SLOVENSKI STANDARD
kSIST FprEN 843-8:2010

01-januar-2010

Sodobna tehniļ na keramika - Mehanske lastnosti monolitske keramike pri sobni temperaturi - 8. del: Smernice za izvajanje preskusov

Advanced technical ceramics - Mechanical properties of monolithic ceramics at room temperature - Part 8: Guidelines for conducting proof tests

Hochleistungskeramik - Mechanische Eigenschaften monolithischer Keramik bei Raumtemperatur - Teil 8: Leitlinien zur Durchführung von Prüfungen der Gebrauchsfähigkeit

Céramiques techniques avancées - Propriétés mécaniques des céramiques monolithiques à température ambiante - Partie 8: Lignes directrices de conduite d'épreuves

Ta slovenski standard je istoveten z: **FprEN 843-8**

ICS:

81.060.30 Sodobna keramika Advanced ceramics

kSIST FprEN 843-8:2010 **en,fr,de**

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

FINAL DRAFT
FprEN 843-8

November 2009

ICS 81.060.30

English Version

Advanced technical ceramics - Mechanical properties of monolithic ceramics at room temperature - Part 8: Guidelines for conducting proof tests

Céramiques techniques avancées - Propriétés mécaniques des céramiques monolithiques à température ambiante - Partie 8: Lignes directrices de conduite d'épreuves

Hochleistungskeramik - Mechanische Eigenschaften monolithischer Keramik bei Raumtemperatur - Teil 8: Leitlinien zur Durchführung von Prüfungen der Gebrauchsfähigkeit

This draft European Standard is submitted to CEN members for unique acceptance procedure. It has been drawn up by the Technical Committee CEN/TC 184.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

This draft European Standard was established by CEN in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, 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 United Kingdom.

Warning : This document is not a European Standard. It is distributed for review and comments. It is subject to change without notice and shall not be referred to as a European Standard.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. FprEN 843-8:2009: E

Contents

Page

Foreword

This document (FprEN 843-8:2009) has been prepared by Technical Committee CEN/TC 184 “Advanced technical ceramics”, the secretariat of which is held by BSI.

This document is currently submitted to the Unique Acceptance Procedure.

EN 843 *Advanced technical ceramics – Mechanical properties of monolithic ceramics at room temperature* has been prepared in 9 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*

Part 5: *Statistical analysis*

Part 6: *Guidance for fractographic investigation*

Part 7: *C-ring tests*

Part 8: *Guidelines for conducting proof tests*

Part 9: *Method of test for edge-chip resistance*

Part 9 is a Technical Specification.

1 Scope

This European Standard describes requirements and methods for proof testing of advanced technical ceramic components. It provides general guidance concerning the design of the test and the methodology for the selection of loading conditions.

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

3 Terms and definitions

For the purpose of this document the following terms and definitions apply.

3.1
delayed failure
fracture of an item after an extended period under stress

3.2
item under test
component to be subjected to the proof test

3.3
proof test
short-term test designed to investigate the mechanical or thermo-mechanical potential of a component, removing by fracture those components which do not meet specified levels

3.4
proof-test ratio
ratio of the stress to be applied in a short-term proof test to the expected long-term service stress within an item under test (**3.2**)

3.5
sub-critical crack growth
extension of existing cracks or flaws under a stress which does not produce instant failure

4 Principle

Since advanced technical ceramic components may contain microstructural inhomogeneities and mechanical damage which are difficult to detect by non-destructive observations (dye tests, ultrasonics, etc.), an individual component may have insufficient strength to perform adequately in a particular application. The objective of mechanical or thermo-mechanical proof testing is to determine whether an individual item has adequate mechanical properties before being placed into service. The principle is to apply a short-term stressing operation to the item under test, the level of stress in which exceeds the expected service conditions. Items which fail in this test, are removed from the population, providing a guarantee of a minimum life in the survivors. The stressing may be direct mechanical, or as a result of thermal stress, such as in a thermal shock test.

This guarantee is valid only for the conditions and state of the test piece item under test directly after the proof test. Any change in the material, the geometry or structure of the item after the proof test (e.g. mechanical, thermal, oxidative, corrosive, wear or other damage) may change the strength and may shorten the minimum life of the item.

5 Main considerations

The short-term fracture stress of an advanced technical ceramic component is determined by the most highly stressed microstructural inhomogeneity or discontinuity, and is therefore determined by the method of manufacture and surface finishing. In general, it is not possible to predict with any certainty the forces that can be applied to a component without risking failure. For some applications where premature failure carries with it considerable costs, it can be beneficial to take steps to minimise the risks by removing from the population of items those individuals which are most at risk from failure.

Additionally, many types of advanced technical ceramic suffer from the slow growth of small cracks under maintained stress, with a consequent loss of the remaining strength. This thermally activated process may be accelerated by the presence of water, or by a corroding environment, which can react with the crystalline or amorphous bonding at the tip of crack. Thus if a component is held under stress for a prolonged period, it can weaken with time and lead to delayed failure. The tendency of a material to behave in this way can be detected, for example, by undertaking strength tests at different stressing rates (see EN 843-3) or by statically stressing the material until failure occurs. Generally, the effect is most marked in silicate glasses, and in glass-phase containing oxide ceramic materials. It is less marked in purely crystalline oxide ceramics, and least marked in non-oxide ceramics.

The principle of the proof-test (see Annex A) is to stress the item to such a level as will probe the item to determine the presence of features that would result in low strength. The stress distribution should ideally match that seen in the application of the item, and should be applied smoothly and quickly, and then removed in a similar manner such that the strength of the surviving items is not reduced by non-catastrophic crack growth. There are several philosophies that can be adopted:

a) Select a stress level which pragmatically removes a certain fraction of the population, by a few percent, providing a guaranteed minimum strength for the remainder.

b) Select a stress level which is a factor of typically two or three times the expected stress level in service, providing a greater assurance that it will survive in service.

c) Numerically determine the over-stress level factor from the fracture mechanical behaviour of the material, specifically the critical stress intensity factor (see CEN/TS 14425-1) and the sub- critical crack growth characteristics (see EN 843-3), combined with Weibull parameters (see EN 843-5) to provide stress-volume or stress-area predictions of the risk of failure. This method, while scientifically rigorous, is time-consuming and effective only if the fracture mechanical data that can be acquired are applicable to the item in every respect.

NOTE Components may be produced and finished in ways which, are not equivalent to the conditions employed for manufacturing, and testing test pieces of closely defined geometry, and thus may vary in density, microstructural homogeneity, surface finishing and residual stress levels. Predictions may be poor unless the equivalence is good.

Of these three philosophies, a and b are pragmatic and can be set by simple judgement. They are typically used to ensure that each item, as supplied, has adequate strength at the point of delivery, but the procedures take no account of the potential of the material to age in service and to fail as a consequence of progressive loss of remaining strength with time. The third philosophy (c) additionally takes the slow loss of strength into account, and has been used successfully on safety-critical components under long-term stress.

The effectiveness of a proposed proof-testing method can be determined by evaluating the short-term strength distribution of proof-tested items compared with the strength distribution before proof testing. In the prior proof-tested batch, there should be an absence of items failing at less than the set proof-test level. The continued presence of items failing at less than the proof-test level is an indication that there is some weakening of items during the proof-test, which either has to be taken into account in selecting the proof-test loading level, or the proof-test schedule itself has to be examined to reduce or eliminate the effect.

Overload proof-testing will not be successful in guaranteeing a component in service in the following circumstances:

— where the item becomes damaged in service, particularly where such damage is in regions of high stress;

— where the stresses in service are poorly defined or undefined, such as shock loading, or localised hard contact;

— where temperature changes are significant;

— where the item has features that would suffer unduly in overload proof-testing, such as sharp edges, joints to other materials or surface coatings, or marking of items by the testing system;

— where the stress distribution under the service conditions cannot be conveniently modelled in a proof-testing situation;

— where proof-testing cannot be performed quickly and smoothly, particularly the unloading part of the cycle;

— where it may not be possible adequately to design an overload thermo-mechanical proof-test because of temperature limitations, oxidation, or unknown or undefinable heat transfer conditions.

The principal considerations are therefore the design of the system for undertaking the proof-test, and ensuring that it adequately matches the service stress condition during item testing.

6 Design of proof-test equipment

The principal factors in the appropriate design of proof-testing equipment are:

- clear understanding of service conditions to be experienced by the item under test, and the lifetime to be expected;
- definition of the stress distribution to be achieved in the item during testing;
- definition of and agreement concerning the overload factor to be employed;
- evaluation of methods of achieving the stress distribution in a non-destructive manner;
- design of a proof-testing system which provides the appropriate stress distribution without otherwise marking or damaging the items under test.

Ideally, the proof-testing system should incorporate the following features:

- easy insertion and removal of the item to be tested;
- contacts between the item under test and metallic parts of the system to be minimised to avoid marking. Use of polymeric loading devices is recommended where practical;
- where possible, protection of parts of the system adjacent to the item under test against fracture of items which fail the proof test;