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English version

Dense shaped refractory products — Part 11: Determination of resistance to thermal shock

Prüfverfahen für dichte geformte feuerfeste Erzeugnisse – Teil 11: Bestimmung der Temperaturwechselbeständigkeit

This Technical Specification (CEN/TS) was approved by CEN on 23 January 2003 for provisional application.

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 993-11:2003 has been prepared by Technical Committee CEN /TC 187, "Refractory products and materials", the secretariat of which is held by BSI.

This document supersedes ENV 993-11:1997.

Reproducibility and repeatability data are not available at present but will perhaps be included in a subsequent edition.

EN 993 'Methods of test for dense shaped refractory products' consists of 20 Parts:

Part 1 : Determination of bulk density, apparent porosity and true porosity

Part 2 : Determination of true density

Part 3 : Test methods for carbon-containing refractories

Part 4 : Determination of permeability to gases

Part 5 : Determination of cold crushing strength

Part 6 : Determination of modulus of rupture at ambient temperature

Part 7 : Determination of modulus of rupture at elevated temperatures

Part 8 : Determination of refractoriness-under-load

Part 9 : Determination of creep in compression

Part 10 : Determination of permanent change in dimensions on heating

Part 11 : Determination of resistance to thermal shock

Part 12 : Determination of pyrometric cone equivalent (refractoriness)

Part 13 : Specification for pyrometric reference cones for laboratory use

Part 14 : Determination of thermal conductivity by the hot-wire (cross-array) method

Part 15 : Determination of thermal conductivity by the hot-wire (parallel) method

Part 16 : Determination of resistance to sulphuric acid

Part 17 : Determination of bulk density of granular materials by the mercury method with vacuum

Part 18 : Determination of bulk density of granular materials by the water method with vacuum

Part 19 : Determination of thermal expansion

Part 20 : Determination of resistance to abrasion at ambient temperature

Introduction

Thermal shock of refractory materials placed in furnaces is influenced by three items:

— brick dimensions;

— heating/cooling conditions;

— material properties

Thermal shock tests usually intend to test material properties. This is done by standardizing brick dimensions and heating conditions. In this way, a relative order of the quality of different types of bricks can be established. However, in case of thermal shock, this can lead to complications in the field of engineering.

The major complication is that, depending on the type of heating conditions, various material properties are involved. This can be best illustrated on the basis of thermal stress parameters which are a measure for critical crack initiation.

Table 1 — Type of heating condition

Hot face condition	Stress parameter	Example
sudden temperature jump	ε / α	filling of metallurgical vessels
constant heat flow into brick	$\lambda . \varepsilon / \alpha$	Furnace preheating
constant heating rate	$\lambda / (\rho . c_p) . \varepsilon / \alpha$	Controlled preheating

Where:

ε maximum allowable deformation

α coefficient of expansion

λ thermal conductivity

ρ bulk density

c_p specific heat

1 Scope

This Technical Specification specifies two alternative methods for determining the resistance to thermal shock of dense shaped refractory materials by the air quenching method which proved to give the most reliable results as compared with the behaviour of the refractories placed in furnace linings. Method B can be applied to unshaped refractory materials too.

2 Normative references

This Technical Specification incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this Technical Specification only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 993-6 *Methods of test for dense shaped refractory products – Part 6: Determination of modulus of rupture at ambient temperature.*

3 Terms and definitions

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

3.1
thermal-shock resistance
resistance of refractory bricks to damage caused by sudden temperature changes between 950°C and room temperature due to air blowing

3.2
measure of thermal-shock resistance
for method A the number of quenchings withstood under the conditions of this test and for method B the residual cold MOR and residual sonic velocity of standard test pieces after 5 quenchings under the condition of this test

4 Principle

4.1 Method A

The test piece is homogeneously heated to 950 °C in an electric furnace, then removed, placed on a steel plate and exposed to air blowing. After quenching, the test piece is subjected to a stress of 0,3 MPa in a bending machine. This cycle is repeated until failure of the test piece.

The resistance to thermal shock is defined by the number of cycles withstood by the test piece before breaking.

4.2 Method B

The test pieces are homogeneously heated to 950 °C in an electric furnace, then removed, placed on a steel plate and exposed to air blowing. After quenching, this cycle is repeated 4 times. After cooling down the residual cold MOR and the residual sonic velocity has to be determined.

The resistance to thermal shock is defined by the percentage of residual MOR and residual sonic velocity related to the MOR and sonic velocity of non quenched test pieces.

NOTE Sonic resonance frequency can be measured too but the results might be different.

For both methods A and B other quenching temperatures may be agreed upon by the parties concerned and shall be noted in the test report.

5 Apparatus

— electrically heated furnace, capable of maintaining a temperature 950°C ± 25 °C

— thermocouple for use for temperatures in excess of 1000 °C

— drying oven