SLOVENSKI STANDARD
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Metode za preskuġanje gostih oblikovanih ognjevzdrġnih izdelkov - 15. del: Ugotavljanje toplotne prevodnosti z metodo vroļ e (vzporedne) ġice

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

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

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

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This European Standard was approved by CEN on 21 March 2005.

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Foreword

This document (EN 993-15:2005) 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of an identical text or by endorsement, at the latest by November 2005, and conflicting national standards shall be withdrawn at the latest by November 2005.

This document supersedes EN 993-15:1998.

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

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 (ENV)*

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 by a differential method*

Part 20: *Determination of resistance to abrasion at ambient temperature*

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

1 Scope

This European Standard describes 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 6.2), for thermal conductivities of less than 25 W/m.K. The limits are imposed by the thermal diffusivity of the test material and therefore by the dimensions of the test pieces; higher thermal conductivities can be measured if larger pieces are used. Electrically conducting materials cannot be measured.

NOTE 1 The thermal conductivity of products with a hydraulic or chemical bond 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 standard 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 Terms and definitions

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

2.1
thermal conductivity, λ
density of heat flow rate divided by the temperature gradient, in units of watt per metre Kelvin (W/m.K)

2.2
thermal diffusivity, a

$$a = \frac{\lambda}{\rho . c_p}$$

where:

λ is the thermal conductivity

ρ is the bulk density

c_p is the specific heat capacity at constant pressure per weight

NOTE Thermal diffusivity is expressed in units of square metre per second (m^2s^{-1})

2.3
power, P
rate of energy transfer, in watts (W)

3 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.

4 Apparatus

4.1 Furnace, electrically heated, capable of taking one or more test assemblies (see 5.1) up to a maximum temperature of 1 250 ºC. The temperature at any two points in the region occupied by the test pieces shall not differ by more than 10 K. 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 K, and shall be known with an accuracy of ± 10 K.

4.2 Hot wire, preferably of platinum or platinum-rhodium, with a minimum length equivalent to that of the test piece. . The voltage taps should be located in the test piece with a length between the taps of about 200 mm known to the nearest ± 0,5 mm.

Both ends of the hot wire are attached to the power source and the voltage taps to the digital multimeter (4.5). 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.

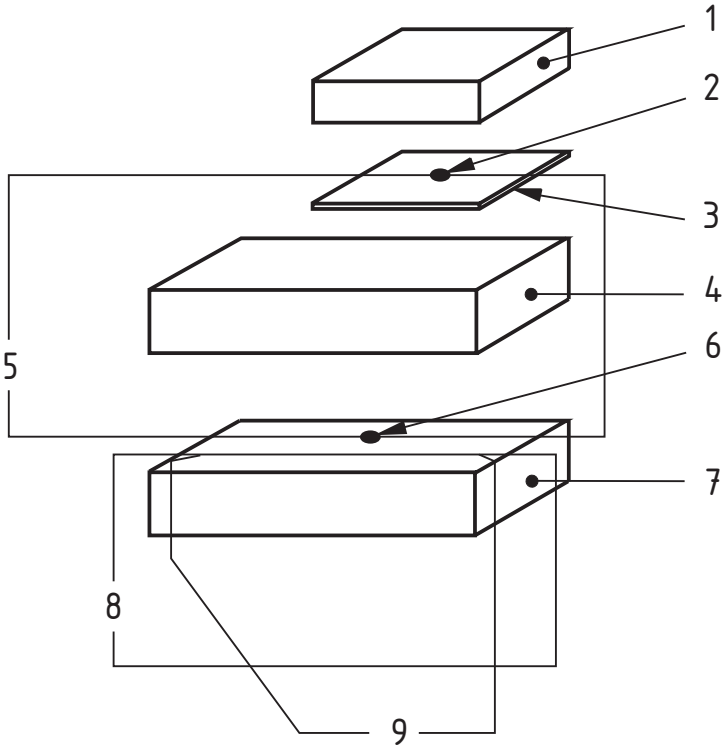
4.3 Power supply, to the hot wire (4.2), which shall be stabilized a.c. or d.c., but preferably a.c., and shall not vary in power by more than 2 % during the period of measurement.

A power supply to the hot wire of at least 250 W/m is required. This is equivalent to 50 W between the voltage taps for a distance of 200 mm.

4.4 Differential platinum/platinum-rhodium thermocouple, (Type R: platinum 13 % rhodium/platinum thermocouple or Type S: platinum 10% rhodium/platinum thermocouple, see Table 1) formed from a measurement thermocouple and a reference thermocouple connected in opposition (see Figure 1). The leads of the measurement thermocouple shall run parallel to the hot wire at a distance of 15 mm ± 1 mm (see Figure 2). The output of the reference thermocouple shall be kept stable by placing it between the top outer face of the upper test piece and a cover of the same material as the test piece (see Figure 1). The diameter of the measurement thermocouple wires shall be the same as that of the hot wire and the wires of both thermocouples shall be long enough to extend outside the furnace where connections to the measuring apparatus shall be made by wire of a different type. The external connections of the thermocouple shall be isothermal.

An insulating layer may be inserted between the cover and the upper test piece.

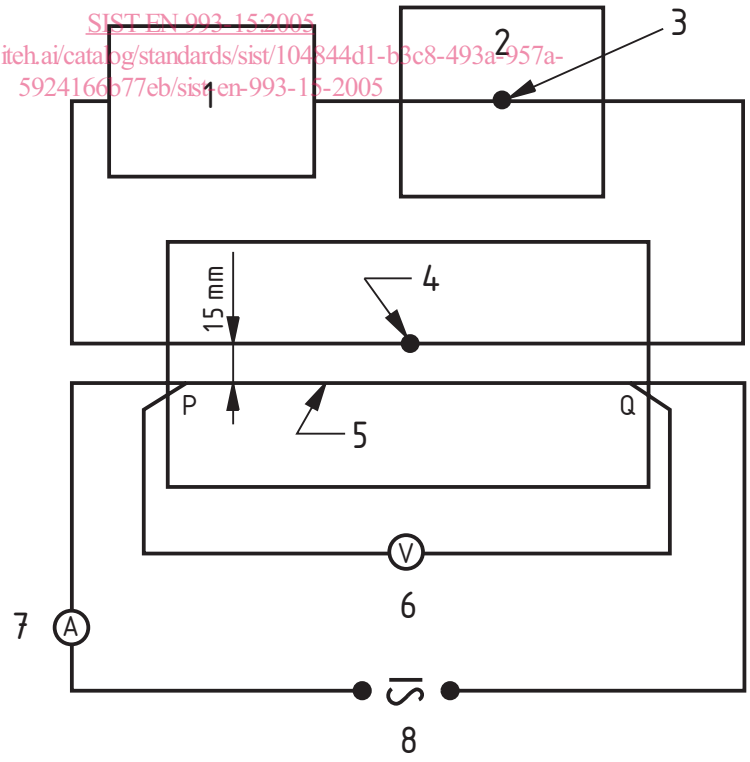
NOTE Base metal thermocouples can be used at temperatures below 1 000 ºC.



Key

1 Cover
2 Reference thermocouple
3 Optional insulating layer
4 Test piece
5 Measurement circuit
6 Measurement thermocouple
7 Test piece
8 Heating circuit
9 Voltage taps

Figure 1 — Location of heating circuit and measurement circuit (differential thermocouple circuit)



Key

1 Temperature/time registration device
2 Cover
3 Reference thermocouple
4 Measurement thermocouple
5 Hot wire
6 Voltmeter
7 Ammeter
8 Power source
PQ = Hot-wire measurement length

Figure 2 — Measurement arrangement