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Thermal insulating products for building applications — Determination of compression behaviour

Produits isolants thermiques destinés aux applications du bâtiment — Détermination du comportement en compression

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 163, *Thermal performance and energy use in the built environment*, Subcommittee SC 1, *Test and measurement methods,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 88, *Thermal insulating materials and products,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 29469:2008), which has been technically revised.

The main changes are as follows:

— subclause 5.1 has been modified;

— the conditioning and testing conditions in 6.4 and 7.1 have been modified;

— subclause 8.1.2 has been clarified;

— Annex A, modifications have been made to the general test method for cellular glass products to include capping in the test protocol;

— some editorial corrections have been made.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Thermal insulating products for building applications — Determination of compression behaviour

1 Scope

This document specifies the equipment and procedures for determining the compression behaviour of specimens. It is applicable to thermal insulating products and can be used to determine the compressive stress in compressive creep tests and for applications in which insulation products are exposed only to short-term loads.

The method can be used for quality control purposes and can also be employed to obtain reference values from which design values can be calculated using safety factors.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

ISO 5725-2, *Accuracy (trueness and precision) of measurement methods and results — Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method*

ISO 29768, *Thermal insulating products for building applications — Determination of linear dimensions of test specimens*

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
strain
ε
ratio of the reduction in thickness of the test specimen to its initial thickness, d_0, measured in the direction of loading and expressed as a percentage

3.2
compressive strength
σ_m
ratio of the maximum compressive force, F_m, reached when the strain, ε, at yield [see Figure 1 b)] or rupture [see Figure 1 a)] is less than 10 %, to the initial cross-sectional area of the test specimen

3.3
compressive stress at 10 % strain
σ_{10}
ratio of the compressive force, F_{10}, at 10 % strain, ε_{10}, to the initial cross-section of the test specimen [see Figure 1, c) and d)] for products presenting 10 % strain before possible yield or rupture

3.4
compression modulus of elasticity
E
compressive stress divided by the corresponding strain below the proportional limit, when the relationship is linear (see Figure 1)

4 Principle

A compressive force is applied at a given rate of displacement perpendicular to the major faces of a squarely cut test specimen and the maximum stress supported by the specimen calculated.

When the value of the maximum stress corresponds to a strain of less than 10 %, it is designated as compressive strength and the corresponding strain is reported. If no failure is observed before the 10 % strain has been reached, the compressive stress at 10 % strain is calculated and its value reported as compressive stress at 10 % strain.

For cellular glass products, the test method described in this document shall be modified in accordance with the provisions given in Annex A.

5 Apparatus

5.1 Compression testing machine, designed to suit the range of force and displacement involved and having two very rigid, polished, square or circular plane parallel platens with a minimum side length (or diameter) equal to the side length (or diagonal) of the test specimen.

One of the platens shall be fixed and the other shall be movable. If appropriate one of the platens shall have a centrally positioned ball joint to ensure that only axial force is applied to the specimen.

The movable platen shall be capable of moving at a constant rate of displacement in accordance with Clause 7.

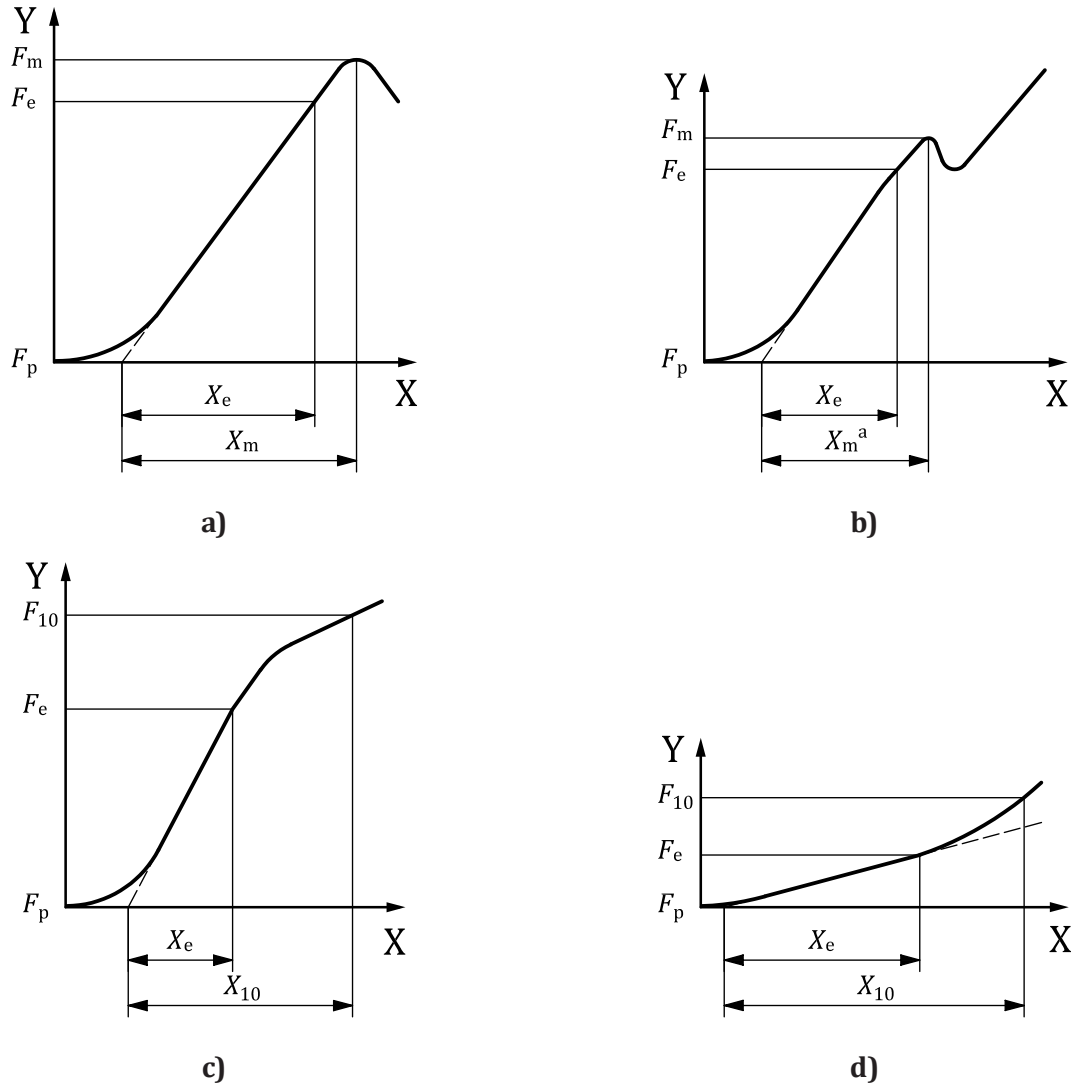
One of the platens shall be fixed and the other shall be movable. If appropriate, one of the platens shall have a centrally positioned ball joint to ensure that only axial force is applied to the specimen.

5.2 Displacement measuring device, fitted to the compression testing machine, which allows continuous measurement of the displacement of the movable platen with a maximum permissible error of ±5 % or ±0,1 mm, whichever is smaller (see 5.3).

5.3 Force measuring device, comprised of a sensor fitted to one of the machine platens to measure the force produced by the reaction of the specimen on the platens. This sensor shall be such that either its own deformation during the measuring operation is negligible compared with that of the object being measured or its own deformation shall be taken into account by calculation. In addition, it shall allow the continuous measurement of the force with a maximum permissible error of ±1 %.

5.4 Recording device, for the simultaneous recording of the force, *F,* and the displacement, *X*, which provides a curve of *F* as a function of *X* (see 7.2).

NOTE The curve gives additional information on the behaviour of the product and possibly enables the determination of the compression modulus of elasticity.



Key

X	displacement
Y	force
F_p	force corresponding to the preload
F_m	maximum force
X_m	displacement at maximum force
F_{10}	force at 10 % strain
X_{10}	displacement at 10 % strain
F_e	force corresponding to X_e (conventional proportional limit)
X_e	displacement in the conventional elastic zone
a	X_m is smaller than 10 %.

Figure 1 — Examples of force displacement curves

6 Test specimens

6.1 Dimensions of specimens

The test specimens shall have the original product thickness. The width of the specimens shall be not less than their thickness. Products with integrally moulded skins that are retained in use shall be tested with these skins intact.

Specimens shall not be layered to produce a greater thickness for testing.

Specimens shall be squarely cut and have the following dimensions:

— 50 mm × 50 mm; or

— 100 mm × 100 mm; or

— 150 mm × 150 mm; or

— 200 mm × 200 mm; or

— 300 mm × 300 mm.

The range of dimensions used shall be specified in the relevant product standard.

In the absence of a product standard, the specimen dimensions may be agreed between the parties involved.

The linear dimensions shall be determined in accordance with ISO 29768, with an uncertainty of measurement of not more than 0,5 %. The tolerance on parallelism and flatness between the two faces of the specimen shall be not greater than 0,5 % of the specimen side length or 0,5 mm, whichever is smaller.

If a specimen is not flat, it shall be ground flat or an adequate coating shall be applied to prepare the surface for the test. No significant deformation shall occur in the coating during the test.

NOTE The accuracy of the test result is reduced if the specimens have a thickness of less than 20 mm.

6.2 Specimen preparation

Specimens shall be cut so that their base is normal to the direction of compression of the product in its intended use. The specimen shall be cut by methods that do not change the structure relative to that of the original product. The method of selecting the specimens shall be as specified in the relevant product standard. In the case of tapered products, the parallelism of the two faces of the specimen shall be in accordance with 6.1.

In the absence of a product standard, the method of selecting the specimens may be agreed between the parties involved.

NOTE Special methods of preparation, when needed, are given in the relevant product standard.

In cases where a more complete characterization of anisotropic materials is desired or where the principal direction of anisotropy is unknown, it can be necessary to prepare additional sets of specimens.

6.3 Number of specimens

The number of specimens shall be as specified in the relevant product standard or any other international specification.

In the absence of a product standard or any other technical specification, either at least five specimens shall be used or the number of specimens may be agreed between the parties.

6.4 Conditioning of specimens

The specimens shall be stored for at least 6 h at (23 ± 5) °C. In case of dispute, they shall be stored at (23 ± 2) °C and (50 ± 5) % relative humidity for the time specified in the relevant product standard.

In tropical climates, different conditioning and testing conditions can be relevant. In this case, the conditions shall be (27 ± 2) °C and (65 ± 5) % RH and be clearly stated in the test report.

7 Procedure

7.1 Test conditions

Testing shall be carried out at (23 ± 5) °C. In case of dispute, it shall be carried out at (23 ± 2) °C and (50 ± 5) % relative humidity.

In tropical climates, different conditioning and testing conditions can be relevant. In this case, the conditions shall be (27 ± 2) °C and (65 ± 5) % RH and be clearly stated in the test report.

7.2 Test procedure

Determine the specimen dimensions in accordance with ISO 29768.

Place the specimen centrally between the two platens of the compression testing machine. Preload with a pressure of (250 ± 10) Pa.

If significant deformation occurs under the preload pressure of 250 Pa, a preload corresponding to 50 Pa may be used if this is specified in the relevant product standard. In this case, the thickness, d_0, should be determined under the same preload.

Compress the specimen with the movable platen at a constant rate of displacement that shall be equal to 0,1 d/min (to within ±25 %), where d is the thickness of the specimen, expressed in millimetres.

Continue compression until the specimen yields, providing a compressive strength value, or until a strain of 10 % has been reached, providing a compressive stress at 10 % strain.

Plot the force-displacement curve.

8 Calculation and expression of results

The results are the mean values of the measurements, which shall be expressed to three significant figures. Results should not be extrapolated to other thicknesses.

Depending on the deformation behaviour (see 7.2), σ_m and ε_m or σ_{10} (see Clause 3) shall be calculated.

8.1 Compressive strength and corresponding strain

8.1.1 Compressive strength

Calculate the compressive strength, σ_m, expressed in kilopascals, using Formula (1):

$$\sigma_m = 10^3 \frac{F_m}{A_0} \quad (1)$$

where

F_m is the maximum force, expressed in newtons;

A_0 is the initial cross-sectional area of the specimen, expressed in square millimetres.

8.1.2 Strain

Before calculating the strain, the zero-deformation point shall be defined. Therefore, a line on the steepest strait portion of the force-displacement curve is extended to the x-axis, which is the line of F_p. The intersection of the line and the x-axis is defined as point of zero deformation, all displacement measurements extend from this point. For example, see Figure 1.

If there is no well-defined straight portion of the force-deformation curve or if the zero-deformation point obtained in this manner results in a negative value, this procedure shall not be used. In such cases, the zero-deformation point shall be taken as the deformation corresponding to a stress of (250 ± 10) Pa.

Calculate the strain, ε_m, expressed as a percentage, using Formula (2):

$$\varepsilon_m = \frac{X_m}{d_0} 100 \tag{2}$$

where

X_m is the displacement corresponding to the maximum force reached, expressed in millimetres;

d_0 is the initial thickness (as measured) of the specimen, expressed in millimetres.

8.2 Compressive stress at 10 % strain

Calculate the compressive stress at 10 % strain, σ_{10}, expressed in kilopascals, using Formula (3):

$$\sigma_{10} = 10^3 \frac{F_{10}}{A_0} \tag{3}$$

where

F_{10} is the force corresponding to a strain of 10 %, expressed in newtons;

A_0 is the initial cross-sectional area of the specimen, expressed in square millimetres.

NOTE If required, the compressive stress for strains lower than 10 % can also be calculated.

8.3 Compression modulus of elasticity

If required, calculate the compression modulus of elasticity, E, expressed in kilopascals, using Formulae (4) and (5):

$$E = \sigma_e \frac{d_0}{X_e} \tag{4}$$

where

$$\sigma_e = 10^3 \frac{F_e}{A_0} \tag{5}$$

F_e is the force at the end of the conventional elastic zone (distinct, straight portion of the force-displacement curve), expressed in newtons;

X_e is the displacement at F_e, expressed in millimetres.

If there is no distinct, straight portion of the force-displacement curve or if the zero-deformation point obtained in accordance with 8.1.2 results in a negative value, this procedure shall not be used. In such cases, the zero-deformation point shall be the deformation corresponding to a stress of (250 ± 10) Pa.

9 Accuracy

An interlaboratory test was performed with 10 laboratories. Four products with different compression behaviour were tested, three of which were used for statistical evaluation of reproducibility (two test results for each product), and one product was used for statistical evaluation of repeatability (five test results).

The results, analysed in accordance with ISO 5725-2, are given in Tables 1 and 2.

Table 1 — Compressive strength, σ_m, or compressive stress at 10 % strain, σ_{10}

Range	95 kPa to 230 kPa %
Estimate of repeatability standard deviation, s_r	0,5
95 % repeatability limit	2
Estimate of reproducibility standard deviation, s_R	3
95 % reproducibility limit	9

Table 2 — Compression modulus of elasticity, *E*

Range	2 500 kPa to 8 500 kPa %
Estimate of repeatability standard deviation, s_r	3
95 % repeatability limit	8
Estimate of reproducibility standard deviation, s_R	10
95 % reproducibility limit	25

The above-mentioned terms shall be in accordance with ISO 5725-2.

10 Test report

The test report shall include the following information:

a) reference to this document, i.e. ISO 29469:2022;

b) product identification:

   1) product name, factory, manufacturer or supplier;

   2) production code number;

   3) type of product;

   4) packaging;

   5) form in which the product arrived at the laboratory;

   6) other information as appropriate (e.g. nominal thickness, nominal density);

c) test procedure:

   1) pre-test history and sampling (e.g. sampling site and person taking the specimens);

   2) conditioning;

   3) any deviations from Clauses 6 and 7;

   4) conditioning and testing conditions in tropical climates, if applicable;

5) date of the test;

6) dimensions and number of test specimens;

7) kind of surface treatment (grinding or type of coating);

8) general information relating to the test;

9) any events which can have affected the results;

d) results:

1) all individual values of compressive strength and corresponding strain or compressive stress at 10 % strain, mean value, and the compression modulus of elasticity, if required.

Annex A
(normative)

Modifications to the general test method for cellular glass products

A.1 General

For cellular glass products, the test method described in this document shall be modified in accordance with the provisions of this annex.

A.2 Apparatus

A.2.1 Compression-testing machine

The compression-testing machine shall be equipped with a ball joint connected to one of the platens.

A.3 Test specimen

A.3.1 Dimensions of specimens

The test specimen shall be a quadrant of an original full-size slab (e.g. in the case of 600 mm × 450 mm slabs, specimens shall be 300 mm × 225 mm in size, with two edges from the original slab).

Where this is not possible, each specimen 200 mm × 200 mm in size shall be taken from any one of the four quadrants of the slab, in a way that respects the symmetry of the quadrant.

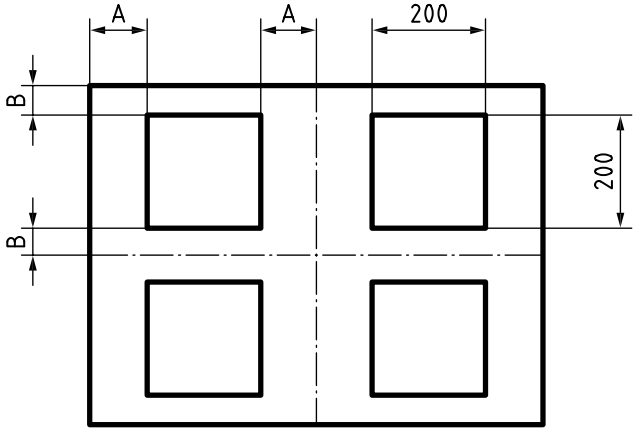


Figure A.1 — Cutting plan for 200 mm × 200 mm specimens out of one slab

A.3.2 Preparation of specimens

A.3.2.1 Flatness specimens

The bearing surfaces of the specimen shall be parallel and flat (see 6.1). If necessary, they shall be rubbed with a suitable abrasive surface to produce the required flat surface.

A.3.2.2 Capping

To smooth the bearing surfaces of the specimens, a suitable capping material shall to be used.

Unfaced cellular glass specimens shall capped by using hot applied bitumen (see A.3.2.2.1) or alternatively by using a thin flexible sheeting (see A.3.2.2.2).

Faced or coated cellular glass specimens, as far as the facing or coating is not smoothly flat, a plaster mortar shall be used (see A.3.2.3).

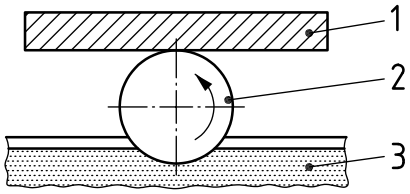
A.3.2.2.1 Bitumen capping

Apply a layer of hot bitumen of type R 85/25 that has been heated to (170 ± 10) °C, to completely fill the open surface cells.

The surface density of the bitumen shall be approximately (1 ± 0,25) kg/m^2.

The hot bitumen is applied on both surfaces of the test specimen by tilting the specimen slightly, and either dip the bearing surface into a bitumen bath or preferably place the bearing surface on a horizontal roller turning into the bitumen bath (see Figure A.1). Scrape off any surplus bitumen. If the open surface cells have not been adequately filled, repeat the process. Dip the specimen again with the coated bearing surface down or repeat the treatment with the horizontal roller. Allow any surplus bitumen to drip off the treated surface. Turn the specimen up and shake it slightly in a horizontal position to ensure uniform distribution of the bitumen.

It has been found convenient to employ a partially submerged roller for applying the bitumen (see Figure A.2).



Key

1 test specimen
2 roller
3 bitumen

Figure A.2 — Application of hot applied bitumen to the specimen surface

Place the specimen with the treated bearing surface on a thin flexible sheet that extends beyond the slab on all sides and that rests on a flat steel platen. The sheet shall be thin, flexible, homogenous and compatible with hot bitumen [e.g. a thin bitumen roofing felt having a surface density of (1 ± 0,25) kg/m^2 or a lightweight kraft paper or a plastic film, possibly reinforced with non-woven glass fibre, having a surface density of (0,15 ± 0,08) kg/m^2]. Apply a load of (200 ± 25) N by means of a load distribution platen with a size not smaller than the specimen.

After about 1 min, remove the load.

After 15 min, coat the second bearing surface as before.

The purpose of the thin, flexible sheeting is to prevent the bitumen applied on the specimen face from sticking to the compression platens during the test.

Set the specimen on edge, supporting only the core of the cellular glass (e.g. with a small piece of wood), exposing both capped surfaces to ambient temperature for a minimum of 15 min to allow the bitumen to harden before testing.

The bitumen shall not be subjected to excessive temperatures that can cause oxidation.

A.3.2.2.2 Alternative capping

In case a hot applied bitumen capping is not possible, an alternative capping method shall be considered, having the same smoothness and cell filling capacity as hot bitumen, e.g. soft butyl or bitumen cold sheet with low shore hardness.

To get valid results, the following should correspond well to the bitumen capping method:

— the compressive strength;

— the stress-deformation behaviour;

— the fracture behaviour (fracture noise and fracture orientation).

Approximately 1 mm to 2 mm thick bitumen-based or butyl-based soft self-adhesive sealings or damping layers for capping have proved to be suitable.

A.3.2.3 Faced or coated cellular glass board

The specimens cut out of a faced or coated cellular board shall be in accordance with A.3.1.

The preparation with hot bitumen shall not be carried out in the case of cellular glass faced or coated board.

If the surface of the facing is not sufficiently flat, a layer of plaster having a thickness of (2 ± 1) mm shall be applied to the surface. The compression test shall be carried out only when the plaster is dry.

A.4 Test procedure

The rate of displacement of the movable platen shall be equal to 0,01 d/min (to within ±25 %), where d is the thickness of the specimen, expressed in millimetres.

Run the test until the specimen yields, usually with a marked drop in load accompanied by a loud noise.

NOTE Given the specimen surface preparation, the method is not suitable for determining the strain and the compression modulus of elasticity by measuring the displacement of the platens of the compression testing machine. An alternative method consists in fixing reference points on the edges of the specimen and in measuring their relative displacement.

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