INTERNATIONAL STANDARD

ISO 10635

First edition
1999-06-01

Refractory products — Methods of test for ceramic fibre products

Produits réfractaires — Méthodes d'essai des produits à base de fibres céramiques

Reference number
ISO 10635:1999(E)

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Printed in Switzerland

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 10635 was prepared by Technical Committee ISO/TC 33 *Refractories*.

Annex A of this International Standard is for information only.

Refractory products — Methods of test for ceramic fibre products

1 Scope

This International Standard specifies methods for determining the thickness, bulk density, resilience, permanent linear change on heating, thermal conductivity, tensile strength and shot content of ceramic fibre products. It applies to ceramic fibre bulk, blankets, felts, mats, boards, papers and pre-formed shapes with the exception of products delivered in a wet state.

The application of the individual test methods is given in table 1, with reference to the type of products.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 565, *Test sieves — Metal wire cloth, perforated metal plate and electroformed sheet — Nominal sizes of openings.*

ISO 7500-1, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tensile testing machines.*

3 Preparation of test pieces

The number of items to be tested shall be determined by agreement between the parties. The number of test pieces per item shall be determined in accordance with Table 1.

When the material to be tested is wound, any compressed material at the extreme ends shall be excluded. A strip shall be cut perpendicular to the length across the full material width, of sufficient size for the different tests planned.

The required number of test pieces of required dimensions shall be cut using a template, a sharp knife, a saw or other method which will not damage the test piece. Avoid excess pressure as this may crush the fibre.

Table 1 — Summary of test methods and designations, applicability to product types and number of test pieces per item required

Clause	Test	Material	Number of test pieces
4	Thickness: 725 Pa method or 350 Pa method	blanket, felt, mat, board, paper	3
5	Bulk density	blanket, felt, mat, board, paper	3
6	Resilience	blanket, felt, mat	3
7	Permanent linear change on heating by the: slow heat method hot furnace method	blanket, felt, mat, board, paper, pre-formed shapes	3
8	Thermal conductivity: calorimetric method up to hot face temperature of 1300 °C	blanket, felt, mat, board	1
9	Tensile strength	blanket, felt, paper	5
10	Shot content	bulk fibre, blanket, felt, mat, paper	3

4 Determination of thickness

4.1 Principle

Determination of the thickness of a product subjected to a compressive stress which depends on its nominal bulk density. There are two methods, of which the dial gauge comparator method (see 4.3.1) is the reference method and is the only method applicable to ceramic fibre paper.

4.2 Test piece dimensions

The size of the test piece shall be such that the disc rests on it entirely, and shall be at least 100 mm × 100 mm.

4.3 Methods

4.3.1 The dial gauge comparator method

4.3.1.1 Apparatus, consisting of a machined reference plate, a dial gauge comparator with a metallic disc, 75 ± 1 mm in diameter, fixed at right angles to the dial gauge measuring probe. The apparatus shall be capable of applying a 350 Pa ± 7 Pa compressive stress to products with a nominal bulk density < 96 kg/m^3 and a 725 Pa ± 15 Pa compressive stress to products with a nominal bulk density $\geqslant 96$ kg/m^3.

4.3.1.2 Procedure. Brush the reference plate free of any residual material and check that the disc lies parallel to the reference plate and, when they are in contact, the dial gauge reads zero.

Gently raise the disc and slide the test piece underneath it. Slowly lower the disc on to the test piece until it supports the full pressure of the disc and weigh (see 4.3.2.1). When the reading is stable record the dial reading to an accuracy of ± 0,1 mm.

4.3.2 The needle method

4.3.2.1 Apparatus, consisting of a machined reference plate and a measuring device made up of a needle 150 mm ± 1 mm in length and 3 mm ± 0,2 mm in diameter, and a metallic disc 75 mm ± 1 mm in diameter which slides along the needle and has a friction device to grip the needle unless purposely moved (see Figure 1).

The stress determined by the mass of the disc and its securing device shall not exceed 350 Pa ± 7 Pa for products with a nominal bulk density $<$ 96 kg/m^3 and 725 Pa ± 15 Pa for products with a nominal bulk density $\geqslant$ higher than 96 kg/m^3.

4.3.2.2 Procedure. Place the test piece on the reference plate and force the penetrating needle of the depth gauge downward through the test piece, perpendicular to the reference plate. If necessary, to prevent compression of the test piece by the depth gauge needle, first pierce the test piece. When the point of the needle touches the reference plate, lower the sliding disc to the point of contact with the top surface of the test piece until it supports the full pressure of the disc and gripping device. Secure the disc in position and withdraw the gauge. Measure with a steel rule the distance from the point of the needle to the sliding disc within an accuracy of ± 0,5 mm.

4.4 Test report

Report the data required by clause 11, the dimensions of each test piece, the individual values for each test piece and the mean value for each item.

5 Determination of bulk density

5.1 Principle

Determination of the bulk density by calculation of the ratio between the mass of the product and its volume geometrically determined, thickness having been first determined according to clause 4.

5.2 Apparatus

5.2.1 Thickness measurement device, in accordance with 4.3.1 or 4.3.2.

5.2.2 Steel rule, capable of being read to 0,5 mm, possibly with a square angle at the readings origin, or alternatively, callipers.

5.2.3 Ventilated oven, capable of being maintained at 110 °C ± 5 °C;

5.2.4 Balance, accurate to ± 0,1 g.

5.3 Test pieces

The dimensions of the test pieces shall be in accordance with 4.2.

The test pieces shall be dried in the oven at 110 °C ± 5 °C to constant mass. Constant mass can be considered as achieved when the mass variation between two weighings, carried out within an interval of 1 h, does not exceed 0,1 %.

Reject any test piece where the loss of mass exceeds 5 % after drying.

5.4 Procedure

Measure the two other dimensions of the test piece with the steel rule or the callipers to an accuracy of 0,5 mm, and calculate the area of the test piece, the thickness being determined according to clause 4.

Carry out the measurements along the middle of each face of the test piece. Carry out the weighings with an accuracy of ± 0,1 g.

5.5 Expression of results

Calculate the bulk volume V_b of the test piece (in m^3) using the following equation:

$$V_b = S \times t$$

where:

S is the area in square metres;

t is the thickness in metres.

Calculate the bulk density ρ of the test piece in kilograms per cubic metre using the equation:

$$\rho = \frac{m}{V_b}$$

where:

m is the dry mass in kilograms determined in 5.4;

V_b is the bulk volume in cubic metres.

5.6 Test report

Report the data required by clause 11, the mass and dimensions of each test piece, reference to the method for thickness, and the individual values for each test piece and the mean for each item.

6 Determination of resilience

6.1 Definition

Resilience is the ability of ceramic fibre products to spring back after compression to 50 % of thickness. It is the ratio of the thickness of a product after the application and relaxation of a compressive force, to its original thickness.

6.2 Principle

Calculation of the ratio, expressed as a percentage, of the thickness of a product to its initial thickness after application of a compressive stress sufficient to reduce the initial thickness to 50 % for a given period of time.

6.3 Apparatus

6.3.1 Thickness gauge

6.3.2 Compression testing machine, capable of applying the compressive stress at a given rate and provided with means for measuring the test piece deformation.

6.3.3 Ventilated oven, capable of being maintained at 110 °C ± 5 °C.

6.4 Test pieces

6.4.1 Dimensions

The dimensions of the test piece shall be 100 mm × 100 mm × (nominal thickness). Compression of the test pieces when cutting out shall be avoided.

6.4.2 Drying

Dry the test pieces in accordance with 5.3.

6.5 Procedure

Determine the thickness according to clause 4. Set the compression testing machine to give a constant deformation rate of 2 mm/min.

Place the test piece in the compression tester and compress at the given rate until the test piece thickness has been reduced by 50 %.

NOTE 1 If a record of compressive stress versus thickness is required, the compressive stress at regular percentage reductions of the original thickness should be recorded.

Keep the test piece at 50 % of its initial thickness for 5 min and then remove the majority of the pressure applied by the testing machine but just maintaining a nominal pressure, of either 350 Pa ± 7 Pa for products with a bulk density < 96 kg/m^3 or 725 Pa ± 15 Pa for products with a bulk density $\geqslant 96$ kg/m^3. After 5 min, determine the thickness according to clause 4.

NOTE 2 Other values for reduction of the thickness can be chosen by agreement between the parties. The same procedure should be used.

6.6 Expression of the results

Calculate resilience, as a percentage to the nearest 0,5 %, from the following equation:

$$R = \frac{d_f}{d_0} \times 100$$

Calculate permanent deformation, as a percentage to the nearest ± 0,5 %, from the following equation:

$$PD = 1 - \left(\frac{d_f}{d_0} \right) \times 100$$

where

d_f is the thickness after testing;

d_0 is the initial thickness.

6.7 Test report

Report the data required by clause 11, the dimensions of the test pieces and the thickness method, also any value for reduction of the thickness, if different from 50 %, individual values of permanent deformation/resilience, and the mean values of permanent deformation/resilience.

7 Determination of permanent linear change on heating

7.1 Principle

Determination of the permanent linear change of the dimensions of test pieces held at a prescribed temperature and for a prescribed time interval. The permanent linear change is expressed as the ratio of the difference between the initial dimension and the dimension after testing measured between platinum wire markers inserted into the test piece surface on the initial dimension.

7.2 Apparatus

7.2.1 Furnace, gas or electric (oxidizing atmosphere) in which the temperature distribution shall not exceed ± 10 °C and the dimensions of which shall be such as to comply with the test piece placing requirements (see 7.4.3.1) and the temperature measurement requirements (see 7.4.3.2).

7.2.2 Measuring devices, optical such as a cathetometer, accurate to ± 0,01 mm, or callipers, accurate to ± 0,05 mm.

7.2.3 Thermocouples, a minimum of two shall be used to measure the temperature and temperature distribution over the space occupied by the test pieces.

7.3 Test pieces

7.3.1 Dimensions

The dimensions of the test pieces shall be 100 mm × 100 mm × (actual thickness), care being taken to record the direction of rolling of the product.

7.3.2 Drying

Dry the test pieces in accordance with 5.3.

7.4 Procedure

7.4.1 Test piece preparation

On the diagonals of the upper 100 mm × 100 mm surface of each test piece, and 10 mm to 15 mm away from the edges, insert four platinum wire markers so that they are approximately 75 mm apart.

These markers shall be approximately 0,5 mm in diameter, their length being such as to leave 1 mm or 2 mm protruding above the surface when they are inserted at a depth corresponding to at least 3/4 of the test piece thickness.

NOTE For boards and pre-formed shapes, the platinum wire markers can be replaced by painted marks.

Test pieces shall be placed on the lower 100 mm × 100 mm surface.

7.4.2 Measurements

Measure the distance between the markers, the measurements being made parallel to the edges of the test pieces. Measurements made by an optical device shall be accurate to ± 0,05 mm and shall be used as the reference method. Measurements made with callipers shall be accurate to ± 0,1 mm. The method of measurement shall be stated in the test report.

7.4.3 Heating

7.4.3.1 Placing of test pieces

Place each test piece on a support piece cut from the same material, each support piece being used for one test only. For easier handling, place the support piece on a shaped refractory support 10 mm to 15 mm in thickness.

Place test pieces in the kiln so that:

a) they are at least 50 mm apart;

b) they are at least 50 mm away from the heating elements.

7.4.3.2 Temperature measurement and distribution

Measure the temperature using at least two thermocouples. Place the thermocouple junctions at 10 mm to 20 mm over the upper surface of the test pieces. For the hot furnace method, either mount the thermocouples through the wall and roof of the furnace, or on the ceramic fibre support piece which supports the test piece. During the soaking time, the temperatures recorded by the two thermocouples shall not differ by more than 10 °C, and the mean temperature shall not differ by more than 10 °C from the test temperature.

7.4.3.3 Test temperature

The test temperature shall be the service temperature of the product quoted by the manufacturer or that agreed between parties.

7.4.3.4 Heating methods

Test pieces shall be subjected to one of the two heat treatment methods described below, the method being agreed between parties, with the electric furnace slow heat method used as the reference method.

7.4.3.4.1 Hot furnace method

Place the test pieces directly into a furnace pre-heated to test temperature. The soaking time shall start when the temperature has reached test temperature again after introduction of the test pieces. Hold the test temperature to within ± 10 °C for 24 h.

7.4.3.4.2 Slow heat method

Place the test pieces in the furnace and raise the temperature in the furnace at one of the heating rates given in Table 2.

Hold the test temperature to within ± 10 °C for 24 h. At the end of this period, cool the test pieces by at least 200 °C within 30 min.

Table 2 — Heating rates for the slow heat method

Test temperature °C	Temperature range °C	Heating rate °C/min
⩽ 1 250	ambient to 50 < test temperature	5 to 10
	last 50	1 to 2
1 250 to 1 500	ambient to 1 200	5 to 10
	1 200 to 50 < test temperature	2 to 5
	last 50	1 to 2
> 1 500	ambient to 1 200	< 20
	1 200 to 50 < test temperature	< 10
	last 50	< 2

7.4.3.5 Measurement of the test pieces after the test

Allow test pieces to cool to room temperature, then measure the distances between markers as specified in 7.4.2.