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**Thermal insulating products for  
building equipment and industrial  
installations — Determination of  
maximum service temperature for  
preformed pipe insulation**

*Produits isolants thermiques pour l'équipement du bâtiment et  
les installations industrielles — Détermination de la température  
maximale de service des coquilles isolantes préformées*



Reference number  
ISO 18096:2013(E)

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# Contents

	Page
Foreword .....	iv
Introduction .....	v
<b>1 Scope</b> .....	<b>1</b>
<b>2 Normative references</b> .....	<b>1</b>
<b>3 Terms and definitions</b> .....	<b>1</b>
<b>4 Principle</b> .....	<b>1</b>
<b>5 Apparatus</b> .....	<b>2</b>
<b>6 Test specimens</b> .....	<b>4</b>
6.1 Dimensions of test specimens .....	4
6.2 Number of test specimens .....	4
6.3 Conditioning of test specimens .....	5
<b>7 Procedure</b> .....	<b>5</b>
7.1 Test conditions .....	5
7.2 Test procedure .....	5
<b>8 Calculation and expression of results</b> .....	<b>6</b>
8.1 Thickness deformation versus time .....	6
8.2 Additional tests and/or observations .....	8
8.3 Internal self-heating .....	8
<b>9 Accuracy of measurement</b> .....	<b>8</b>
<b>10 Test report</b> .....	<b>8</b>
<b>Annex A (normative) Modifications of and additions to the general test method for mineral wool products</b> .....	<b>10</b>
<b>Annex B (normative) Modifications of and additions to the general test method for polyethylene foam (PEF) and flexible elastomeric foam (FEF) products</b> .....	<b>12</b>
<b>Annex C (normative) Modifications of and additions to the general test method for phenolic foam products</b> .....	<b>15</b>

## 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. [www.iso.org/directives](http://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. [www.iso.org/patents](http://www.iso.org/patents)

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

The committee responsible for this document is ISO/TC 163, *Thermal performance and energy use in the built environment*, Subcommittee SC 1, *Test and measurement methods*.

ISO 18096 includes the original EN 14707 prepared by Technical Committee CEN/TC 88, *Thermal insulating materials and products*. However

- subclause [6.3](#) “Conditioning of test specimens”,
- subclause [7.1](#) “Test conditions”,
- [Clause 10](#) “Test report” and
- C.2 “Conditioning of test specimens”

have been modified to reflect conditions for tropical countries.

## Introduction

This International Standard is one of a series of International Standards which specify test methods for determining dimensions and properties of thermal insulating materials and products. The original EN 14707 supports a series of product standards for thermal insulating materials and products which derive from the Council Directive of 21 December 1988 on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products (Directive 89/106/EEC) through the consideration of the essential requirements.

This International Standard has been prepared for products used to insulate building equipment and industrial installations, but it may also be applied to products used in other areas.

A similar International Standard, ISO 18097, is available for testing of flat products.

This International Standard is one of a series of existing European Standards on test methods for products used to insulate building equipment and industrial installations which comprises the following group of International Standards:

ISO standard	Title	Respective EN standard
ISO 12623	<i>Thermal insulating products for building equipment and industrial installations — Determination of short-term water absorption by partial immersion of preformed pipe insulation</i>	EN 13472
ISO 12624	<i>Thermal insulating products for building equipment and industrial installations — Determination of trace quantities of water soluble chloride, fluoride, silicate, sodium ions and pH</i>	EN 13468
ISO 12628	<i>Thermal insulating products for building equipment and industrial installations — Determination of dimensions, squareness and linearity of preformed pipe insulation</i>	EN 13467
ISO 12629	<i>Thermal insulating products for building equipment and industrial installations — Determination of water vapour transmission properties of preformed pipe insulation</i>	EN 13469
ISO 18096	<i>Thermal insulating products for building equipment and industrial installations — Determination of maximum service temperature for preformed pipe insulation</i>	EN 14707
ISO 18097	<i>Thermal insulating products for building equipment and industrial installations — Determination of maximum service temperature</i>	EN 14706
ISO 18098	<i>Thermal insulating products for building equipment and industrial installations — Determination of the apparent density of preformed pipe insulation</i>	EN 13470
ISO 18099	<i>Thermal insulating products for building equipment and industrial installations — Determination of the coefficient of thermal expansion</i>	EN 13471

A further series of existing European Standards on test methods was adopted by ISO. This “package” of standards comprises the following group of interrelated standards:

ISO standard	Title	Respective EN standard
ISO 12344	<i>Thermal insulating products for building applications — Determination of bending behaviour</i>	EN 12089

## ISO 18096:2013(E)

ISO standard	Title	Respective EN standard
ISO 12968	<i>Thermal insulation products for building applications — Determination of the pull-off resistance of external thermal insulation composite systems (ETICS) (foam block test)</i>	EN 13495
ISO 29465	<i>Thermal insulating products for building applications — Determination of length and width</i>	EN 822
ISO 29466	<i>Thermal insulating products for building applications — Determination of thickness</i>	EN 823
ISO 29467	<i>Thermal insulating products for building applications — Determination of squareness</i>	EN 824
ISO 29468	<i>Thermal insulating products for building applications — Determination of flatness</i>	EN 825
ISO 29469	<i>Thermal insulating products for building applications — Determination of compression behaviour</i>	EN 826
ISO 29470	<i>Thermal insulating products for building applications — Determination of the apparent density</i>	EN 1602
ISO 29471	<i>Thermal insulating products for building applications — Determination of dimensional stability under constant normal laboratory conditions (23 degrees C/50 % relative humidity)</i>	EN 1603
ISO 29472	<i>Thermal insulating products for building applications — Determination of dimensional stability under specified temperature and humidity conditions</i>	EN 1604
ISO 29764	<i>Thermal insulating products for building applications — Determination of deformation under specified compressive load and temperature conditions</i>	EN 1605
ISO 29765	<i>Thermal insulating products for building applications — Determination of tensile strength perpendicular to faces</i>	EN 1607
ISO 29766	<i>Thermal insulating products for building applications — Determination of tensile strength parallel to faces</i>	EN 1608
ISO 29767	<i>Thermal insulating products for building applications — Determination of short-term water absorption by partial immersion</i>	EN 1609
ISO 29768	<i>Thermal insulating products for building applications — Determination of linear dimensions of test specimens</i>	EN 12085
ISO 29769	<i>Thermal insulating products for building applications — Determination of behaviour under point load</i>	EN 12430
ISO 29770	<i>Thermal insulating products for building applications — Determination of thickness for floating-floor insulating products</i>	EN 12431
ISO 29771	<i>Thermal insulating materials for building applications — Determination of organic content</i>	EN 13820
ISO 29803	<i>Thermal insulation products for building applications — Determination of the resistance to impact of external thermal insulation composite systems (ETICS)</i>	EN 13497

ISO standard	Title	Respective EN standard
ISO 29804	<i>Thermal insulation products for building applications — Determination of the tensile bond strength of the adhesive and of the base coat to the thermal insulation material</i>	EN 13494
ISO 29805	<i>Thermal insulation products for building applications — Determination of the mechanical properties of glass fibre meshes</i>	EN 13496
ISO 16534	<i>Thermal insulating products for building applications — Determination of compressive creep</i>	EN 1606
ISO 16535	<i>Thermal insulating products for building applications — Determination of long-term water absorption by immersion</i>	EN 12087
ISO 16536	<i>Thermal insulating products for building applications — Determination of long-term water absorption by diffusion</i>	EN 12088
ISO 16537	<i>Thermal insulating products for building applications — Determination of shear behaviour</i>	EN 12090
ISO 16544	<i>Thermal insulating products for building applications — Conditioning to moisture equilibrium under specified temperature and humidity conditions</i>	EN 12429
ISO 16545	<i>Thermal insulating products for building applications — Determination of behaviour under cyclic loading</i>	EN 13793
ISO 16546	<i>Thermal insulating products for building applications — Determination of freeze-thaw resistance</i>	EN 12091

The Application of Agreement on technical cooperation between ISO and CEN (Vienna Agreement), Modes 1, 2, 4 and 5, was not approved by CEN/TC 88 and the necessity not seen by its stakeholders.

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# Thermal insulating products for building equipment and industrial installations — Determination of maximum service temperature for preformed pipe insulation

## 1 Scope

This International Standard specifies the equipment and procedures for determining the maximum service temperature for preformed pipe insulation. It is applicable to thermal insulating products.

## 2 Normative references

The following referenced documents are indispensable for the application 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 9229, *Thermal insulation — Vocabulary*

ISO 16544, *Thermal insulating products for building applications — Conditioning to moisture equilibrium under specified temperature and humidity conditions*

ISO 12628, *Thermal insulating products for building equipment and industrial installations — Determination of dimensions, squareness and linearity of preformed pipe insulation*

## 3 Terms and definitions

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

### 3.1

#### **maximum service temperature**

highest temperature at which the insulation product, when installed at the recommended thickness in a given application, continues to function within specified limits of performance

[ISO 9229:2007, definition 2.6.9.1]

Note 1 to entry: The required performance may be in the areas of dimensional stability, thermal properties, and mechanical properties, as well as changes in appearance and resistance against creation of hazards such as internal self-heating (see annexes and requirements in the relevant product standard).

Note 2 to entry: In the present test procedure, which is used as a reference, the test specimen is exposed to a temperature difference going from ambient to the maximum service temperature. This may not reflect the actual application conditions when products are exposed to different temperatures on the two main faces, e.g. in multi-layer systems or for faced products where the facing may limit the maximum service temperature.

## 4 Principle

Measure thickness and length after one sided heat treatment for a specified time period, at the maximum service temperature, achieved using a specified rate of temperature increase. The thickness of the test specimen is measured during heat treatment and the length only after cooling to ambient temperature.

NOTE The procedure may be an iterative process.

Additional requirements for assessing the maximum service temperature of specific materials are described in the annexes to this International Standard or the relevant product standard or any other international technical specification.

## 5 Apparatus

A general arrangement of the apparatus is indicated in [Figures 1](#) and [2](#) and is comprised of:

**5.1 Hot pipe**, with a uniform temperature distribution in the measuring zone on the hot surface and a heat flux perpendicular to the surface of the pipe within the measuring zone (two pipes are required, with diameters that fulfil the requirements of [6.1](#)). The hot pipe shall be linear to within  $\pm 1$  mm in the measuring zone at ambient temperature.

The hot pipe shall be capable of being controlled to within  $\pm 2$  % of a predetermined temperature  $\pm 10$  °C whichever is smaller over the central 60 % of the total pipe length.

The hot pipe shall be capable of being heated at 50 °C/h and/or 300 °C/h.

**5.2 End insulation**, with a gap as small as possible between end insulation and guard piece of the test specimen (e.g.  $\leq 3$  mm) which will permit free movement during the test of the test specimen.

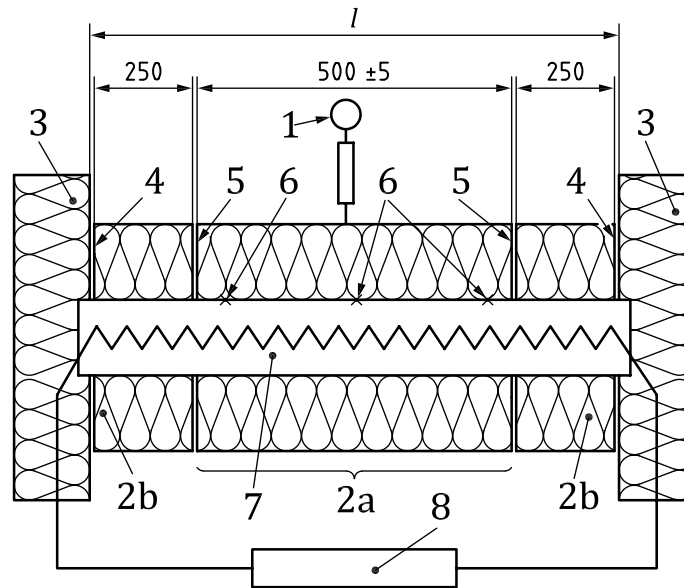
**5.3 Temperature sensors** (e.g. thermocouples) capable of recording the hot surface temperature of the test pipe to the nearest  $\pm 1$  % in centigrade but not less than  $\pm 1$  °C, which are placed within grooves on the hot pipe.

**5.4 Flexible metal foil, three pieces**, (e.g. brass) capable of exerting a uniform pressure of 500 Pa on the upper surface of the test specimen along its testing length of  $(500 \pm 5)$  mm and the two end guards, length  $(250 \pm 5)$  mm. The pressure shall be calculated using the area: e.g. the test length of 500 mm times the diameter of the hot pipe.

**5.5 Device**, e.g. electromechanical for measuring the thickness of the test specimen during the test to the nearest 0,1 mm.

When determining the thickness of the test specimen the thermal movement of the apparatus (e.g. quartz rod) shall be taken into account up to the maximum service temperature.

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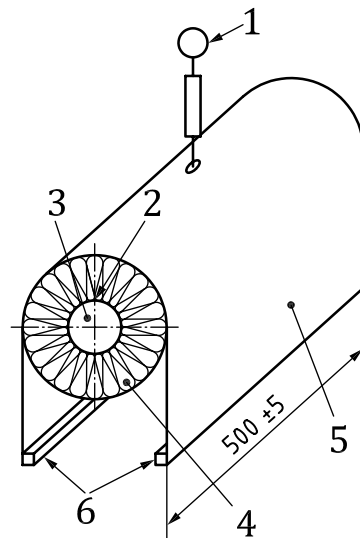


**Key**

- |    |  |   |                                      |
|----|--|---|--------------------------------------|
| 1  | device for measuring thickness, e. g. electromechanical device | 5 | circumferential joints               |
| 2a | test length of the test specimen                               | 6 | thermocouples                        |
| 2b | test specimen end guard  | 7 | hot pipe                             |
| 3  | end insulation   | 8 | power supply and temperature control |
| 4  | small gap  |   |                                      |

NOTE All dimensions are in millimetres.

**Figure 1 — Example of an apparatus for determining maximum service temperature — General arrangement**



**Key**

- |   |                       |
|---|-----------------------|
| 1 device for measuring thickness, e.g. electromechanical device | 4 test specimen       |
| 2 thermocouple  | 5 flexible metal foil |
| 3 hot pipe  | 6 weights for loading |

NOTE All dimensions are in millimetres.

**Figure 2 — Example of an apparatus for determining maximum service temperature — Test specimen loading arrangement**

## 6 Test specimens

### 6.1 Dimensions of test specimens

**Length:** The test specimen, length  $(1\ 000 \pm 10)$  mm, shall be cut at right angles to its length to give two end guards, length each  $(250 \pm 5)$  mm, and a test length of  $(500 \pm 5)$  mm.

**Thickness:** The thickness shall be 100 mm or the largest thickness below 100 mm available.

**Inside diameter:** Two sizes shall be tested, in the range 22 mm to 220 mm.

The dimensions shall be as specified in the relevant product standard or annex to this International Standard.

NOTE 1 In the absence of a product standard or any other international technical specification, the dimensions may be agreed between parties.

NOTE 2 Testing may be performed on multi-layer systems to simulate the conditions existing in the application.

If the pipe insulation is cut from a homogeneous, isotropic flat product, then the maximum service temperature can be obtained from tests carried out on the flat product with similar properties in accordance with ISO 18097.

### 6.2 Number of test specimens

The number of test specimens shall be as specified in the relevant product standard. If the number is not specified, then at least one test specimen for each size shall be used.

NOTE In the absence of a product standard or any other international technical specification the number of test specimens may be agreed between parties.

### 6.3 Conditioning of test specimens

The test specimens shall be stored for at least 6 h at  $(23 \pm 5) ^\circ\text{C}$ . In case of dispute they shall be stored at  $(23 \pm 2) ^\circ\text{C}$  and  $(50 \pm 5) \% \text{RH}$  for the time specified in the relevant product standard or at least 24 h.

In tropical countries, different conditioning and testing conditions can be relevant. In this case, the conditions shall be  $(27 \pm 5) ^\circ\text{C}$  and  $(65 \pm 5) \% \text{RH}$ .

## 7 Procedure

### 7.1 Test conditions

The initial temperature of test specimen and the hot pipe shall be  $(23 \pm 5) ^\circ\text{C}$ .

In tropical countries, different conditioning and testing conditions can be relevant. In this case, the conditions shall be  $(27 \pm 5) ^\circ\text{C}$  and  $(65 \pm 5) \% \text{RH}$ .

### 7.2 Test procedure

Measure the length, the inside diameter and the thickness of the test specimen,  $l_0$ ,  $D_i$ ,  $d_0$ , in accordance with ISO 12628 to the nearest 0,5 mm.

Install the test specimen (the two guards and the test length of the test specimen) on the hot pipe and ensure contact on the upper part of the hot pipe between the test specimen and the hot surface. Avoid any longitudinal gaps and any gaps between the end guards and the test length of the test specimen. The installation practice shall duplicate the practice, if required in the product standard.

**NOTE** In cases where gaps of more than two millimetres develop between the end guards and the test length during the test, action should be taken to close the gap without disturbing the measurement.

Place the two pieces of flexible metal foil over the two end guards, length  $(250 \pm 5) \text{ mm}$ , and exert a pressure of 500 Pa (see 5.4).

Place the third flexible metal foil, length  $(500 \pm 5) \text{ mm}$ , over the test specimen test length and exert a pressure of 500 Pa (see 5.4).

**NOTE** For polyethylene foam and flexible elastomeric foam products, see Annex B.

Measure the thickness of the test specimen,  $d_1$ , to the nearest 0,1 mm.

Heat the test specimen using a temperature rate of increase between  $50 ^\circ\text{C}/\text{h}$  and  $300 ^\circ\text{C}/\text{h}$ , as specified in the relevant product standard or annex of this International Standard.

Maintain the temperature of the hot side, at the expected maximum service temperature, for 72 h within  $\pm 2 \%$  of this temperature or  $\pm 10 ^\circ\text{C}$ , whichever is smaller.

Record the thickness continuously during the test and at the end of the 72 hour period,  $d_2$ , to the nearest 0,1 mm.

Cool the test specimen in the equipment, to a temperature of  $< 35 ^\circ\text{C}$  and remeasure the thickness,  $d_3$ , to the nearest 0,1 mm, unless otherwise specified in the relevant product standard or annex of this International Standard.

Observe the presence of any longitudinal gaps and any gaps between the end guards and the test length of the test specimen and measure their width to the nearest 0,1 mm.

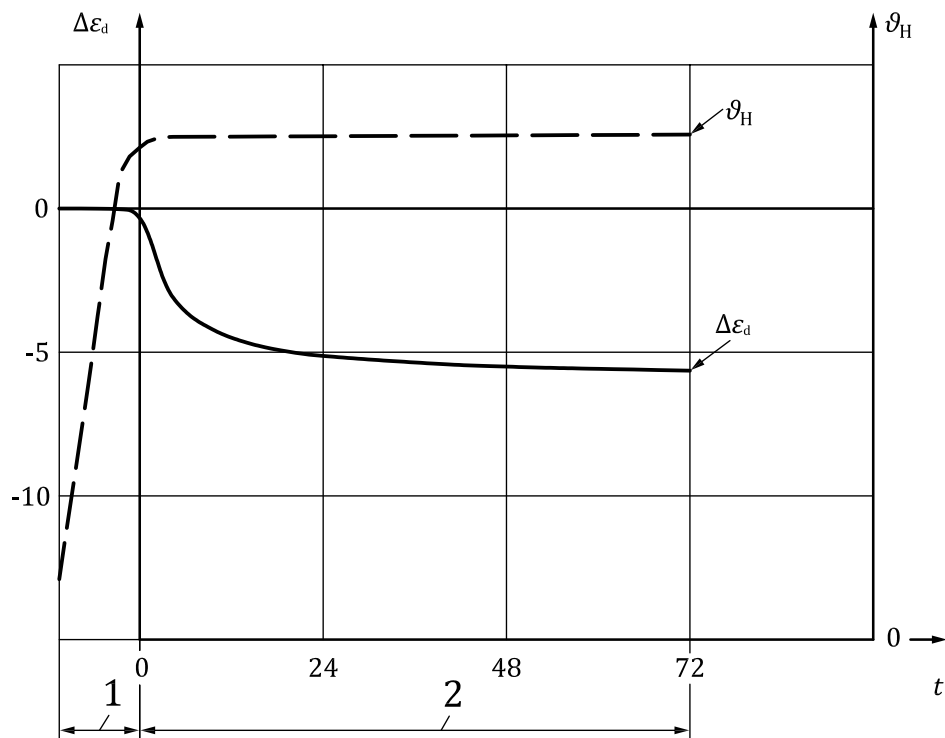
Examine the test specimen visually and note any changes caused by the test.

If the relevant product standard or annex of this International Standard specifies additional requirements the observations and/or tests shall be performed accordingly.

## 8 Calculation and expression of results

### 8.1 Thickness deformation versus time

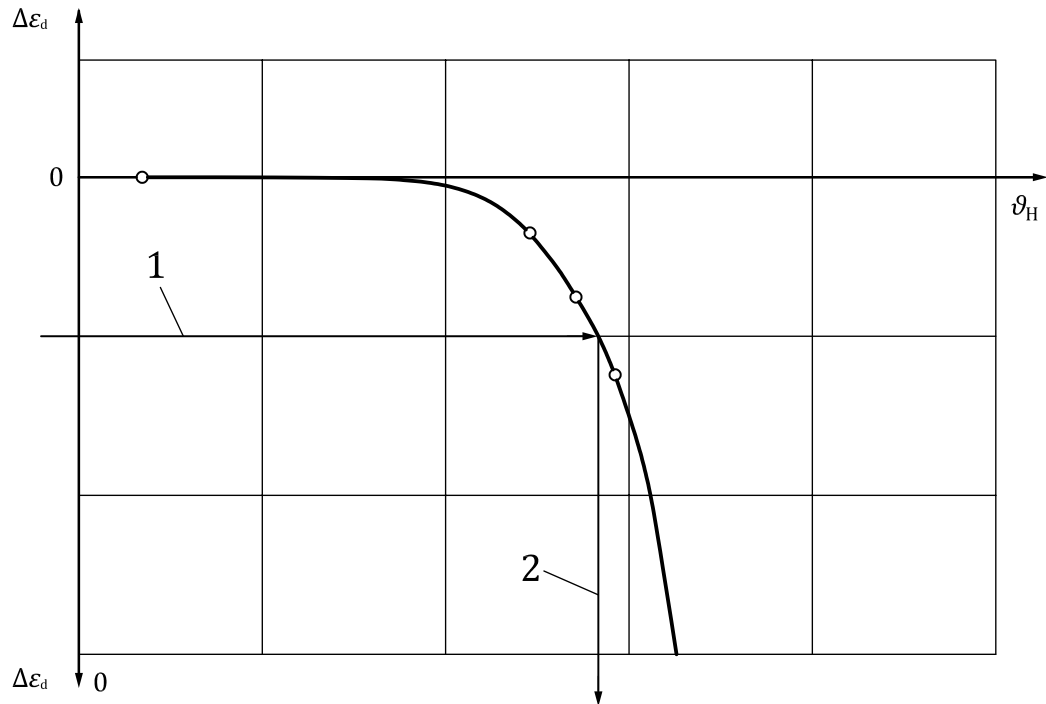
The curve thickness deformation versus time and temperature versus time recorded during testing shall be given. An example is shown in [Figure 3](#).



#### Key

- 1 period of heating
- 2 period of testing
- $\Delta\varepsilon_d$  change in thickness in percentage
- $\vartheta_H$  temperature of the hot plate in centigrade
- $t$  time in h

**Figure 3 — Example of hot plate temperature and thickness change versus time curves**



**Key**

- 1 maximum change of thickness of the relevant product standard in percentage
- 2 maximum service temperature in centigrade
- $\Delta\epsilon_d$  change in thickness in percentage
- $\vartheta_H$  temperature of the hot pipe in centigrade

**Figure 4 — Example of determination of the maximum service temperature (after 72 h)**

Calculate the thickness change,  $\Delta\epsilon_d$ , in percentage, using the following formula:

$$\Delta\epsilon_d = 100 \times \frac{d_2(\text{or } 3) - d_1}{d_1} \tag{1}$$

where:

- $d_1$  is the measured thickness installed on the heating pipe before heating, in millimetres;
- $d_2$  is the measured thickness installed on the heating pipe after 72 h at constant temperature, in millimetres;
- $d_3$  is the measured thickness after cooling down to a temperature of  $< 35 \text{ }^\circ\text{C}$ , in millimetres.

If the change in thickness is larger by using  $d_3$  instead of  $d_2$  in Formula (1), this thickness shall be used in the calculation of the test result.

Calculate the test result as the mean value of the thickness change,  $\overline{\Delta\epsilon_d}$ , in percentage rounded to the nearest 0,5 % from the test results of the individual test specimens.

If the change in the mean thickness exceeds the value specified in the relevant product standard, the test shall be repeated at a lower temperature until the thickness change is smaller than or equal to the specified value. This temperature is then considered as the maximum service temperature (see [Figure 4](#)), provided that the requirements given in [8.2](#) and [8.3](#) are also fulfilled.

## ISO 18096:2013(E)

The steps in centigrade for the indication of the maximum service temperature shall be as specified in the relevant product standard or annex to this International Standard. If the steps are not specified the maximum service temperature shall be declared in steps of not less than 5 °C for temperatures up to 100 °C and in steps of not less than 10 °C for temperatures above 100 °C.

NOTE Results may not be comparable for a product tested at different thicknesses and/or different loads.

### 8.2 Additional tests and/or observations

The result of the visual examination shall be noted.

If a relevant annex of this International Standard and/or the relevant product standard specifies additional requirements, the calculations and/or observations shall be noted accordingly.

### 8.3 Internal self-heating

Evidence of internal self-heating is found when the test specimen temperature, at any time during the test, exceeds the temperature of the hot pipe.

The test procedure is described in the relevant annexes of this International Standard.

## 9 Accuracy of measurement

NOTE It has not been possible to include a statement on the accuracy of the method in this edition of this International Standard, but it is intended to include such a statement when this International Standard is next revised.

## 10 Test report

The test report shall include the following information:

- a) reference to this International Standard;
- 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 dimensions, nominal density;
- c) test procedure
  - 1) pre-test history and sampling, e.g. who sampled and where;
  - 2) conditioning;
  - 3) conditioning and testing conditions in tropical countries, if applicable;
  - 4) if any deviation from [Clauses 6](#) and [7](#);
  - 5) date of testing;
  - 6) dimensions and number of test specimens;
  - 7) chosen temperature increase rate;



- 8) general information relating to the test;
- 9) events which may have affected the results;

NOTE Information about the apparatus and identity of the technician should be available in the laboratory but it need not be recorded in the report.

d) results

- 1) all individual curve deformation and temperature versus time;
- 2) all individual values and the mean value of the thickness change. Note if the thickness change in shrinkage or expansion;
- 3) all individual values and the mean value of the maximum service temperature;
- 4) presence of longitudinal gaps and their width;
- 5) note the visual evaluation;
- 6) additional results as specified in the annexes of this International Standard or the relevant product standard or any other international technical specification.

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## Annex A (normative)

### Modifications of and additions to the general test method for mineral wool products

#### A.1 Introduction

For mineral wool products the test method described in this International Standard shall be modified in accordance with the following clauses.

#### A.2 Dimensions of test specimens

The installed thickness,  $d_1$ , shall not deviate by more than 5 mm from the measured test specimen thickness,  $d_0$ . Facings are not removed.

#### A.3 Procedure

##### A.3.1 Test conditions

The test shall be started at an initial temperature of the test specimen and the hot pipe between 20 °C and 50 °C. In cases of dispute the test shall be started at  $(23 \pm 5)$  °C.

##### A.3.2 Test procedure

Heat the test specimen using a temperature rate of increase of 300 °C/h.

The thickness  $d_3$  after cooling the test specimen down to a temperature of less than 35 °C need not be measured.

#### A.4 Additional tests and/or observations

After the measurement of  $d_2$  and cooling down, remove the test specimen, cut the test specimen in half and examine visually the cut edges to establish if the fibrous structure has deteriorated. If cavities have been formed or if the test specimen has visually collapsed then this shall be reported as evidence of failure.

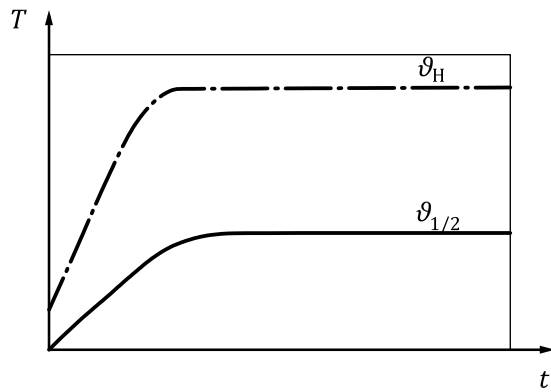
If failure occurs the test shall be repeated at a lower temperature.

**NOTE** Any organic binder present is likely to have been removed from parts of the test specimen that have exceeded about 250 °C. This in itself does not impair the thermal performance of the product and is not a cause of failure in the test.

#### A.5 Test for internal self-heating

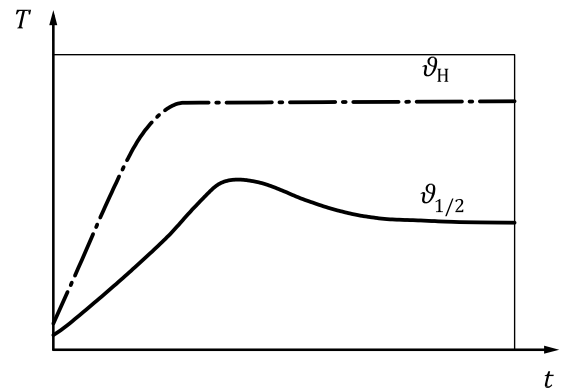
If required the test for internal self-heating has to be carried out. For that purpose an additional thermocouple has to be installed at half the thickness of the test specimen. The temperature  $\vartheta_{1/2}$ , in the middle of the thickness of the test specimen below the device for measuring the thickness, during the test of the maximum service temperature should not exceed the temperature of the heated pipe  $\vartheta_H$ .

The appraisal of the test results is carried out according to [Figure A.1](#). The test has failed if  $\vartheta_{1/2} > \vartheta_H$  [[Figure A.1 c](#)]. If failure occurs the test shall be repeated at a lower temperature.



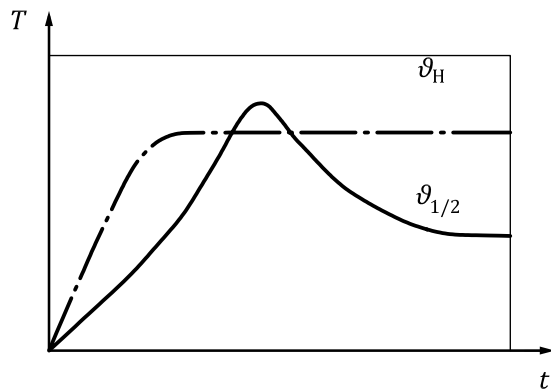
a) No internal self-heating

$$\vartheta_{1/2} < \vartheta_H$$



b) Small amount of internal self-heating

$$\vartheta_{1/2} < \vartheta_H$$



c) Extensive internal self-heating

$$\vartheta_{1/2} > \vartheta_H$$

**Key**

$T$  temperature in centigrade

$t$  time

**Figure A.1 — Typical temperature profiles during the test for the internal self-heating versus time**

## Annex B (normative)

### Modifications of and additions to the general test method for polyethylene foam (PEF) and flexible elastomeric foam (FEF) products

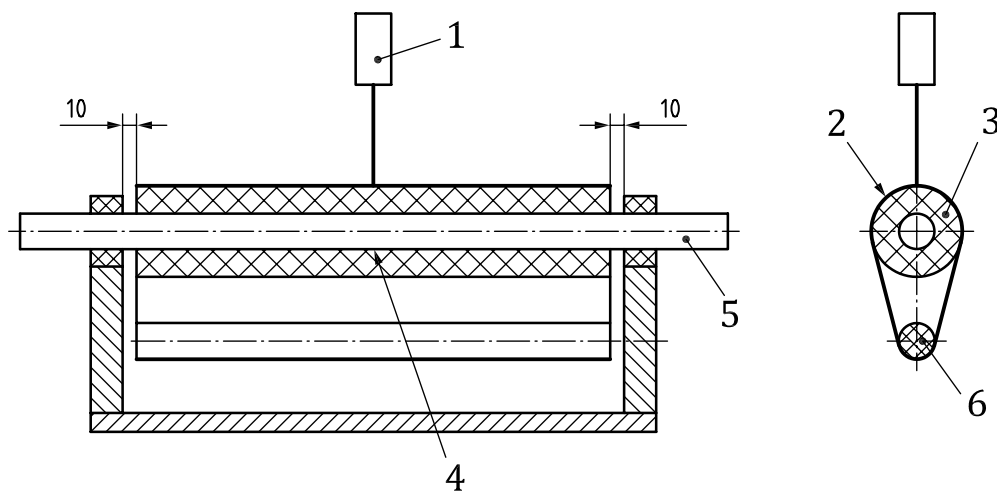
#### B.1 Introduction

For polyethylene foam and flexible elastomeric foam products the test method described in this International Standard shall be modified in accordance with the following clauses.

#### B.2 Apparatus

The hot pipe material is steel, one side is fixed with an insulated pipe hanger, the other side is only guided on an insulated support (for free thermal extension).

The distance between the pipe hanger and the pipe support shall be 320 mm for the pipe diameter less than or equal to 30 mm and 1 020 mm for larger pipe diameters; see [Figure B.1](#).



#### Key

- |   |   |   |                     |
|---|---|---|---------------------|
| 1 | device for contact less measuring thickness | 4 | thermocouple        |
| 2 | 200 µm thick HDPE film                      | 5 | hot pipe            |
| 3 | test specimen                               | 6 | weights for loading |

**Figure B.1 — Example of suitable equipment for maximum service test**

#### B.3 Dimensions of test specimens

The length of test specimens with inside diameter less than or equal to 30 mm shall be 300 mm; for larger diameters, it shall be 1 000 mm.

The largest product thickness shall be tested. Multilayered products may be used for thickness up to 100 mm.

### B.4 Test procedure

Measure the dimensional changes in thickness only.

The thickness shall be measured, with  $d_1$  being the thickness taken at ambient temperature 24 h after the pressure film has been applied to flatten the surface (at room temperature 23 °C).  $d_2$  is the thickness as stated in 7.2 of this International Standard.  $d_3$  shall not be measured.

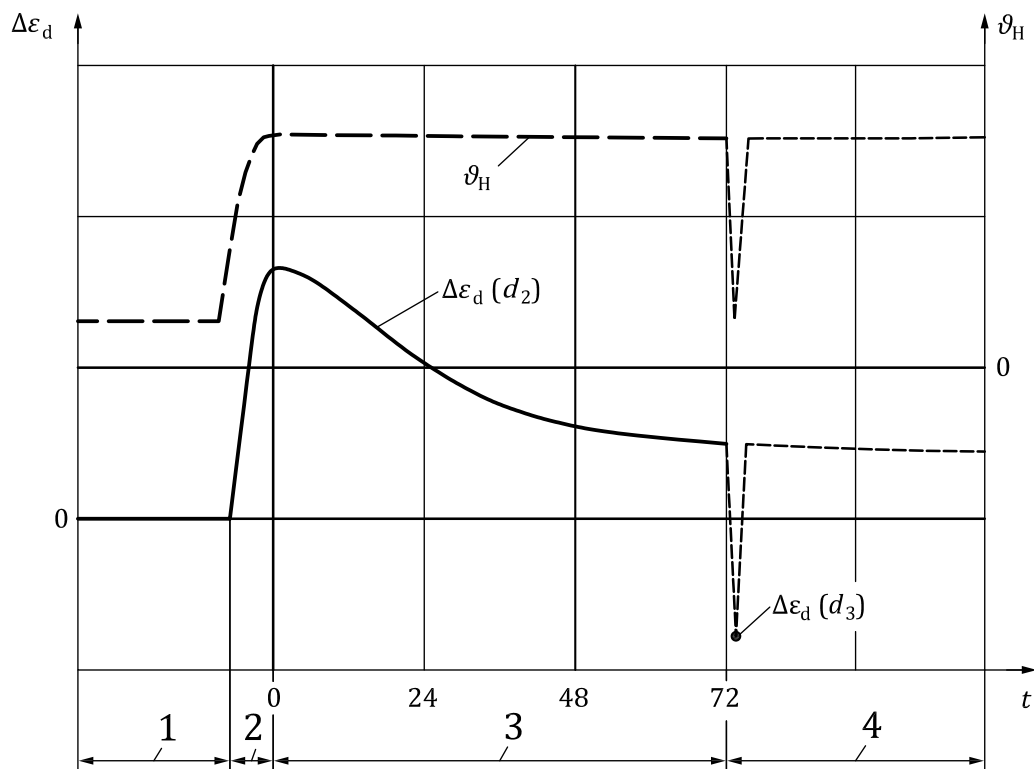
Install the test specimen. Place a 200 µm thick HDPE film over the test specimen length and exert the load 50 Pa for FEF or 250 Pa for PEF. Leave the test specimen for 24 h at ambient temperature to ensure that small initial surface unevenness is flattened out. Measure  $d_1$ .

Heat the test specimen using a temperature rate of 50 °C/h.

Maintain the temperature of the hot side, at the expected maximum service temperature, for 72 h within ± 2 % of the temperature or ± 10 °C, whichever is smaller.

Record the thickness continuously during the test and at the end of the 72 h period,  $d_2$ , to the nearest 0,1 mm (at least after 0, 0,5, 1, 6, 24, 48, 72 h).

NOTE Because of the thermal expansion of the entrapped cell gas when heating the foam from the start to the expected maximum service temperature (gas law), the thickness of the test specimen may initially increase (typical curve see Figure B.2).



**Key**

- |   |  |                    |                                   |
|---|--|--------------------|-----------------------------------|
| 1 | ambient conditions, load installed                           | $\Delta\epsilon_d$ | change of thickness in %          |
| 2 | period of heating  | $\vartheta_H$      | temperature of the hot pipe in °C |
| 3 | period of testing  | $t$                | time in h                         |
| 4 | extra period of cooling down and heating up (exemplary only) |                    |                                   |

**Figure B.2 — Typical example of temperature and thickness deformation versus time curves**

## B.5 Dimensional changes

Calculate the dimensional changes using Formula (1) of this International Standard.

NOTE The wall thickness  $d_3$  at room temperature is not of interest for this kind of product because the reduction in temperature causes a reduction of the pressure inside the cells which leads to a reversible reduction in wall thickness. Heating up again leads to a similar thickness as before under temperature load.

## Annex C (normative)

### Modifications of and additions to the general test method for phenolic foam products

#### C.1 Introduction

For phenolic foam products the test method described in this International Standard shall be modified in accordance with the following clauses.

#### C.2 Conditioning of test specimens

The test specimens shall be conditioned in accordance with ISO 16544 at  $(70 \pm 2)$  °C and then at  $(23 \pm 2)$  °C and  $(50 \pm 5)$  % RH prior to test.

In tropical countries, different conditioning and testing conditions can be relevant. In this case, the conditions shall be  $(27 \pm 5)$  °C and  $(65 \pm 5)$  % RH.

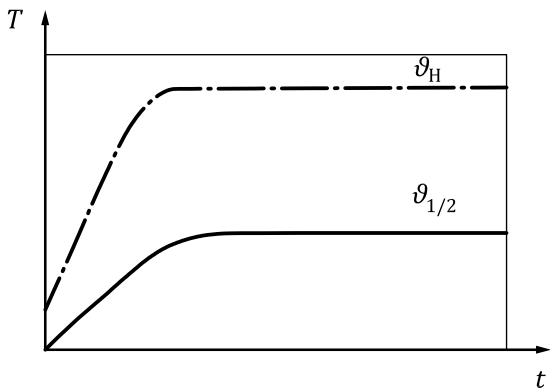
#### C.3 Test procedure

During the test, the test specimens shall be heated at a temperature rate of 50 °C/h up to the manufacturer's claimed maximum service temperature.

#### C.4 Additional tests and/or observations

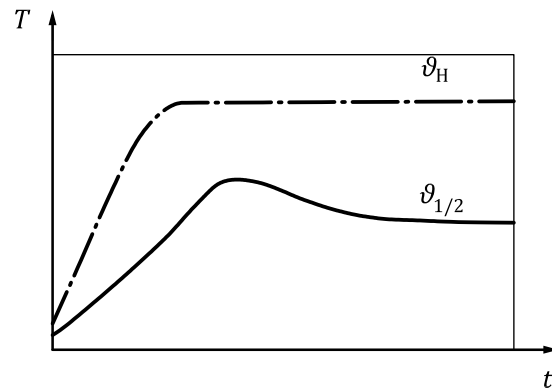
If required the test for internal self-heating has to be carried out. For that purpose an additional thermocouple has to be installed at half the thickness of the test specimen. The temperature  $\vartheta_{1/2}$ , in the middle of the thickness of the test specimen below the device for measuring the thickness, during the test of the maximum service temperature should not exceed the temperature of the heated pipe  $\vartheta_H$ .

The appraisal of the test results is carried out according to [Figure C.1](#). The test has failed if  $\vartheta_{1/2} > \vartheta_H$  [[Figure C.1 c](#)]. If failure occurs, the test shall be repeated at a lower temperature.



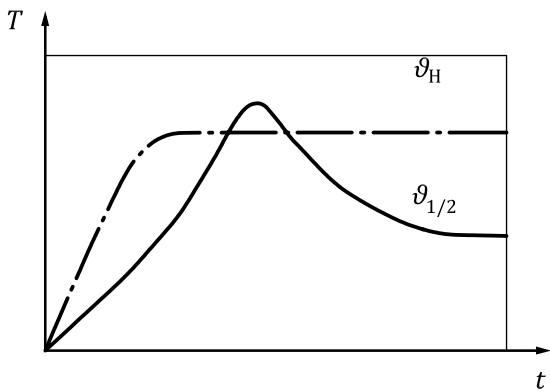
**a) No internal self-heating**

$$\vartheta_{1/2} < \vartheta_H$$



**b) Small amount of internal self-heating**

$$\vartheta_{1/2} < \vartheta_H$$



**c) Extensive internal self-heating**

$$\vartheta_{1/2} > \vartheta_H$$

**Key**

$T$  temperature in centigrade

$t$  time

NOTE Discoloration/change of colour does not impair the thermal performance of the product and is not a cause of failure in the test.

**Figure C.1 — Typical temperature profiles during the test for the internal self-heating versus time**



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