

Methods of test for dense shaped refractory products —

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

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British Standard

ICS 81.080

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National foreword

This British Standard is the English language version of EN 993-15:1998.

The UK participation in its preparation was entrusted by Technical Committee RPI/1, refractory products and materials, to Subcommittee RPI/1/1, Sampling and physical testing of refractory materials, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

The UK did not approve this document as a European Standard at the Formal vote stage. The Subcommittee RPI/1/1 decided that it contained fundamental flaws in the instructions for recording the output of the differential thermocouple.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled “International Standards Correspondence Index”, or by using the “Find” facility of the BSI Standards Electronic Catalogue.

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Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 10, an inside back cover and a back cover.

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English version

Methods of test for dense shaped refractory products — Part 15: Determination of thermal conductivity by the hot-wire (parallel) method

Méthodes d'essai pour produits réfractaires
façonnés denses —
Partie 15: Détermination de la conductivité
thermique par la méthode du fil chaud (parallèle)

Prüfverfahren für dichte geformte feuerfeste
Erzeugnisse —
Teil 15: Bestimmung der Wärmeleitfähigkeit nach
dem Heißdraht-(Parallel-)Verfahren

This European Standard was approved by CEN on 23 March 1998.

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CEN

European Committee for Standardization
Comité Européen de Normalisation
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Foreword

This European Standard has been prepared by Technical Committee CEN/TC 187, Refractory products and materials, 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 October 1998, and conflicting national standards shall be withdrawn at the latest by October 1998.

It is closely based on the corresponding International Standard, ISO 8894-2 *Refractory materials — Determination of thermal conductivity — Part 2: Hot-wire method (parallel)*, published by the International Organization for Standardization (ISO).

The determination of thermal conductivity by the hot-wire (cross-array) method is given in EN 993-14.

Reproducibility and repeatability data are not available, but may be given in a subsequent edition.

EN 993 *Methods of test for dense shaped refractory products* consists of 18 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, ambient temperatures;*
- *Part 7: Determination of modulus of rupture, 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 (ENV);*
- *Part 12: Determination of pyrometric cone equivalent;*
- *Part 13: Specification of pyrometric cones;*
- *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 acids;*
- *Part 17: Determination of bulk density of granular material (mercury method);*
- *Part 18: Determination of bulk density of granular material (water method).*

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

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1 Scope

This part of EN 993 specifies a hot-wire (parallel) method for the determination of thermal conductivity of refractory products and materials. It is applicable to dense and insulating shaped products and to powdered or granular materials (see 7.2), for thermal conductivities of less than 25 W/m·K. The limits are imposed by the dimensions of the test pieces and higher thermal conductivities can be measured if larger pieces are used. Electrically conducting materials cannot be measured.

NOTE 1 The thermal conductivity of bonded bricks can be affected by the appreciable amount of water that is retained after hardening or setting and is released on firing. These materials may therefore require pre-treatment; the nature and extent of such pre-treatment and the period for which the test piece is held at the measurement temperature, as a preliminary to carrying out the test, are details that are outside the scope of this part of EN 993 and should be agreed between the parties concerned.

NOTE 2 In general it is difficult to make measurements on anisotropic materials and the use of this method for such materials should also be agreed between the parties concerned.

2 Normative references

This European Standard incorporates by dated or undated references, 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 European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 993-14, *Methods of test for dense shaped refractory products — Determination of thermal conductivity by the hot wire (cross-array) method.*

ISO 31-4, *Specification for quantities, units and symbols. Heat.*

3 Definitions

For the purposes of this standard, the following definitions, in accordance with EN 993-14, and ISO 31-4 apply:

3.1

thermal conductivity, λ

density of heat flow rate divided by the temperature gradient, in units of watt per metre kelvin (W/m·K)

3.2

thermal diffusivity, a

$$a = \frac{\lambda}{\rho \cdot C_p}$$

where:

λ is the thermal conductivity;

ρ is the bulk density;

C_p is the specific heat capacity at constant pressure

thermal diffusivity is expressed in units of square metre per second (m²·s⁻¹)

3.3

power, P

rate of energy transfer, in units of watts (W)

4 Principle

The hot-wire method (parallel) is a dynamic measuring procedure based on the determination of the temperature increase against time at a certain location and at a specified distance from a linear heat source embedded between two test pieces.

The test pieces are heated in a furnace to a specified temperature and maintained at that temperature.

Further local heating is provided by a linear electrical conductor (the hot wire) that is embedded in the test piece and carries an electrical current of known power that is constant in time and along the length of the test piece.

A thermocouple is fitted at a specified distance from the hot wire, the thermocouple leads running parallel to the wire (see Figure 1). The increase in temperature as a function of time, measured from the moment the heating current is switched on, is a measure of the thermal conductivity of the material from which the test pieces are made.

5 Apparatus

5.1 Furnace, electrically heated, capable of taking one or more test assemblies (see 6.1) up to a maximum temperature of 1 250 °C. The temperature at any two points in the region occupied by the test pieces shall not differ by more than 10 °C. The temperature measured on the outside of the test assembly during a test (of duration about 15 min) shall not vary by more than ±0,5 °C, and shall be known with an accuracy of ±5 °C.

5.2 Hot wire, preferably of platinum or platinum-rhodium, about 200 mm in length and not exceeding 0,5 mm in diameter; the actual length being known to within ±0,5 mm.

NOTE A hot wire made of base metal can be used at temperatures below 1 000 °C.

Both ends of the hot wire are attached to the power source and the digital multimeter (see 5.5). The wires to the power source may also be a continuation of the hot wire itself and shall have the same diameter as the wire within the assembly. The wires to the digital multimeter shall be of a diameter not greater than that of the hot wire when within the assembly. Leads outside the assembly shall consist of two or more tightly twisted wires of 0,5 mm diameter. The current lead connections external to the furnace shall be made with heavy gauge cable.

5.3 Power supply, to the hot wire (see 5.2), which shall be stabilized a.c. or d.c. and shall not vary in power by more than 2 % during the period of measurement. A supply to the hot wire of at least 80 W is required.

NOTE This is equivalent to 400 W/m for a 500 mm long wire.