1+\alpha)^2} \tag{4}$$

where

K_{Ipp}	is the fracture toughness, single-edge precracked plate method, in MPa·m$^{1/2}$;
$K_{\mathrm{Ic,SEVNP}}$	is the fracture toughness, single-edge V-notch plate method, in MPa·m$^{1/2}$;
P_{f}	is the fracture load, in MN;
B	is the specimen thickness, in m;
W	is the specimen width, in m;
d_1	is the support span, in m;
d_2	is the loading span ($d_1 > d_2$), in m;
α	is the average relative precrack length or the average relative V-notch depth;
Y	is the stress intensity shape factor.

The mean fracture toughness, $\overline{K}_{\mathrm{Ipp}}$ or $\overline{K}_{\mathrm{Ic,SEVNP}}$, and the standard deviation, s, are given by Formulae (5) and (6), respectively.

$$\overline{K}_{\mathrm{Ipp}} = \frac{\sum_{1}^{n} K_{\mathrm{Ipp},i}}{n} \quad \text{or} \quad \overline{K}_{\mathrm{Ic,SEVNP}} = \frac{\sum_{1}^{n} K_{\mathrm{Ic,SEVNP},i}}{n} \tag{5}$$

$$s = \left[\frac{\sum_{1}^{n} (K_{\mathrm{Ipp},i} - \overline{K}_{\mathrm{Ipp}})^2}{n-1} \right]^{1/2} \quad \text{or} \quad s = \left[\frac{\sum_{1}^{n} (K_{\mathrm{Ic,SEVNP},i} - \overline{K}_{\mathrm{Ic,SEVNP}})^2}{n-1} \right]^{1/2} \tag{6}$$

where

$K_{\mathrm{Ipp},i}$ is the fracture toughness of the ith specimen, single-edge precracked plate method;

$K_{\mathrm{Ic,SEVNP},i}$ is the fracture toughness of the ith specimen, single-edge V-notch plate method;

n is the total number of specimens.

10 Test report

The test report shall include the following information:

a) type of material, code, batch number, date of manufacture;

b) type of test method (either single-edge precrack plate method or single-edge V-notch plate method);

c) number of specimens conforming to the specifications given in Clause 8;

d) measured fracture toughness values, K_{Ipp} or $K_{\mathrm{Ic,SEVNP}}$, the average and the standard deviation, in megapascal metres to the power half;

e) specimen dimensions: thickness, B, width, W, in millimetres;

f) precracking conditions (e.g. depth and width of notch and pop-in load) or a description of the method employed to prepare the V-notches;

g) environment conditions, relative humidity and temperature;

h) maximum load before fracture, P_{f}, in newtons;

i) precrack lengths, l, in millimetres, or depth of the V-notches, a, notch-root width, S, in millimetres, and V-notch angle, β.

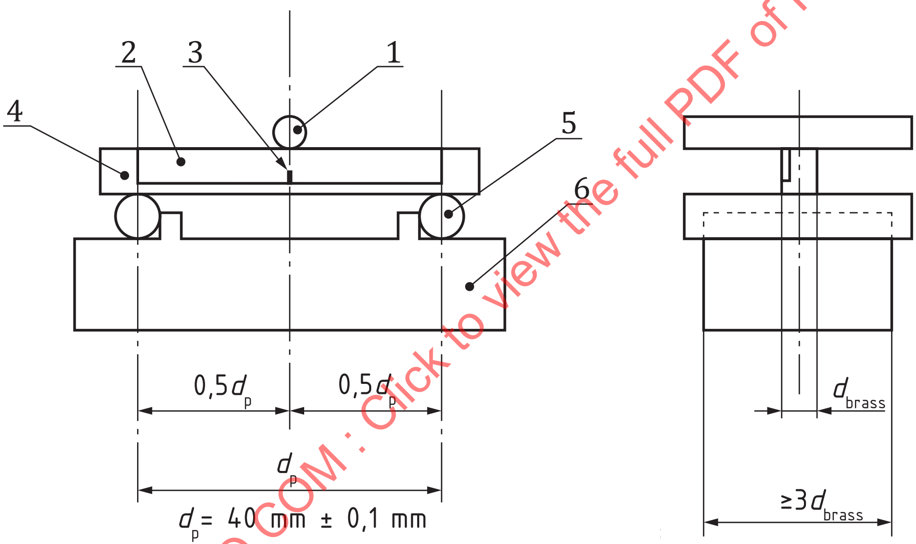
Annex A
(normative)

Test piece preparation for the precracked plate method

A.1 Apparatus

A.1.1 Precracking fixture.

An example of the three-point precracking fixture assembled with a test piece which is bonded to a brass beam is shown in Figure A.1. The precracking fixture shall be symmetrical about the centre line shown and have a depth exceeding at least three times the thickness, d_{brass}, of the brass beam to be used. The diameter of loading roller pin and supporting roller pins should be 4,0 mm to 5,0 mm. The roller pins shall have a smooth surface.



Key

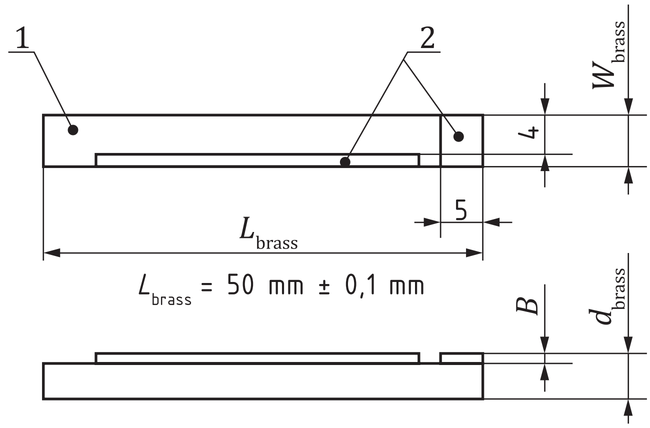
1 loading roller pin
2 specimen
3 notch
4 brass beam
5 supporting roller pins
6 supporting member

Figure A.1 — Example of three-point precracking fixture

A.1.2 Brass beam.

The brass beam shall have guides or stops for a specimen to set it at the proper position as shown in Figure A.2, so that the longitudinal centre of the specimen is located at the centre of the brass beam. Thus, the length and width of the brass beam shall be larger than the specimen. For example, the length and width of the brass beam should be 50 mm and more, and 5 mm to 6 mm, respectively, for the specimen with the length of 40 mm and width of 4 mm. The thickness of the brass beam should be 4 mm to 5 mm. Two or three kinds of brass beam with different widths, for example 5 mm to 7 mm, should be prepared in case the regular brass beam doesn't work.

Dimensions in millimetres



Key

1 brass beam

2 guide or stop for specimen

Figure A.2 — Example of brass beam for specimen support

A.1.3 Wax.

The test piece with a notch shall be bonded to the brass beam with wax. The wax layer between the test piece and the brass beam shall be thin, about 30 µm, because the success rate of the pop-in procedure decreases with an increase in the thickness of the layer. The thickness of the wax depends on the viscosity at the temperature of the hot plate. The temperature of the hot plate should be about 100 °C because compressive stress in the specimen, caused during cooling, hinders smooth precracking. To thin down the wax layer at a given temperature, wax with a lower softening point – about 60 °C – shall be employed. The wax shall be soluble in wax-removing liquid.

A.1.4 Wax-removing liquid.

The test piece shall be cleaned in the wax-removing liquid, suitable for the wax used, after it is separated from the brass beam on the hot plate, since the residual wax adheres to the test piece. The test piece with a precrack breaks easily if you wipe off the wax since the test piece is so thin and delicate. To remove wax completely from the test piece without any damage, cleaning in the wax-removing liquid is necessary.

A.1.5 Precrack introduction loading apparatus.

The loading apparatus shall be capable of smoothly applying the compression load to the fixture. High load accuracy is not required.

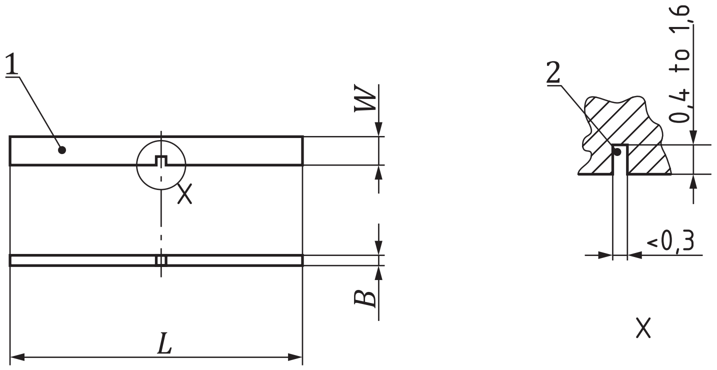
A.1.6 Sonic sensor (acoustic emission sensor or stethoscope).

The pop-in sound shall be detected by the sonic sensor to stop the loading when the precrack is introduced. The sonic sensor is connected to the precracking fixture directly, or to the table of the loading apparatus on which the precracking fixture is set. An acoustic emission sensor is preferable to a stethoscope.

A.2 Introduction of precrack starter

As the precrack generating start point, a straight-through saw notch near the middle of the $B \times L$ surface of the specimen shall be introduced according to the schematic diagram in Figure A.3. The width of the notch shall be not more than 0,3 mm. The shape of the tip of the notch is not specified. The depth of the notch shall be 0,4 mm to 1,6 mm.

Dimensions in millimetres



Key

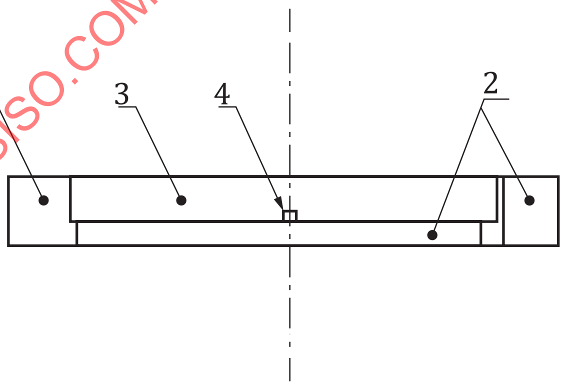
1 specimen

2 notch

Figure A.3 — Introduction of straight-through saw notch

A.3 Introduction of precrack

A.3.1 Heat both brass beams with support guides (or stops) and specimens with the starter notch up to more than the melting point of the wax. Melt a slight amount of the wax on the brass beam. Then, put the specimen at the proper position of the brass beam as shown in Figure A.4 by pushing the test piece against the stops so that the starter notch locates at the centre of the brass beam. The upper $B \times L$ surface of the specimen shall not protrude from the edge of the brass beam. Press the specimen against the brass beam to thin down the wax layer homogeneously until they cool down, because the thicker wax layer can't hold the test piece solidly.



Key

1 brass beam

2 guide or stop for the specimen

3 specimen

4 notch

Figure A.4 — Position of the specimen on the brass beam

A.3.2 Arrange the brass beam with the test piece, between the support roller pins of the precracking fixture and the loading roller pin, as shown in Figure A.1. Introduce an unstable grown pop-in crack. The procedure is described in A.3.3 to A.3.7.

A.3.3 Sufficiently remove the residual wax from both upper and bottom $d_{brass} \times L_{brass}$ surfaces of the brass beam and the upper $B \times L$ surface of the specimen. Place the brass beam on the supporting roller pins, taking care to arrange the precrack starter positions in the range of ± 0,1 mm from the centre of the supporting span.

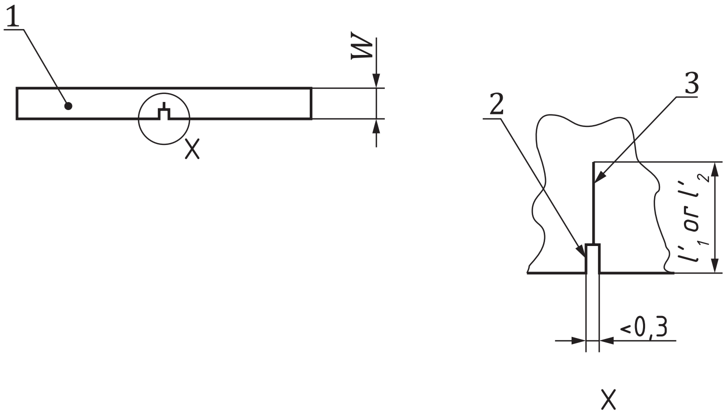
A.3.4 Place the loading roller pin on the brass beam softly, making sure that the brass beam does not slide. Fix the sonic sensor directly to the precracking fixture using a magnet, or to the table using, for example, adhesive tape or glue.

A.3.5 Increase the compression load vertically to the loading roller pin. The compression load should be applied at a speed of 0,1 mm/min. Stop loading immediately after a pop-in sound is detected, because an excessive compression load can damage the fixture and cause uneven development of precrack. The test shall be conducted in a quiet room so that the noise doesn't hinder detection of the pop-in sound. For some materials with high-fracture toughness, the pop-in sound is difficult to detect. In this case, stop loading before the compression force exceeds 400 N to prevent both fracture of the specimen and deformation of the brass beam. A thin wax layer is very helpful for easy introduction of the precrack. Thus, when it is difficult to introduce a precrack, it is recommended that the specimen is removed from the brass beam and re-attached with a new brass beam so that the wax layer becomes thinner. It is also advisable to use other types of brass beam with different widths. If it is difficult to detect a pop-in sound, increase the compression force to 200 N and stop to check the precrack optically. The metallurgical microscope can be used for the clear precrack detection, if necessary. If the precrack is detected, proceed to the next step. Otherwise, set the specimen back to the fixture and increase the target force in a stepwise manner, for example every 50 N, and check the precrack after each target force.

A.3.6 Remove the brass beam from the fixture and put a dye penetrant, such as oil-based paint mixed with acetone, on the notch of the specimen to confirm that the precrack has been introduced. If the pop-in sound has not been detected but precrack is observed optically, go to the next step.

A.3.7 Heat the brass beam with the specimen up to more than the melting point of the wax. Remove the specimen from the brass beam carefully after complete melting of the wax. Cool the specimen to room temperature, put the specimen into the wax-removing liquid and hold for sufficient time, for example 1 h, to remove the wax completely. If wax remains in the crack, the wax prevents dye penetrant going deep into the crack. Rinse thoroughly in the distilled water. Dry the specimens in the oven at 110 °C.

A.3.8 Put the dye penetrant on the notch from both sides and remove it from the surfaces by wiping off with a cotton swab and solvent, such as ethanol or acetone. It is recommended that the dye penetrant is added and removed three times in order to infiltrate the dye into the precrack completely. Observe the precrack with an optical microscope from both sides of the specimen. Measure the precrack length, l'_1 and l'_2, using the optical microscope or a travelling microscope as shown in Figure A.5. The correct precrack length is measured afterwards from the fracture surfaces. The precrack length measured at this stage is a spare value in cases where the crack front is difficult to detect on the fracture surfaces. Put the specimens in the drying oven at 110 °C for more than 1 h to dry the dye penetrant completely.



Key

1	specimen	W	4,0 mm ± 0,2 mm
2	notch	l'_1 and l'_2	precrack length (spare value)
3	precrack		

Figure A.5 — Measurement of length of precrack from both side surfaces of the specimen

Annex B
(normative)

Test piece preparation for the V-notch plate method

B.1 Apparatus

B.1.1 Ordinary razor blades.

The razor blades should be supported along one edge but alternatively inserted in a suitable holder. Razor blades thinner than about 0,2 mm are not ideal for this task unless stiffened by a support, such as by gluing or screwing between two steel plates, leaving only about 2 mm of edge showing. A razor blade with a tip angle of 30° or smaller is ideal.

B.1.2 Notch honing machine.

The detail of the notch honing machine is given in ISO 23146:2012, Annex A.

B.1.3 Metallographic diamond paste.

The grain size of the diamond paste should be fine, typically 1 µm to 3 µm, and the paste should contain a viscous organic carrier.

B.1.4 Lubricant.

A light lubricating oil, such as clock oil, shall be employed for lubricating the razor blades.

B.1.5 Test piece support.

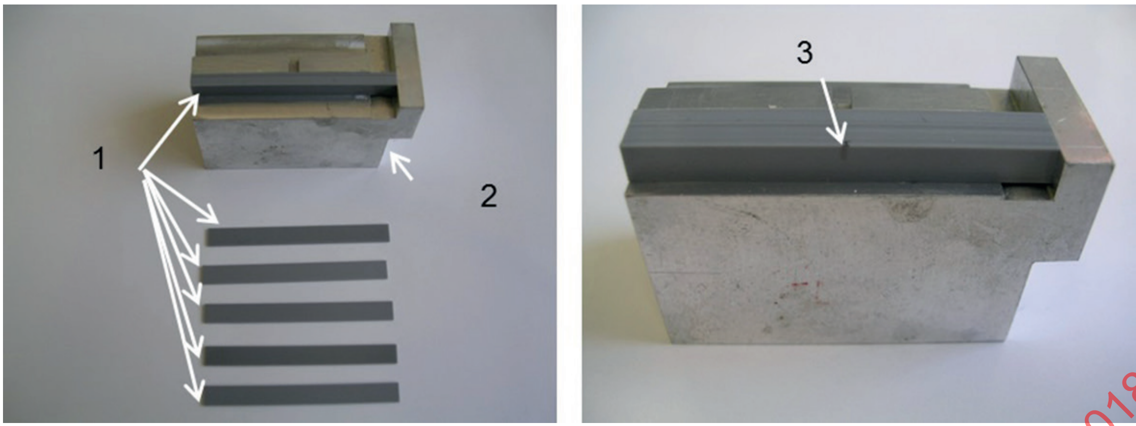
The test piece support shall consist of a mounting block with a stop on the top surface or other suitable fixture for mounting test pieces during notch honing.

B.1.6 Diamond slitting saw or slitting machine.

The diamond slitting saw or slitting machine shall be capable of preparing a shallow notch in a set of test pieces no more than 0,5 mm in width and about 0,5 mm in depth. See B.2 for guidance.

B.2 Preparing the V-notch by machine

Mount the test pieces side by side on the test-piece support with appropriate wax, as shown in Figure B.1. Mount the test pieces as close together as possible. Ensure that the top surfaces of the test pieces are level. Draw a pencil line at the mid-point of their length to indicate where the notch is to be introduced. Handle the thin test pieces with care so as not to bend or drop them while mounting on the holder, since the sample is fragile.



Key

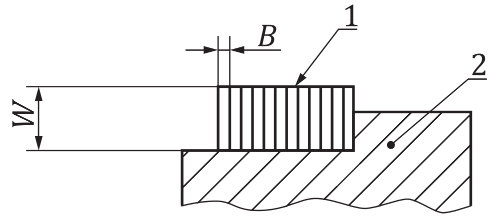
1 test pieces

2 mounting block

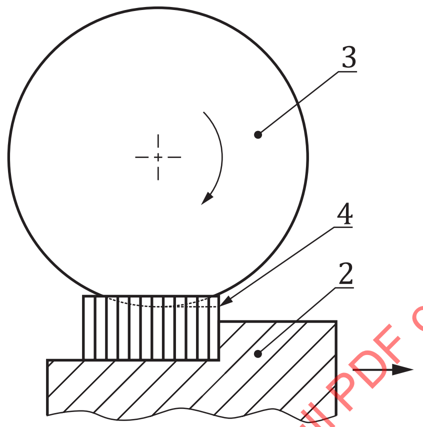
3 pencil line as a guide for introducing a diamond-sawn starter notch

Figure B.1 — Mounting procedure for the set of test pieces

Mount the holder on a diamond saw. Saw a starter notch at the pencil line. The width of the notch shall be not more than 0,5 mm. The thickness of the diamond saw blade should be slightly larger than the thickness of the razor blade used for notch honing. Otherwise, the razor-blade tip 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 tip can help if available saw blades are significantly thicker than the razor blades. The notch should have the same depth of about 0,5 mm over its entire length. Figure B.2 shows a schematic arrangement for sawing. After sawing, clean the holder, test pieces and especially the notch.



a) Test pieces arranged on the mounting block



b) Machining a starter notch with a thin diamond saw blade

Key

1 tensile surface
2 mounting block
3 diamond saw blade
4 sawn notch

Figure B.2 — Schematic diagrams for sawing

Fix the test-piece holder in a table of a honing machine. An example of a machine and its principal requirements is shown in ISO 23146:2012, Annex A. Make sure that the direction of movement of the holder is in alignment with the longitudinal direction of both razor blade and notch. Fill the starter notch with the fine diamond paste. Put the exposed edge of the razor blade in the starter notch and apply a light force. Excessive force can be counter-productive, causing the razor-blade tip to blunt more quickly. Using a force of about 1 N to 3 N on the razor blade while polishing is normally sufficient.

Hone the V-notch with the razor blade with a smooth, gentle, reciprocal motion by the machine. A drop of lubricating oil placed in the notch reduces any tendency for the razor blade to jerk or bind while honing.

Examine the depth of the V-notch periodically with an optical microscope at both ends of the V-notch. It is advisable not to remove the test pieces from the test-piece holder for examination. If it is necessary to remove them and further honing is required, remount the test pieces on the holder with a razor blade inserted in the V-notch to act as a guide. If the total V-notch depth is less than 0,8 mm, continue to hone. The total final V-notch depth should be between 0,8 mm and 1,2 mm. With a machine of sufficient rigidity employing a 1 µm diamond paste for the final stages of notching, the notch width can be reduced typically to 1 µm for ceramics ,with a grain size of about 1 µm to 2 µm.

By commencing the notching directly on the flat test-piece surfaces using a razor blade and medium grit size diamond paste, typically 10 µm, you can skip the saw-notching procedure. When the notch is deep enough, the notch tip is sharpened using a new blade and fine grit paste, after cleaning out the medium grit from the notch.

Remove the test pieces from the holder with care so as not to apply external bending force to them. Clean the test pieces carefully with appropriate organic solvents such as acetone or wax-removing liquid in a small, powerful ultrasonic bath. Take care not to damage the test pieces while cleaning, for example by allowing them to come into contact during ultrasonic cleaning. Dry the test pieces in the oven for at least 1 h at 110 °C. Cleaning of the V-notch can be difficult, especially when the tip radius is small. Alternative steps might be necessary to flush or scrape out the diamond grains.

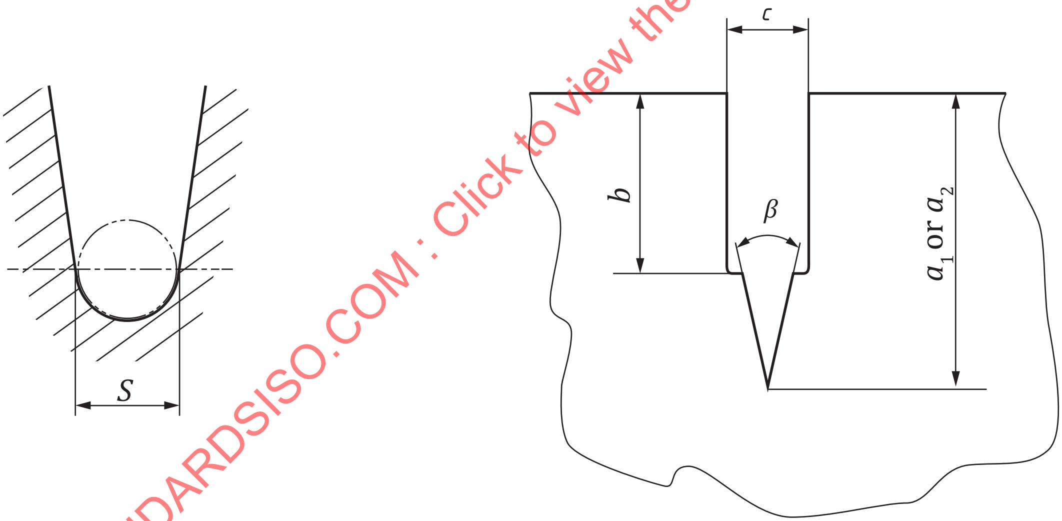
B.3 Measurements of both notch-root radius and notch depth

Select two test pieces from the set for testing. Photograph the V-notch on one side of each of the selected test pieces using a magnification of about 50 × or greater if the notch tip is not resolved at this magnification. Control the V-notch geometry with the help of the photograph. Report any deviation from the geometry shown in Figure B.3.

Photograph the V-notch tip on the same two test pieces with a magnification of approximately 300 ×. Measure the V-notch angle and width in accordance with Figure B.3. Report the V-notch angle β and width S.

The notch width shall be of the same order as, or smaller than, twice the average grain size of the test material. Notches of width greater than 20 µm are not acceptable in any test material regardless of grain size. Acceptability of the notch width can be determined using the outermost test pieces before removing them from the mounting block. This allows the notch-honing process to be continued if the notch width is too large.

NOTE Linear intercept methods for determining the average grain size are described in ISO 13383-1:2012.



a) Notch depth, width and angle measurement

