SLOVENSKI STANDARD
SIST EN 843-7:2010

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Sodobna tehnična keramika - Mehanske lastnosti monolitske keramike pri sobni temperaturi - 7. del: Preskus vzorcev v obliki obroča C

Advanced technical ceramics - Mechanical properties of monolithic ceramics at room temperature - Part 7: C-ring tests

Hochleistungskeramik - Mechanische Eigenschaften monolithischer Keramik bei Raumtemperatur - Teil 7: C-Ring-Prüfungen

Céramiques techniques avancées - Propriétés mécaniques des céramiques monolithiques à température ambiante - Partie 7: Essais d'échantillons en forme d'anneau en C

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Advanced technical ceramics - Mechanical properties of monolithic ceramics at room temperature - Part 7: C-ring tests

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Foreword

This document (EN 843-7:2010) has been prepared by Technical Committee CEN/TC 184 “Advanced technical ceramics”, the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2010, and conflicting national standards shall be withdrawn at the latest by December 2010.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

EN 843, *Advanced technical ceramics — Mechanical properties of monolithic ceramics at room temperature*, consists of the following nine parts:

— *Part 1: Determination of flexural strength*

— *Part 2: Determination of Young's modulus, shear modulus and Poisson's ratio*

— *Part 3: Determination of subcritical crack growth parameters from constant stressing rate flexural strength tests*

— *Part 4: Vickers, Knoop and Rockwell superficial hardness tests*

— *Part 5: Statistical analysis*

— *Part 6: Guidance for fractographic investigation*

— *Part 7: C-ring tests*

— *Part 8: Guidelines for conducting proof tests*

— FprCEN/TS 843-9, *Advanced technical ceramics — Mechanical properties of monolithic ceramics at room temperature — Part 9: Method of test for edge-chip resistance*

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

1 Scope

This European Standard describes a method for undertaking ultimate strength tests on slotted rings (C-rings) in order to determine the strength of ring or tube-shaped components in the manufactured geometry.

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 843-5:2006, *Advanced technical ceramics — Mechanical properties of monolithic ceramics at room temperature — Part 5: Statistical analysis*

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

EN 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 7500-1:2004)*

EN ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories (ISO/IEC 17025:2005)*

ISO 3611:1978, *Micrometer callipers for external measurement*

ISO 6906:1984, *Vernier callipers reading to 0,02 mm*

3 Definitions

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

3.1
C-ring test piece
ring-shaped test piece in which a radial slot has been cut to convert it into an incomplete ring

3.2
C-ring compression test
test in which a C-ring test piece is compressed across a diameter away from the slot, and which imposes the maximum tensile stress on the outside surface of the ring remote from the points of compression load application

3.3
C-ring tension test
test in which a C-ring test piece is pulled across a diameter away from the slot, and which imposes the maximum tensile stress on the inside surface of the ring remote from the point of tensile load application

4 Significance and use

This method of test permits the strength of circular symmetry test pieces such as thin-walled rings or tubes to be determined. The diametral loading of a short length of slotted tube or a slotted ring produces a tensile stress in the mid-section of the tube wall, either in the outside region of the wall thickness if the ring is compressed, or in the inside region if the ring is pulled in tension. In both cases the maximum stresses are in

the tube surface, and are remote from the points of load application, and thus only weakly influenced by the precise geometry of load application. In contrast, diametral compression of a ring without a slot leads to high tensile stresses immediately opposite the points of load application, with much poorer calibration and greater sensitivity to the precise geometry of loading.

The result of a C-ring test is sensitive to the surface finish applied to the cylindrical surfaces of the ring, for example by the method of shaping the article, and additionally to the planar ring faces. Thus if a ring is cut from a tube, the cutting shall be done in such a manner as not to influence the result of the test if the purpose of the test is to determine the as manufactured tube strength.

The results obtained from this test are representative of the strength of pressurized tubes and other cylindrical shapes.

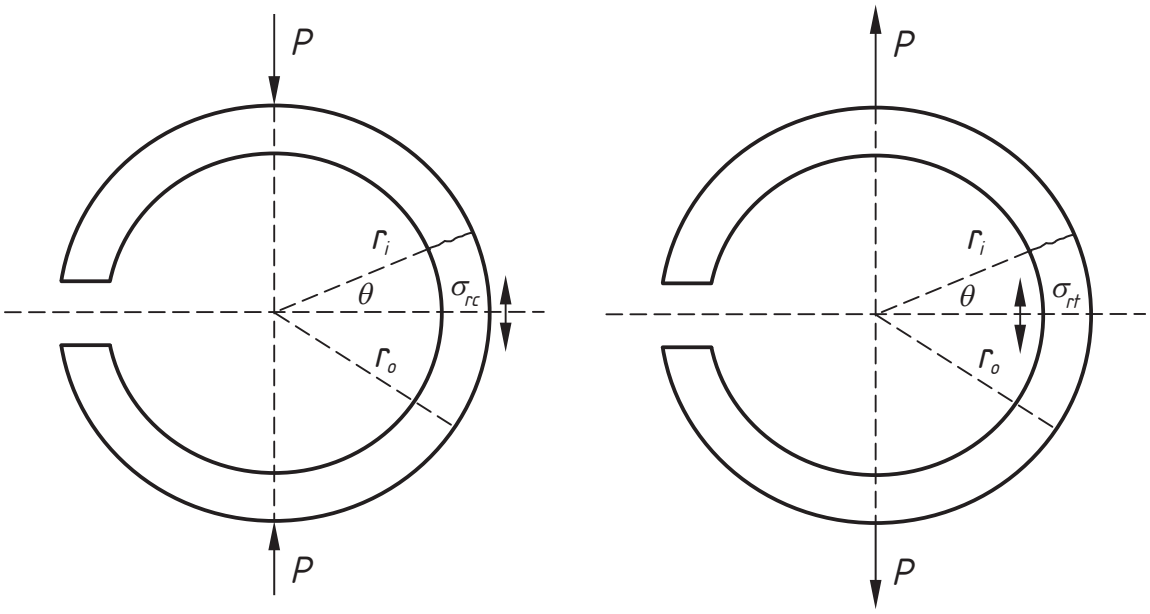
5 Principle

5.1 Method A: C-ring compression

A slotted ring test-piece is placed on its cylindrical surface on a flat anvil of a mechanical testing machine with the slot remote from anvil (Figure 1a)). The second anvil of the test machine is brought into contact with the top surface of the ring, and the load is increased until failure occurs by closing the C-ring. The strength is computed from the ring geometry and the maximum force applied.

5.2 Method B: C-ring tension

Two opposed horizontal pull bars connected to a mechanical testing machine are used to contact the slotted ring at diametrally opposed positions remote from the slot (Figure 1b)). The force is increased until failure by opening the ring. The strength is computed from the ring geometry and the maximum force applied.



a) C-ring test in compression **b) C-ring test in tension**

Key

θ angle between the mid-plane and the location of the crack developed during the test

σ_{rc} C-ring strength determined in compression mode

σ_{rt} C-ring strength determined in ring tension mode

r_0 outside wall tube radius

r_i inside wall tube radius

P applied load

Figure 1 — C-ring test in compression and in tension

6 Apparatus

6.1 Cutting machine

A cutting machine equipped with a diamond saw blade suitable for preparing parallel faced slices from tube material. The saw blade may be selected to be appropriate for the material being cut, but the grit size should be minimised, and the cutting process adjusted to minimise edge chipping and other damage. If the available machine does not cut adequately dimensioned test-pieces (see Clause 7), test-pieces may be subsequently ground or lapped flat and parallel faced using other appropriate machines.

6.2 Vernier callipers

Vernier callipers reading to 0,02 mm in accordance with ISO 6906:1984, but additionally equipped with the ability to measure internal diameters of test pieces, or other suitable measurement device of equivalent accuracy.

6.3 Micrometer callipers

Micrometer callipers reading to 0,01 mm or better in accordance with ISO 3611:1978, or other suitable measurement device of equivalent accuracy.

NOTE Micrometer callipers with flat anvils are normally recommended for making measurements on ceramic materials to avoid risks of indentation associated with rounded anvils. However, rounded anvils will be required for measuring wall thickness, and should be used with considerable caution.

6.4 Mechanical testing machine

A mechanical testing machine capable of applying a force to the test jig at a constant displacement rate or at constant loading rate. The testing machine shall be equipped for recording the load applied to the test jig at any point in time. The accuracy and calibration of the testing machine shall be in accordance with EN ISO 7500-1:2004, Grade 1 (1 % of indicated load).

For Method A, the testing machine shall be equipped with hard flat anvils with faces either fixed parallel to within 0,05 mm over the area to be used for testing, or self-aligning during testing.

For Method B, the testing machine shall be equipped with a device for permitting two hard steel rollers to be inserted through the ring and supported at each end by yokes connected to the testing machine which permit a tensile force to be applied. Universal joints shall be incorporated into the load train to permit alignment and to minimise stress concentrations towards one face or other of the ring.

NOTE Any suitable alternative arrangement may be used in which the load can be applied in compression mode using a lever system containing the loading rollers.

Precautions shall be taken to avoid flying fragments from the test-piece during fracture.

6.5 Interface material

Thin, compliant materials such as cardboard, metal foil or rubber sheet, to be placed between the test piece and the compression anvils (Method A) or steel rollers (Method B).

7 Test pieces

Test pieces or test material shall be selected in accordance with the guidelines in EN 1006. If the test rings are to be cut from tube stock, select stock which is acceptably round and straight.

This standard does not prescribe any particular dimensions for test pieces, but the following size ratios are recommended to avoid problems with alignment or validity of the calculation equations:

a) 0,05 < (wall thickness/outer ring radius) < 0,5;

b) 0,2 < (axial length/outer ring radius) < 1,0;

c) 1,0 < (axial length/wall thickness) < 4,0.

Cut or otherwise machine the side faces of the test pieces to a parallelism of better than 0,015 mm using a diamond saw with or without additional machining by lapping or surface grinding. This process shall introduce a minimum of damage such that failure does not occur from the cut face.

NOTE 1 Guidance on machining processes may be found in EN 843-1 [6] and ASTM C1495 [1].

Make an axial cut through the wall of the ring using a diamond saw. For Method A the slot width shall be sufficiently large that the sides of the slot do not close during the test before failure of the test-piece. For thick-walled test-pieces, a slot of 1 mm to 2 mm is adequate, but for thinner walled test-pieces, the slot shall be rather wider.

All edges shall be chamfered at 45° to a distance of at least (0,15 ± 0,05) mm or rounded to a radius of at least (0,15 ± 0,05) mm to avoid edge dominated failures.