
**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*



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Contents

	Page
Foreword.....	iv
1 Scope.....	1
2 Normative references.....	1
3 Terms and definitions.....	1
4 Principle.....	1
5 Apparatus.....	2
6 Test specimens.....	4
6.1 Dimensions of test specimens.....	4
6.2 Number of test specimens.....	4
6.3 Conditioning of test specimens.....	5
7 Procedure.....	5
7.1 Test conditions.....	5
7.2 Test procedure.....	5
8 Calculation and expression of results.....	6
8.1 Thickness deformation versus time.....	6
8.2 Additional tests and/or observations.....	8
8.3 Internal self-heating.....	8
9 Accuracy of measurement.....	8
10 Test report.....	9
Annex A (normative) Modifications of and additions to the general test method for mineral wool products.....	10
Annex B (normative) Modifications of and additions to the general test method for polyethylene foam (PEF) and flexible elastomeric foam (FEF) products.....	12
Annex C (normative) Modifications of and additions to the general test method for phenolic foam products.....	15
Bibliography.....	17

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).

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

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 18096:2013), which has been technically revised.

The main changes are as follows:

- EN 14707:2012 and ISO 18096:2013 have been merged into one document;
- editorial revisions.

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 equipment and industrial installations — Determination of maximum service temperature for preformed pipe insulation

1 Scope

This document 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 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 5725-2:2019, *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 12628, *Thermal insulating products for building equipment and industrial installations — Determination of dimensions, squareness and linearity of preformed pipe insulation*

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

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

maximum service temperature

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

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: The test procedure in this document, 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.

[SOURCE: ISO 9229:2020, 3.6.9.1, modified — Notes 1 and 2 to entry have been added.]

4 Principle

The thickness and length shall be measured 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 can be an iterative process.

Additional requirements for assessing the maximum service temperature of specific materials are described in [Annexes A](#) to [C](#) 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 ± 1 mm in the measuring zone at ambient temperature.

The hot pipe shall be capable of being controlled to within ± 2 % of a predetermined temperature or ± 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. ≤ 3 mm) which permits free movement during the test of the test specimen.

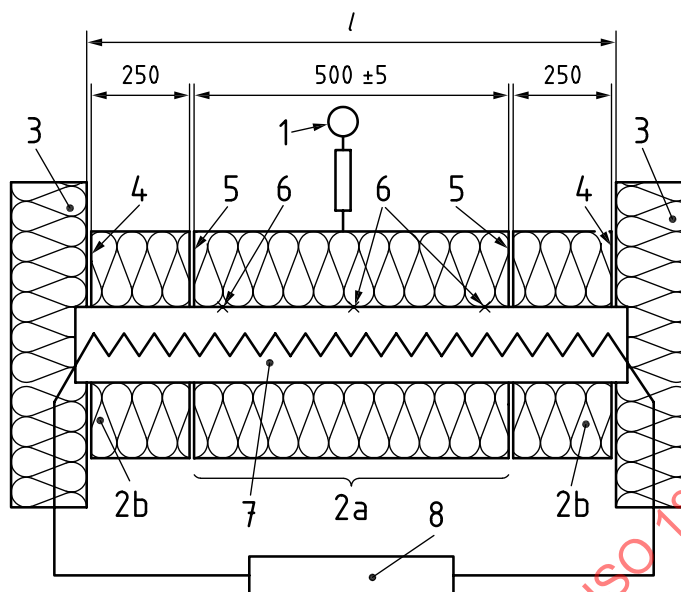
5.3 Temperature sensors (e.g. thermocouples), capable of recording the hot surface temperature of the test pipe to the nearest ± 1 % in centigrade but not less than ± 1 °C, which are placed within grooves on the hot pipe.

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 ± 5) mm and the two end guards, length (250 ± 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.

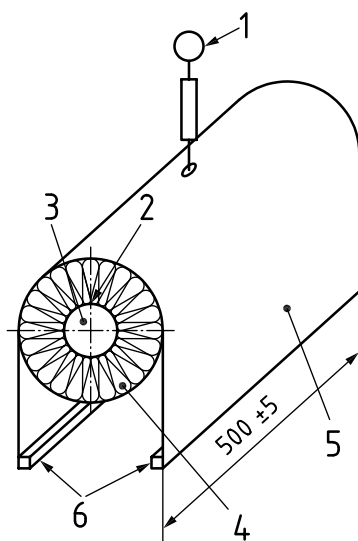
Dimensions in millimetres



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 | l | length of the hot pipe between the end insulation |

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 |

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 ± 5) mm, and a test length of (500 ± 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 in [Annexes A to C](#).

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

NOTE 2 Testing can 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 according to 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 can 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 $(50 \pm 5) \%$ relative humidity (RH) for the time specified in the relevant product standard or at least 24 h.

In tropical climates, different conditioning and testing conditions can be relevant. In this case, the conditions shall be $(27 \pm 5) ^\circ\text{C}$ and $(65 \pm 5) \%$ 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 climates, different conditioning and testing conditions can be relevant. In this case, the initial temperature of test specimen shall be $(27 \pm 5) ^\circ\text{C}$.

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.

In cases where gaps of more than 2 mm 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).

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 of $50 ^\circ\text{C/h}$ or $300 ^\circ\text{C/h}$, as specified in the relevant product standard or in Annexes A to C.

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 h 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 in Annexes A to C.

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.

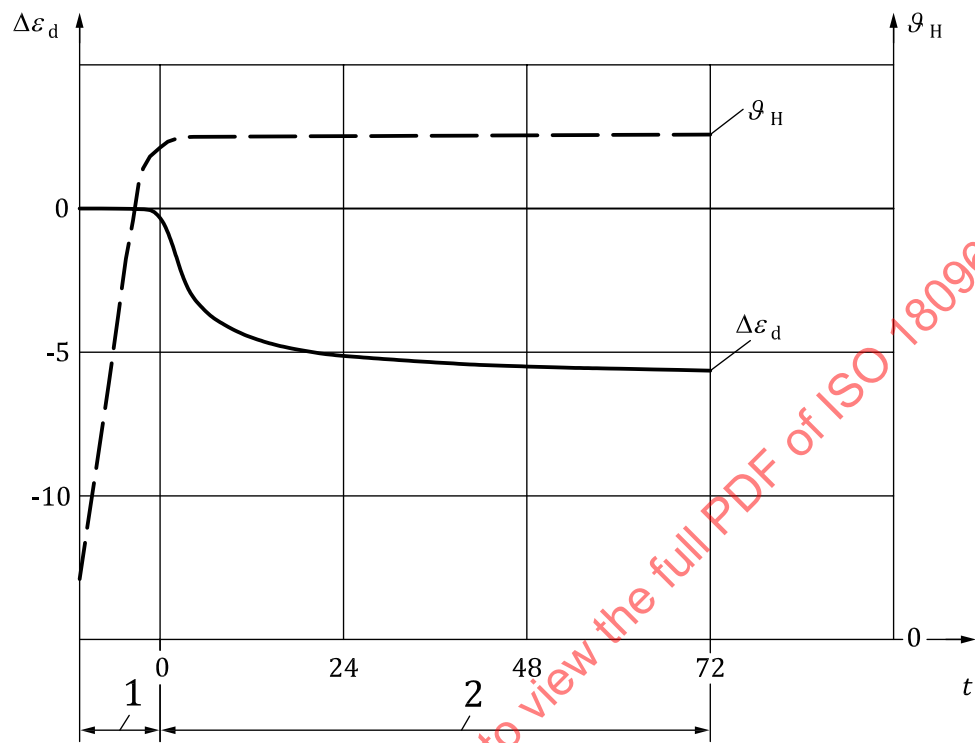
Examine the test specimen visually and note any changes caused by the test.

If the relevant product standard or Annexes A to C specifies additional requirements, the observations and/or tests shall be performed accordingly.

8 Calculation and expression of results

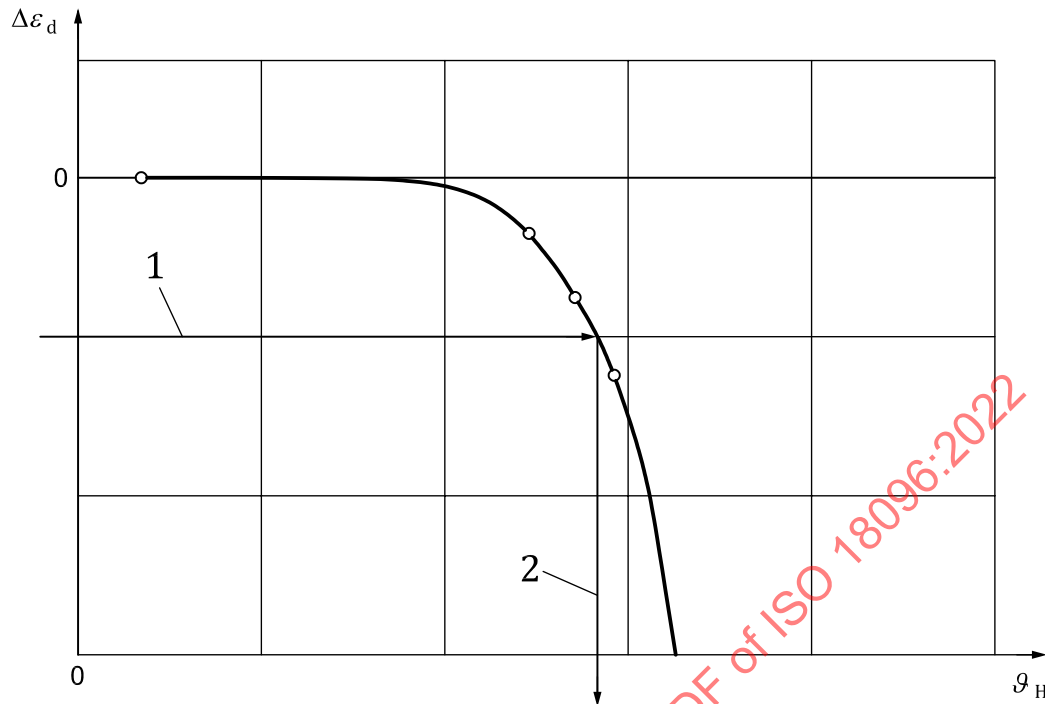
8.1 Thickness deformation versus time

The curve thickness deformation versus time and relative thickness change versus applied temperature recorded during testing shall be given. Examples are shown in [Figure 3](#) and [Figure 4](#).



- Key**
- 1 period of heating
 - 2 period of testing
 - $\Delta\epsilon_d$ change in thickness in percentage
 - ϑ_H temperature of the hot pipe in °C
 - t time in h

Figure 3 — Example of hot pipe 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 °C
- $\Delta\epsilon_d$ change in thickness in percentage
- θ_H temperature of the hot pipe in °C

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

Calculate the thickness change, $\Delta\epsilon_d$, in percentage, using [Formula \(1\)](#):

$$\Delta\epsilon_d = 100 \times \frac{d_2(\text{or } d_3) - d_1}{d_1} \quad (1)$$

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 °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.

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 document. 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 It is possible that results will 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 (see [Annexes A to C](#)) 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 [Annexes A to C](#).

9 Accuracy of measurement

An interlaboratory test was performed with 13 pieces of equipment from five laboratories. One product was tested.

The results, analysed according to ISO 5725-2:2019, are given in [Table 1](#).

Table 1 — Relative change of thickness at a chosen temperature (equipment verification in comparative testing)

Temperature level used °C	660 °C
Estimate of repeatability standard deviation s_r	0,2 %
95 % repeatability limit	0,5 %
Estimate of reproducibility standard deviation s_R	0,8 %
95 % reproducibility limit	2,1 %

All values given in [Table 1](#) are expressed in percentage of the test specimen thickness.

The above-mentioned terms shall be applied as described in ISO 5725-2:2019.

Bias cannot be determined in this test method as there is not any accepted reference material for it.

NOTE The choice of products was made to get a wide range of diameters of the test pipes (22 mm up to 159 mm) and also test a worst-case situation (for the most complicated test specimen preparation, see [Figure A.1](#)). It is possible that the higher values of the reproducibility compared with the test method ISO 18097 (flat products) is caused by variations in the fibre structure of the used different dimensions of the pipe sections.

10 Test report

The test report shall include the following information:

- a) reference to this document, i.e. ISO 18096:2022;
- 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 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 climates, 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 can have affected the results;

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 [Annexes A](#) to [C](#) or the relevant product standard or any other international technical specification.

Annex A (normative)

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

A.1 General

For mineral wool products the test method described in this document 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 ± 5) °C, in tropical climates (27 ± 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 shall 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 ϑ_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.

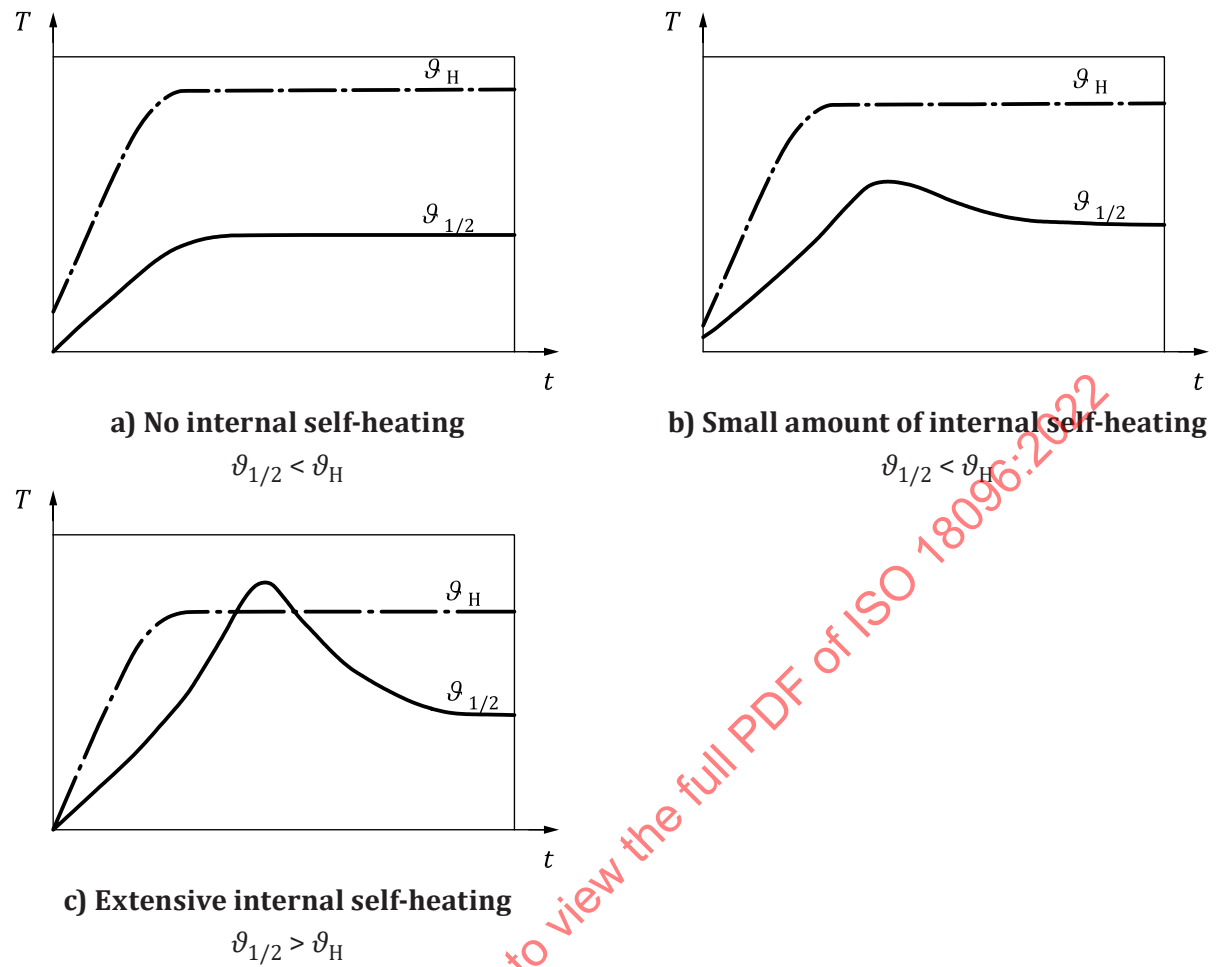
**Key** T temperature in °C t time

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 General

For polyethylene foam and flexible elastomeric foam products the test method described in this document 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.

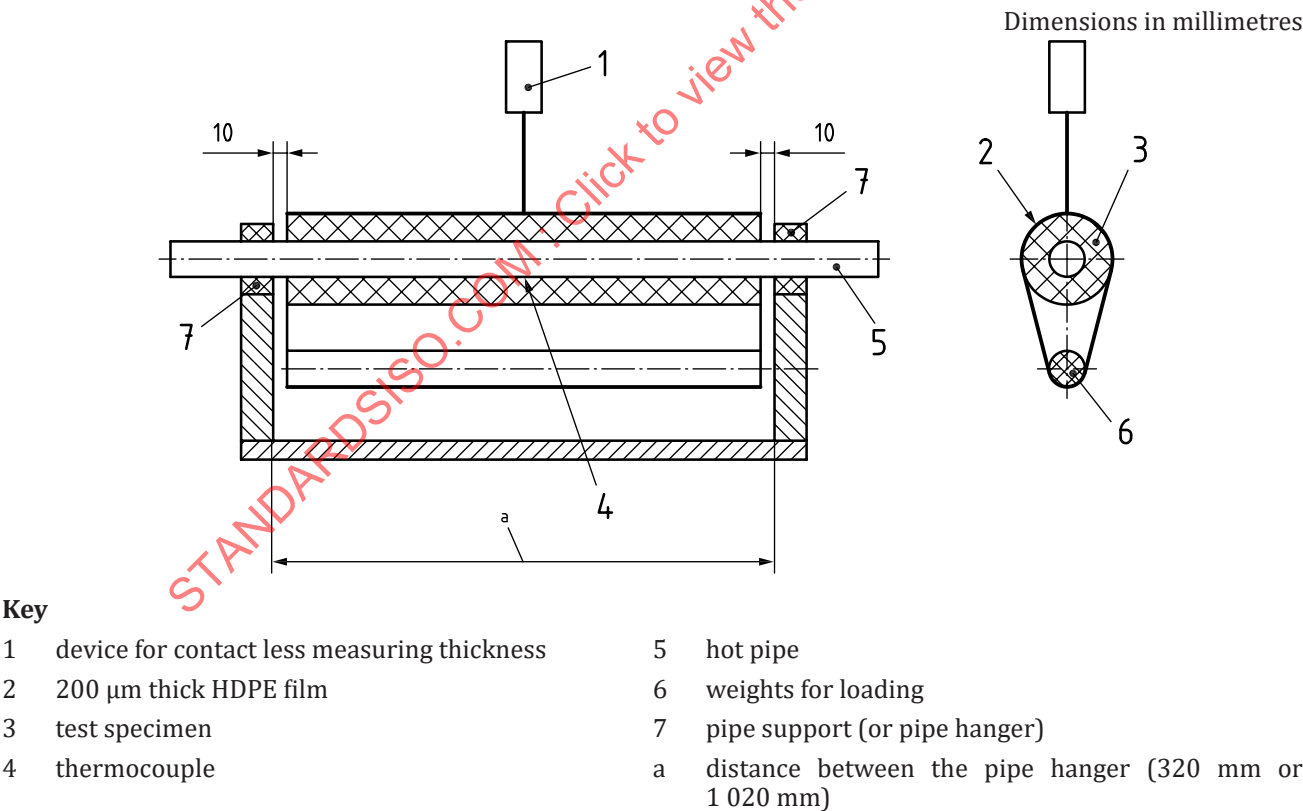


Figure B.1 — Example of suitable equipment for maximum service temperature test

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. Multi-layered 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 ± 5) °C, in tropical climates (27 ± 5) °C]. d_2 is the thickness as stated in 7.2. 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 h, 0,5 h, 1 h, 6 h, 24 h, 48 h, 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 can initially increase (for a typical curve, see [Figure B.2](#)).