INTERNATIONAL STANDARD

ISO 22097

First edition
2023-06

Thermal insulation for buildings — Reflective insulation products — Determination of thermal performance

Isolation thermique des bâtiments — Produits isolants réfléchissants — Détermination de la performance thermique

Reference number
ISO 22097:2023(E)

Contents

Page

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 3, *Thermal insultation products, components and systems,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 89, *Thermal performance of buildings and building components,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

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.

Introduction

Reflective (low emissivity at the appropriate wavelength) surfaces are utilized in a number of ways to enhance the thermal performance of insulating products. Their role is to reduce the heat transfer by thermal radiation in some parts of the system. This is achieved because low emissivity surfaces reduce the radiant heat transferred through a product that is wholly or partially transparent to infra-red radiation (e.g. very low-density fibrous insulation). They also reduce the radiant heat transfer across any air gap or gaps that are present in the system. In some cases, air gaps can be an intrinsic part of the structure and in other cases the insulation can be installed in such a way as to deliberately create an air gap between the reflective surfaces and the structure.

When correctly installed in buildings, the thermal performance of reflective insulation products can be influenced quite significantly by such air gaps, hence the value of thermal performance reported from any of the test procedures should also be accompanied by a statement indicating the presence of, and sizes of, any adjacent air spaces. For maximum versatility and reduced confusion, the measured values from any test should be given as the combination of the thermal resistance of the “core” of the product together with the measured value of the emissivity of the surfaces. This does not preclude the provision of values indicating the total thermal resistance of a product and one or two airspaces (where relevant) as additional information, provided full details of the product and the air spaces are included. Some reflective insulation products have poorly defined thickness due to the nature of the materials and the manufacture. Care is thus needed to define either the nominal thickness or the test thickness, or both. When installed in buildings, the final thickness depends upon the degree of handling and fixing, which is not addressed in this document. The purpose of this document is to provide harmonized procedures to give reproducible measured thermal performance values that can be readily compared with other thermal insulation products.

Since all conventional thermal insulation products declare their thermal performance on the basis of the value to be expected over a reasonable working life, this is also addressed in a limited manner in this document in the assessment of emissivity of the surface(s) of reflective insulation. In the absence of any quantified and certified data on the aged performance of a facing over a normal lifetime for a building material, the ageing of the low emissivity surface is assessed by use of an accelerated ageing procedure.

How the thermal properties of insulation materials that utilize reflective surfaces are determined depends on the form in which they are sold and how they are intended to be used. This document describes a number of different approaches which can be utilized and specifies which approach to use for the different types of product. Where a product is already subject to a product specification that describes procedures for the measurement of the aged 90/90 fractile thermal conductivity or thermal resistance of the core insulation material, the following guidance should only be used to determine the component of its thermal performance that depends on the emissivity of its external faces. However, the measured value is only the first step, giving comparative performance values under specified conditions, and the design value can give more information for use by the designer in specific applications, especially under different climatic conditions.

Thermal insulation for buildings — Reflective insulation products — Determination of thermal performance

1 Scope

This document describes a set of procedures for using existing standardized CEN or ISO test and calculation methods to determine the thermal performance of reflective insulation products. This document supports and does not replace existing CEN or ISO test methods.

This document applies to any thermal insulation product that derives a proportion of its claimed thermal properties from the presence of one or more reflective or low emissivity surfaces together with any associated airspace(s). It does not replace the existing procedures for the determination of the thermal performance of products already covered by an existing harmonized product standard where the declared value of these products does not specifically include any claims attributable to the emissivity of the facing. It does not, and cannot, give an in-use or design value of thermal performance, but provides standardized information from which these can be determined.

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/IEC Guide 98-3, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

EN 1946-2, *Thermal performance of building products and components — Specific criteria for the assessment of laboratories measuring heat transfer properties — Part 2: Measurements by guarded hot plate method*

EN 1946-3, *Thermal performance of building products and components — Specific criteria for the assessment of laboratories measuring heat transfer properties — Part 3: Measurements by heat flow meter method*

EN 1946-4, *Thermal performance of building products and components — Specific criteria for the assessment of laboratories measuring heat transfer properties — Part 4: Measurements by hot box methods*

ISO 6946, *Building components and building elements — Thermal resistance and thermal transmittance — Calculation methods*

ISO 7345, *Thermal performance of buildings and building components — Physical quantities and definitions*

ISO 8301, *Thermal insulation — Determination of steady-state thermal resistance and related properties — Heat flow meter apparatus*

ISO 8302, *Thermal insulation — Determination of steady-state thermal resistance and related properties — Guarded hot plate apparatus*

ISO 8990, *Thermal insulation — Determination of steady-state thermal transmission properties — Calibrated and guarded hot box*

ISO 9229, *Thermal insulation — Vocabulary*

ISO 9288, *Thermal insulation — Heat transfer by radiation — Vocabulary*

ISO 10456:2007, *Building materials and products — Hygrothermal properties — Tabulated design values and procedures for determining declared and design thermal values*

EN 12664, *Thermal performance of building materials and products — Determination of thermal resistance by means of guarded hot plate and heat flow meter methods — Dry and moist products of medium and low thermal resistance*

EN 12667, *Thermal performance of building materials and products — Determination of thermal resistance by means of guarded hot plate and heat flow meter methods — Products of high and medium thermal resistance*

ISO 29466:2022, *Thermal insulating products for building applications — Determination of thickness*

3 Terms, definitions and symbols

For the purposes of this document, the terms and definitions given in ISO 7345, ISO 9288, ISO 9229 and the following 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 Terms and definitions

3.1.1
indentation
concave depression in the surface of the facing (foil), such that shallow air pockets are created when the surface is in contact with a smooth flat plate

3.1.2
core thermal resistance
thermal resistance of the product from face to face at the tested thickness, excluding the contribution of any low *emissivity* (3.1.3) outer surface or any air space(s) adjacent to the product

3.1.3
emissivity
ratio of the energy radiated by a surface relative to the energy radiated by a blackbody at the same temperature

Note 1 to entry: It is a measure of a material's ability to radiate heat.

3.1.4
reflective surface
low emissivity surface
surface, which has a low emissivity at the appropriate wavelength within the temperature range found in building elements

3.1.5
reflective insulation
insulation product, which has one or both external face(s) comprising a reflective (low emissivity) surface

3.2 Symbols and units

For the purposes of this document, the following symbols and units apply.

Symbol	Quantity	Unit
P	perimeter	m
R	thermal resistance	m^2 K/W
U	sensor signal	V
ε	emissivity	—
λ	thermal conductivity	W/(m K)
ϕ	heat flow rate	W
ψ	linear thermal transmittance	W/(m K)
$\Delta\Theta$	temperature difference	K

Symbol	Quantity
L	low
H	high
e	edge
sur	surround
90/90	90 % fractile with a confidence level of 90 %

4 Description of product types

4.1 Product classification

Clause 4 describes the various generic product types to which this document refers. Product type is defined solely for the purpose of selecting the most appropriate test method (product type number does not refer to a generic species of product). Together with 4.2, 4.3 and 4.4, the flow charts in Annexes A, B and C shall be followed in assigning a given product to a product type.

In 4.2, 4.3 and 4.4, the product type is determined by reference to its compressibility or otherwise to achieve flat parallel surfaces. This implies the removal of measurable air gaps between the specimen and the hot and cold plates of the test apparatus whilst not unduly reducing the overall thickness of the specimen to be tested. The thickness shall be determined using the procedures in 5.2 and shall, if less than the nominal thickness, be the thickness subsequently used for the measurement of the core thermal resistance and given in the test report. Otherwise, the nominal thickness shall be used.

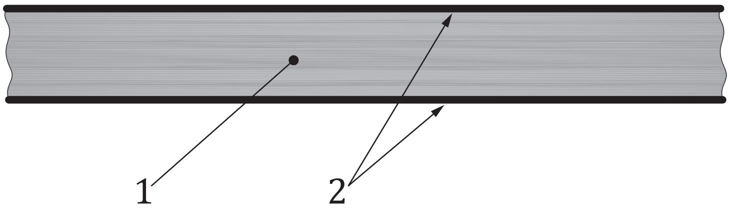
4.2 Product Type 1

A product shall be classified as Type 1 when:

— it has a regular geometry with parallel faces; or

— it is compressible so that the product can be contained between, and in full contact with, the hot and cold plates of the apparatus. Such Type 1 products can be so constrained without significantly compressing the product below its nominal thickness or the thickness measured using the procedure in Clause 5, whichever is the lesser. This is usually achieved when its surfaces are predominantly smooth and flat with no discernible depth of pattern or indentation.

EXAMPLE Including (but not limited to) multi-foil insulation product which is stitched or seamed only at the edges and substantially flat with parallel faces (see also the limitation in Clause 1) and some other insulation materials with aluminium foil facing on each side (see Figure 1).



Key

1 insulation core

2 low emissivity surface or surfaces

Figure 1 — Example of insulation material with reflective facing on each side

4.3 Product Type 2

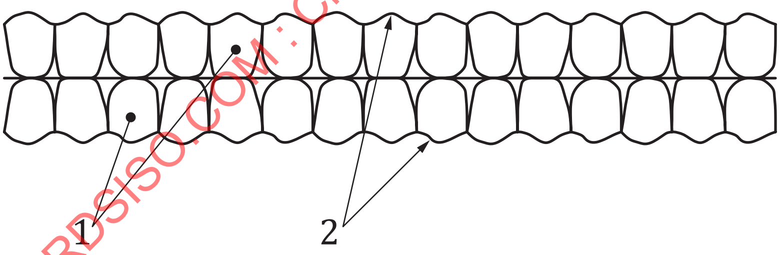
A product shall be classified as Type 2 when:

— it has a regular geometry with parallel faces; or

— it is compressible so that the product can be contained between the test apparatus hot and cold plates without significantly compressing the product below its nominal thickness or the thickness measured using the procedure in Clause 5, whichever is the lesser. In addition, the surface or surfaces may not be flat and smooth and can have indentations of less than 5 mm depth. The indentations shall be measured using the pin and plate described in ISO 29466:2022, Clause B.1, or an alternative method with at least the same level of accuracy. The pin shall be placed in the lowest point of any indentation but shall not pierce the surface.

If the indentations are 5 mm or greater, it shall be classified as product Type 3.

EXAMPLE Including, but not limited to, some types of bubble foil insulation with reflective surfaces (see Figure 2).



Key

1 air filled plastic bubbles

2 reflective surface(s)

Figure 2 — Example of bubble foil insulation with reflective surfaces

4.4 Product Type 3

A product shall be classified as Type 3 when:

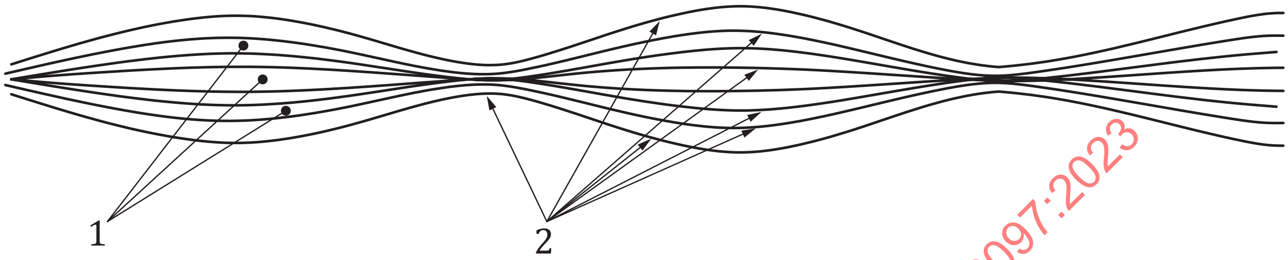
— it has irregular thickness geometry and does not have flat parallel faces; or

— it cannot be installed between the hot and cold plates of the apparatus using the lesser of the nominal thickness or the thickness measured using the procedure in Clause 5 to produce flat and parallel faces, free of air spaces.

A small degree of compression may be permitted to eliminate air gaps, but not exceeding 10 % of the thickness, or 5 mm, whichever is the greater in mm.

NOTE 1 Its surfaces might or might not have indentations, the depth of which is not limited to any specific value.

NOTE 2 It can include stitching or seams. A typical example would be the stitched multi-foil reflective insulation products or sealed “pockets” or “pillows” made from reflective foil sheets, as shown in Figure 3.



Key

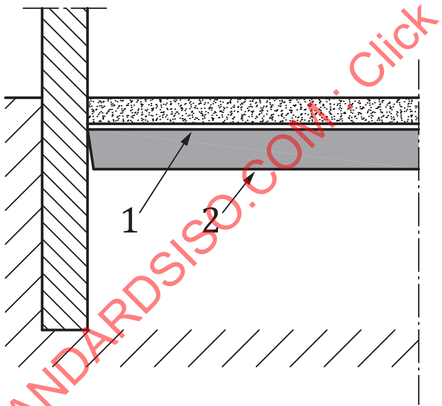
1 air filled plastic bubbles

2 reflective surface(s)

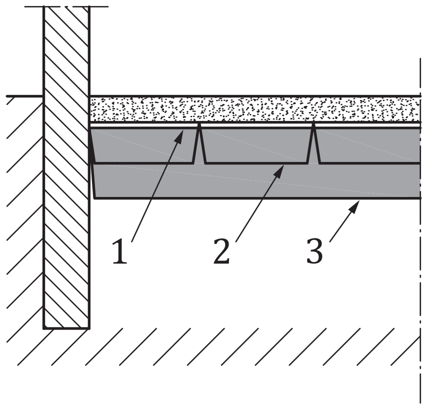
Figure 3 — Example of stitched multi-foil insulation

4.5 Product Type 4

Product Type 4 is a thin film or sheet, less than 2 mm thickness, using single or in multiple layers, which makes use of a low emissivity surface to increase the thermal resistance of adjacent or enclosed air space(s), but which has no significant thermal resistance of its own (see Figure 4).



a) 2-layer foil system



b) 3-layer foil system

Key

1, 2, 3 foil layers

Figure 4 — Example of multiple layers of product Type 4 under flooring

5 Methods of assessment

5.1 General

In addition to the general requirements for testing thermal performance in accordance with EN 12664, EN 12667 and ISO 8990, the specific requirements for mounting of specimens given in 5.4 to 5.8 shall also be followed. The measurement of thermal performance of reflective insulation products Type 1, Type 2 and Type 3 shall require the measurement of the thickness of the specimens.

Thickness measurement shall be in accordance with 5.2.

The test conditions should be chosen to represent the intended market (temperate or tropical), according to ISO 10456:2007, Table 1, and the relevant conditions for testing for determination of a declared value shall be stipulated in the relevant product technical specification. Unless stipulated elsewhere, thermal testing should use a mean temperature of either 10 °C or 23 °C. By default, this document uses 10 °C as the reference condition.

5.2 Thickness measurement

With the exception of thin single layer films or sheets, the thickness of all types of product which are in excess of a 2 mm nominal declared thickness shall be determined according to ISO 29466 using the procedures in this document and other relevant product technical specifications. For all other reflective products or in the absence of a product technical specification, the thickness shall be determined in accordance with ISO 29466 using the lowest weight of plate permitted by the test method that substantially eliminates any air gaps as per the compressibility criteria in Clause 4.

EXAMPLE The minimum weight of plate may be reduced from 50 Pa to 25 Pa.

The method of assessment for thickness and the values used for testing shall be given in the test report.

The thickness of thin films and sheets with a nominal, declared thickness of < 2 mm may not be measured.

5.3 Test specimens

5.3.1 Size and number of specimens

The specimen size shall be appropriate to the apparatus being used. In the absence of harmonised product specifications for any product type and to permit statistical calculation of the thermal performance, a minimum of three samples shall be tested, taken from at least three different production batches wherever possible, but shall be representative of the mean value of weight per unit area of the product under test. Where a harmonized product specification exists, the rules from that standard should be followed.

5.3.2 Conditioning and specimen preparation

Except for the measurement of emissivity, where special conditioning requirements exist, all test specimens shall be stored for at least 6 h at (23 ± 5) °C. In cases of dispute, they shall be stored at (23 ± 2) °C and (50 ± 5) % relative humidity (RH) for the time specified in any relevant harmonized product standard, or for a minimum of 6 h.

NOTE 5.7.2 specifies the procedure to be followed to determine the conditioning of specimens to be used in hot box measurements where the emissivity of the facing can be subject to ageing.

In the case of products supplied in compressed form, the material shall be allowed to recover fully before conditioning for the test. This shall be for a minimum of 6 h or longer if recommended by the manufacturer. In cases of dispute, the procedure specified in ISO 29466:2022, Annex A shall be followed.

5.4 Determination of thermal resistance — Outline

Four different methods (A, B, C and D) are defined in this document. Some methods are more appropriate than others for different forms of reflective insulation materials, as described in Clause 4. The actual measured performance using each method gives comparable performance values.

Of the four methods, three, (A, B, C) provide a measurement of thermal resistance as follows:

— Method A

  Guarded hot plate apparatus shall meet the requirements of ISO 8302, EN 1946-2, EN 12664 and EN 12667;

— Method B

  Heat flow meter apparatus shall meet the requirements of ISO 8301, EN 1946-3, EN 12664 and EN 12667;

— Method C

  Hot box apparatus shall meet the requirements of ISO 8990 and EN 1946-4

— Method D

  A fourth method provides for measurement of surface emissivity and calculation of airspace thermal resistance.

The method relevant for each product type shall be performed in accordance with 5.5 to 5.8. The correct process for each product type shall be identified through the use of the flow charts in Annex A, Annex B and Annex C. The surface of the material shall be assessed as given in Clause 4 to determine the appropriate product type and test method, which shall be specified in the test report.

5.5 Determination of core thermal resistance of product Type 1

5.5.1 Test thicknesses

The test thickness shall be the nominal thickness of the product, or the thickness measured in accordance with 5.2, whichever is the lesser.

5.5.2 Product thickness greater than 20 mm

5.5.2.1 Thermal resistance expected to be greater than 0,5 $m^2·K/W$

Use either:

— Method A: Measure in a guarded hot plate apparatus; or

— Method B: Measure in a heat flow meter apparatus.

5.5.2.2 Thermal resistance expected to be 0,5 $m^2·K/W$ or less

Use either:

— Method A: Measure in a guarded hot plate apparatus; or

— Method B: Measure in a heat flow meter apparatus.

In each case, thermocouples shall be attached to the specimen surface (using the procedures specified in EN 12664).

5.5.3 Product thickness less than or equal to 20 mm

5.5.3.1 Thermal resistance expected to be greater than 0,5 $m^2 \cdot K/W$

Use either:

— Method A: Measure in a guarded hot plate apparatus using thermocouples embedded in the hot and cold plates; or

— Method B: Measure in a heat flow meter apparatus using the "dummy specimen" technique given in Annex E.

5.5.3.2 Thermal resistance expected to be 0,5 $m^2 \cdot K/W$ or less

Use either:

— Method A: Measure in a guarded hot plate apparatus using thermocouples attached to the specimen surface (the procedures specified in EN 12664 shall be used); or

— Method B: Measure in a heat flow meter apparatus using the "dummy specimen" technique given in Annex E.

If thermocouples are to be fixed to aluminium or other metal foil, the bare thermocouple wire shall be electrically isolated from the foil by a strip of thin adhesive tape.

5.5.4 For all thicknesses and nominal thermal resistances

As an alternative to the options described in 5.5.1 and 5.5.2 above, any Type 1 product may also be measured using the procedure described as Method C in 5.7.

5.6 Determination of core thermal resistance of Product Type 2

5.6.1 General

The test thickness shall be the nominal thickness of the product or the thickness measured in accordance with 5.2, whichever is the lesser.

5.6.2 Product Type 2 with surface indentations less than 2 mm in depth

Treat as product Type 1 (see 5.5 to select appropriate methodology depending upon thickness and expected thermal resistance).

5.6.3 Product Type 2 with surface indentations greater than or equal to 2 mm, but less than 5 mm in depth

Use Method A or Method B using a guarded hot plate apparatus or heat flow meter apparatus using thermocouples attached to the specimen surface. The procedures specified in EN 12664, ISO 8301 and ISO 8302 shall be used.

To prepare the specimens, fill any indentations with aqueous gel and cover with a thin layer of low conductivity film such as polyethylene. Then treat specimen as product Type 1 to measure core thermal resistance (see 5.5 to select appropriate methodology). Use Method A or Method B using a guarded hot plate apparatus or heat flow meter apparatus using thermocouples attached to the specimen surface (using the procedures specified in EN 12664).

5.6.4 Product Type 2 with surface indentations 5 mm in depth or greater

Where the surface indentations are 5 mm in depth or greater, the product shall be treated as if it were product Type 3 (see 5.7).

5.6.5 For either all thicknesses or nominal thermal resistances, or both

As an alternative to the options described in 5.6.1 to 5.6.3, any Type 2 product may also be measured using the procedure described as Method C in 5.7.

5.7 Determination of core thermal resistance of product Type 3 (Method C)

5.7.1 Principle

The thermal resistance of an air cavity insulated with the product mounted in the centre of the air cavity, shall be determined by measurement in a hot box apparatus that conforms to the requirements of ISO 8990. The thermal resistance of the two air cavities is calculated and deducted from the measured total thermal resistance to give the core thermal resistance of the product. The test thickness of the product shall be the nominal thickness, or the thickness measured in accordance with 5.2, whichever is the lesser.

5.7.2 Determination of the need for specimen conditioning

To determine the need for specimen conditioning, the following procedure shall be followed:

a) Measure the emissivity of the facing "as received" and after conditioning (ageing) using the procedures in Annex D.

b) If the difference between the two measurements is 0,02 or less, then the ageing is considered negligible and within uncertain limits for the test; therefore, the test specimen for the hot box can be the material as supplied (with no further need for ageing).

c) If the difference between the emissivity of “as received” and aged specimens is greater than 0,02 then the insulation material to be used in the hot box shall be tested after undergoing conditioning according to D.5.3, taking care not to damage the test specimen.

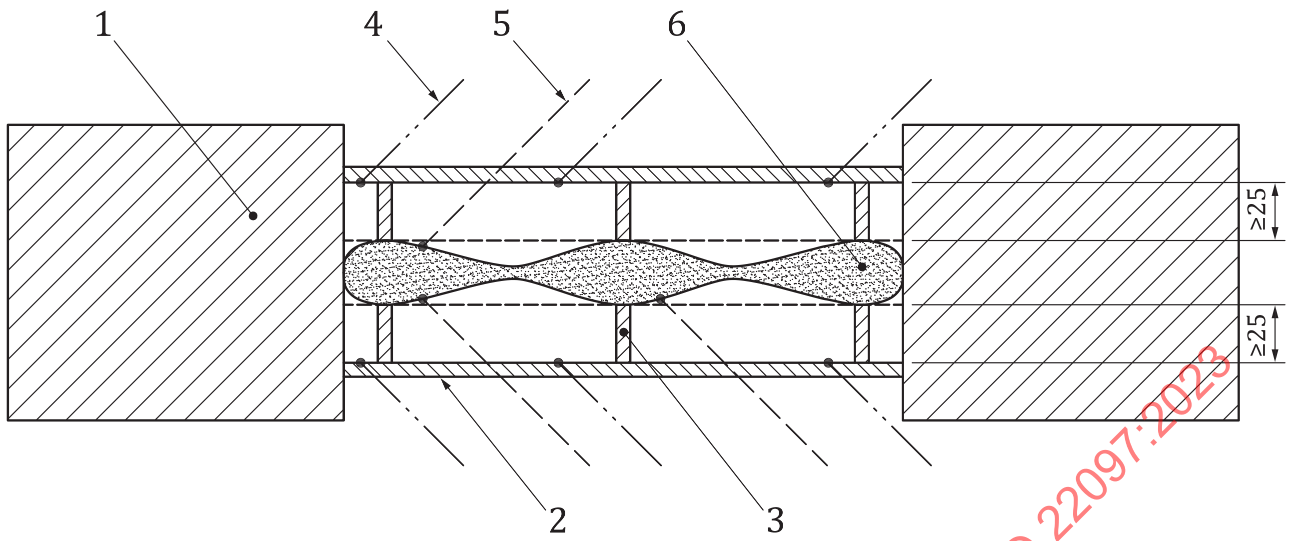
5.7.3 Air cavity and specimen installation

Measure the thermal resistance of an air cavity insulated with a specimen that is representative of the test product including any stitching or welding in the body of the material.

The overall depth of the insulated air cavity shall be the sum of either the lesser of the nominal thickness, or, if different, the manufacturer’s specified installed thickness, or the thickness measured in accordance with 5.2 and the width of the two air spaces, which shall be specified in the report, but which shall normally be at least 25 mm on each side of the product test specimen. Expansion of the product beyond its test thickness into the adjacent air spaces shall be limited and controlled by the use of small polystyrene pillars (see below and Figure 5). The depth of the polystyrene pillars shall be equal to the chosen air space thickness on each side of the test specimen. The number of pillars used shall be the lowest number that prevents over-expansion of the product into the adjacent air space.

The outside faces of the test specimen shall be fixed at their edges to narrow strips of polystyrene [or similar material with a maximum thermal conductivity of 0,035 W/(m·K)] that have a thickness equal to the test thickness of the specimen, with a tolerance of 0 mm to +5 mm. These strips prevent local compression of the specimen at its edge. The air spaces either side of the test specimen may also be secured at the perimeter by additional strips of polystyrene between the face of the test specimen and the outer wall. The individual layers may be fixed to the surrounding frame using adhesive tape or the whole assembly may be held together by other means, such as temporary bolts that should be removed before testing. Any holes in the specimen or in the edge detail shall also be either covered or sealed, or both, to prevent heat flow. See Figure 5 and Figure 6 for suggested details.

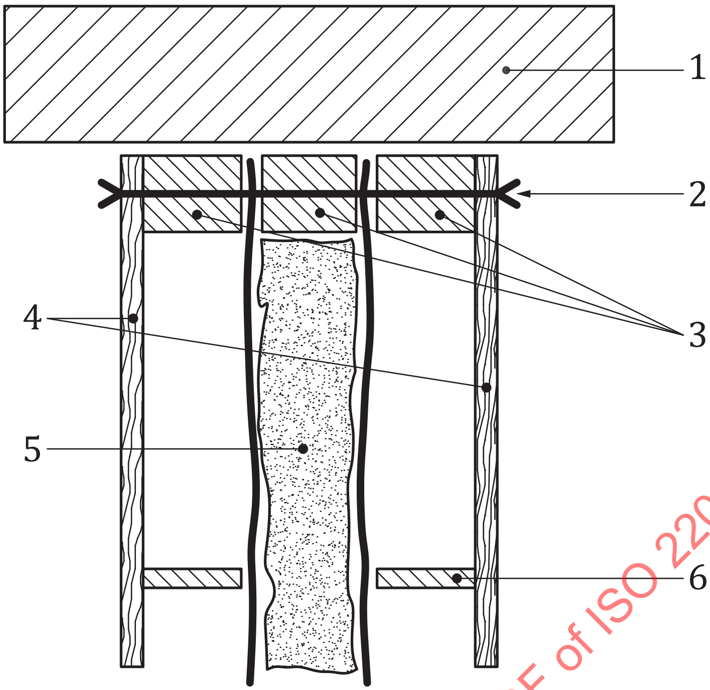
Dimensions in millimetres



Key

1 hot box surround panel
2 cavity walls
3 small expanded polystyrene pillars
4 thermocouples measuring the inside surface temperature of the cavity walls
5 thermocouples measuring the surface temperature of the specimen
6 test specimen

Figure 5 — Typical test element used to measure the thermal resistance of an insulated air cavity



Key

1 surround panel
2 removable screw element
3 rigid expanded polystyrene (EPS) perimeter pieces
4 wood panels
5 reflective product type 3
6 EPS pillars

Figure 6 — Suggested edge detail for fixing product Type 3

The arrangement in Figure 5 measures the thermal resistance of the insulated air cavity without the need to measure the core thermal resistance of the material, emissivity or cavity geometries. The following conditions shall apply:

a) External “walls” to form the cavity shall be made from a suitable dry material such as plywood or MDF.

b) The length and width of the test specimen and associated air cavity shall not be less than 1 m × 1 m.

c) Air cavities created at each side of the product shall be at least 25 mm deep at any point.

d) An appropriate number of expanded polystyrene pillars shall be used between the plywood and the product to ensure the air cavity depths are maintained during the test. Each EPS pillar shall have a cross section of 20 mm × 20 mm and a thermal conductivity of less than 0,04 W/(m·K).

e) The product being tested shall be taped to the surround panel using low emissivity tape as recommended by the manufacturer.

f) Overlapped joints shall be avoided wherever possible.

g) At least nine thermocouples shall be fixed to the inside of each cavity wall, installed in the centres of squares of equal area.

NOTE The thermal resistance of these walls is not part of the measured value.

h) At least five thermocouples shall be fixed to each side of the product (using low emissivity tape). If the product has a metallic surface, the thermocouples shall be fixed on top of a layer of thin adhesive tape to stop them being electrically connected.

i) The surround panel shall be between 100 mm and 300 mm thick, made from a material with a thermal conductivity <0,04 W/(m·K).

5.7.4 Hot box test conditions

The surround panel, with the air cavities, shall be installed between the warm and cold chambers of the hot box apparatus, which can then be positioned to the appropriate specimen orientation (if required) and the target temperature difference established between the two chambers. Normally, the specimens shall be mounted vertically with horizontal heat flow, and the test conditions shall be selected to establish a temperature difference of (20 ± 1) K across the air cavity, as measured with the thermocouples mounted on the internal cavity wall surfaces, and a mean test temperature of (10 ± 2) °C.

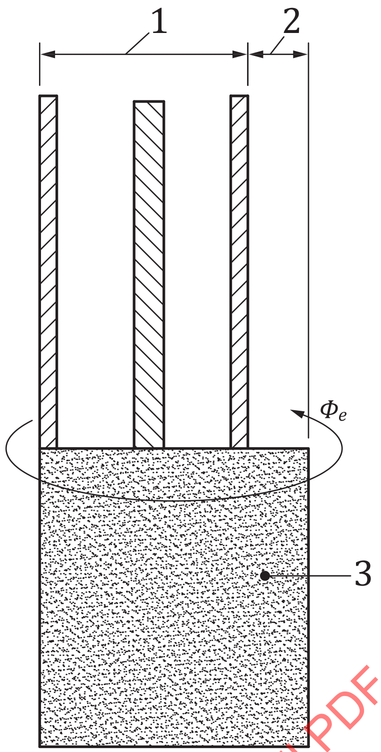
In some hot boxes, it is impossible to cool the cold side sufficiently to achieve a mean temperature of 10 °C. In this case, the mean temperature used for test may be increased up to 15 °C but this shall be reported in the test report.

Although vertically mounted specimens shall be measured and reported in each case, other specimen orientations may be used to obtain information on the performance of products in various building applications. Such results shall be considered advisory and not form part of the derivation of any subsequent declared value.

Cavity orientation and heat flow direction shall be specified in the test report.

5.7.5 Allowance for heat transfer around the specimen (edge surround)

When measuring a test element installed in a surround panel, there will be a small additional heat transfer around the specimen perimeter through the surround panel (see Figure 7) which shall be taken into account.



Key

1 test element thickness

2 reveal depth

3 surround panel

Figure 7 — Heat transfer around the specimen perimeter

This additional heat flow is expressed as the linear thermal transmittance, Ψ_e, associated with the test element and surround panel and its value can be obtained from Table 1. The boundary heat flow, Φ_e, shall be calculated using Formula (1).

$$\Phi_e = \Psi_e P \Delta\Theta \quad (1)$$

where

- P is the perimeter of the air cavity, in m;
- $\Delta\Theta$ is the air temperature difference between warm and cold chambers, in K;
- ψ_e is the linear thermal transmittance obtained according to ISO 10211. Tabulated values of Table 1 may also be used if the assumptions listed in 5.7.5, NOTE 1 are fulfilled.

The heat flow through the test element shall be corrected for this boundary heat flow when calculating the thermal resistance of the air cavity from the measured data.

Table 1 — Linear thermal transmittance for insulated cavity in a surround panel

Overall cavity thickness (mm)	**Hot side reveal depth** (mm)	Ψ_e W/(m·K)		
		λ_{sur} = 0,030 W/(m·K)	λ_{sur} = 0,035 W/(m·K)	λ_{sur} = 0,040 W/(m·K)
124	26	0,000 5	0,000 7	0,000 8
124	76	0,003 3	0,003 9	0,004 4
124	126	0,006 4	0,007 3	0,008 4

Values of Ψ_e for intermediate values λ_{sur} can be obtained by linear interpolation.

NOTE 1 The linear thermal transmittance values shown in Table 1 have been calculated assuming the following:

— the reflective insulation product is in the centre of the cavity;

— there is a 30 mm air cavity each side of the product under test;

— the emissivity of the external surfaces of the product under test is 0,05;

— the effective thermal conductivity of the product under test is 0,032 W/(m·K);

— the effective thickness of the product under test is 30 mm;

— the walls of the cavity are made from 17 mm thick plywood;

— the thermal conductivity of the plywood is 0,16 W/(m·K);

— the insulated cavity is mounted vertically with horizontal heat flow.

NOTE 2 For a 2 m × 1 m cavity measured in a surround panel 2,4 m × 2,4 m and 200 mm thick, which has a thermal conductivity of 0,035 W/(m·K), the boundary loss Φ_e will be about 1,6 % of the total power into the hot box.

5.7.6 Calculating the core thermal resistance of the product

The following process should be followed to calculate the core thermal resistance of the product.

a) Use the procedures in ISO 6946 and the measured temperatures to calculate the thermal resistance of each air cavity using the emissivity determined in accordance with 5.9.2 and Annex D. The emissivity of the plywood (or other similar material) walls of the cavity shall be assumed to be 0,9.

b) Derive the thermal resistance of the complete insulated air cavity from the hot box data.

c) Derive the core thermal resistance of the product by subtracting the thermal resistance of each air cavity from the total thermal resistance of the assembly.

5.8 Determination of the thermal performance of product Type 4

The core thermal resistance of product Type 4 is assumed to be negligible. The thermal performance of the specified system or installed product shall be determined using Method D; the measured value of the surface emissivity shall be determined in accordance with 5.9.2, and the thermal performance of the product together with an airspace or airspaces shall be calculated according to ISO 6946 at a nominal mean temperature of 15 °C, and a temperature difference of 10 K across the sum of the air cavities.

NOTE Specific designs and installations of product Type 4 materials can be tested using Method C, the hot box according to ISO 8990, but in view of the range of possible installed variations in this product type, it is not possible to standardize the large variety of possible designs.

5.9 Emissivity

5.9.1 General

The emissivity of the reflective surface is a fundamentally important parameter affecting the thermal resistance of an adjacent airspace, and which, depending upon the type of facing material and the way in which it is used, may change over time due to ageing (e.g. oxidation; corrosion; exposure to UV radiation, elevated or low temperature, humidity). Long-term functionality of a low emissivity surface in its application is primarily linked to the ability of the material to resist this ageing. Generally, the ageing effect due to corrosion is limited to bright aluminium foil surfaces without any protective coating, but reflective facings which have only minimal surface protection can also be prone to ageing.

In certain applications, dust collection on upward facing surfaces can also reduce the benefit of the low emissivity surface, but as this is application specific it is not addressed in this document.

Ageing of the low emissivity surface due to oxidation, corrosion, or exposure to UV light is relevant for any application.

NOTE The types of materials, protective surfaces and their thicknesses used in reflective insulation products can cover a wide range of specifications and hence properties. The possible surface emissivity and the potential impact of ageing for any particular specimen can be very difficult to determine without direct measurement. It is, therefore, impossible to provide tabulated values, or default values, that would encompass every possible variation. Furthermore, identification of the actual facing, the coating, and its resistance to ageing is even more difficult after the product is placed on the market. Hence the use of default values cannot be recommended, and measurement is the only accurate procedure.

5.9.2 Measurement of emissivity

5.9.2.1 Procedure

The emissivity shall be measured using the apparatus defined in Annex D (or other equipment giving at least the same level of accuracy and validated against the total hemispherical integrative sphere method, which is the fundamental physical reference procedure).

5.9.2.2 Size and number of specimens

The size and number of specimens shall be done in accordance with the requirements in D.5.2.

5.9.2.3 Specimen preparation and conditioning

Wherever possible, the outer low emissivity facing of composite type products should be removed from the specimens prior to testing, provided this does not damage the facing. This makes the measurement of emissivity easier to carry out. If the facing cannot easily be removed, special precautions should be taken (see D.6) to prevent overheating of the specimen during test.

Each specimen for measurement of emissivity shall be subject to conditioning using the procedures in Annex D. The edges of each specimen shall be protected from moisture ingress as described in D.5.3 using self-adhesive waterproof aluminium foil tape prior to conditioning.

6 Uncertainty

6.1 General

The following subclauses identify the additional sources of measurement uncertainty that will be associated with the measurements specified in this document.

NOTE The measurement standards ISO 8301, ISO 8302, ISO 8990, EN 1946-1, EN 1946-2, EN 1946-3 and EN 1946-4, assist with establishing measurement uncertainties. The general requirements for the competence of testing and calibration laboratories are given in ISO/IEC 17025 as well as the methods to calculate uncertainties.

6.2 Thickness measurements

If thermal resistance is measured, the thickness is required to define the product and set the separation of the plates in a hot plate measurement. The method set out in ISO 29466 shall be used. Manufacturers of these products may agree on the most appropriate procedures to be applied. This measurement can introduce additional errors and shall be assessed by those carrying out the measurements.

6.3 Use of thermocouples on thin samples in a guarded hot plate or in heat flow meter measurement

Surface thermocouples shall be used when the thermal resistance of the specimen is below 0,5 $m^2 \cdot K/W$ and this procedure is always associated with additional measurement errors which shall be determined.

6.4 Use of dummy insulation specimens

Annex E shall be used for the dummy specimen method and the measurement error associated with the measurement of the dummy specimens shall be combined with the measurement uncertainty associated with the test method itself using the procedures set out in ISO/IEC Guide 98-3.

6.5 Derivation of the core resistance of a Type 3 product from hot box measurements

Each step of this process will have either a measurement or calculation uncertainty, or both, including:

a) the “normal” measurement uncertainty associated with the hot-box measurement of the insulated air cavity;

b) measurement of the air cavity depths;

c) the emissivity of the test material surface 1;

d) the emissivity of the test material surface 2;

e) the emissivity of the internal cavity walls (both walls assumed to be the same);

f) the uncertainty in the temperature difference between the cold face of the test element and the internal cold face of the cavity;

g) the uncertainty in the temperature difference between the warm face of the test element and the internal warm face of the cavity;

h) the calculated thermal resistance of the cold side air cavity;

i) the calculated thermal resistance of the warm side air.

Each of these possible sources of uncertainty shall be evaluated and combined in accordance with ISO/IEC Guide 98-3, and the range of uncertainty included in the report.

7 Expression of results

7.1 Results derived from hot plate and emissivity measurements (products Type 1 and 2)

The thermal performance determined in accordance with this document shall be established from a minimum of three test results (although a minimum of 10 is highly desirable to reduce errors and correction factors) and expressed in accordance with the rules and procedures specified in a relevant product technical specification. In the absence of guidance in a relevant product specification, the results shall be calculated and expressed using the 90/90 fractile rules according to ISO 10456 as:

a) the 90/90 fractile value of the thermal resistance of the core as determined in Clause 5, rounded downwards to the nearest 0,01 m^2·K/W, together with;

b) the 90/90 fractile value of the emissivity of the surface or surfaces (if different) as determined by D.7, expressed to two decimal places; and

c) optionally, depending upon the intended application, and for unventilated airspaces only, the 90/90 fractile value of the thermal resistance of the core [see 7.1 a)], together with the thermal resistance of one or two adjacent notional (vertical, unventilated) airspace(s), which may be provided for information using the following procedure:

   1) Calculate the thermal resistance of a notional air cavity or air cavities adjacent to the product using standardized calculation procedures specified in ISO 6946, and the emissivity of the surfaces from the procedure specified in 5.9.

   2) Use the core thermal resistance determined from the procedures specified in 5.5 or 5.6.

   3) Use a temperature difference across each air cavity of 5 K, if this calculation is being carried out for the purpose of product comparison. Alternatively, the air cavity thermal resistance may be calculated using a temperature difference suitable for the application. The temperature difference used shall be stated with the measured thermal resistance.

   4) The result, rounded downwards to the nearest 0,05 m^2· K/W, should include the specification of the notional air space(s).

NOTE This calculation will not be able to take account of the effects of overlapping the products (where the foil surface on the cold side is brought directly through to the warm side).

7.2 Results derived from hot box and emissivity measurements (product Types 1, 2 and 3)

The thermal performance determined in accordance with this document shall be established from a minimum of three test results using the rules and procedures specified in a relevant product technical specification. In the absence of guidance in a relevant product specification, the results shall be calculated and expressed using the 90/90 fractile rules according to ISO 10456 as:

a) the 90/90 fractile value of the measured emissivity of the surfaces expressed to two decimal places, and

b) the 90/90 fractile value of the thermal resistance of the core as determined in 5.7, rounded downwards to the nearest 0,01 m^2·K/W,

c) optionally, the 90/90 fractile value of the thermal resistance of the core together with the thermal resistance of the unventilated vertical air space(s), rounded downwards to the nearest 0,05 m2·K/W, and the specification of the air space(s).

7.3 Results derived from emissivity measurements only (product Type 4)

The thermal performance determined in accordance with this document shall be established using a minimum of three test results using the rules and procedures specified in a relevant product technical specification. In the absence of guidance in a relevant product specification, the results shall be calculated and expressed using the 90/90 fractile rules according to ISO 10456 as:

a) the 90/90 fractile value of the emissivity of the surface (or surfaces), as specified in Annex D, expressed to two decimal places, together with;

b) the calculated thermal resistance of associated (vertical, unventilated) air space(s), rounded downwards to the nearest 0,05 $m^2 \cdot K/W$, the specification of the air space(s), the temperature differences used and the calculation method used.

8 Report

The report shall include at least the following details:

a) description of the product, to include at least the product name, types of facing and degree of any printing on the surface;

b) product manufacturer or supplier;

c) the product type determined (1, 2, 3 or 4);

d) the test method used and the conditions of test, including hot and cold test chamber mean temperatures (as required by 5.7.4, 2nd paragraph), hot and cold face specimen temperatures and direction of heat flow;

e) the nominal thickness of the product;

f) the thickness used for the test and the weight of plate used to measure thickness;

g) the relevant product technical specification or the rules or procedures used in the determination of and expression of the results;

h) for hot box tests, the overall width of the test cavity containing the specimen and the depth of the air space either side of the specimen;

i) the measured mean weight per square metre of the product and of the tested specimen;

j) the measured thermal performance of the product as described in Clause 7 for the relevant product type;

k) for emissivity tests, the samplings, ageing and expression of results as stated in Annex D.

l) date of test;

m) range of uncertainty of the test result.

Annex A
(normative)

Decision making flow chart for identification of product types

The decision-making process outlined in Figure A.1 shall be followed to identify product types.

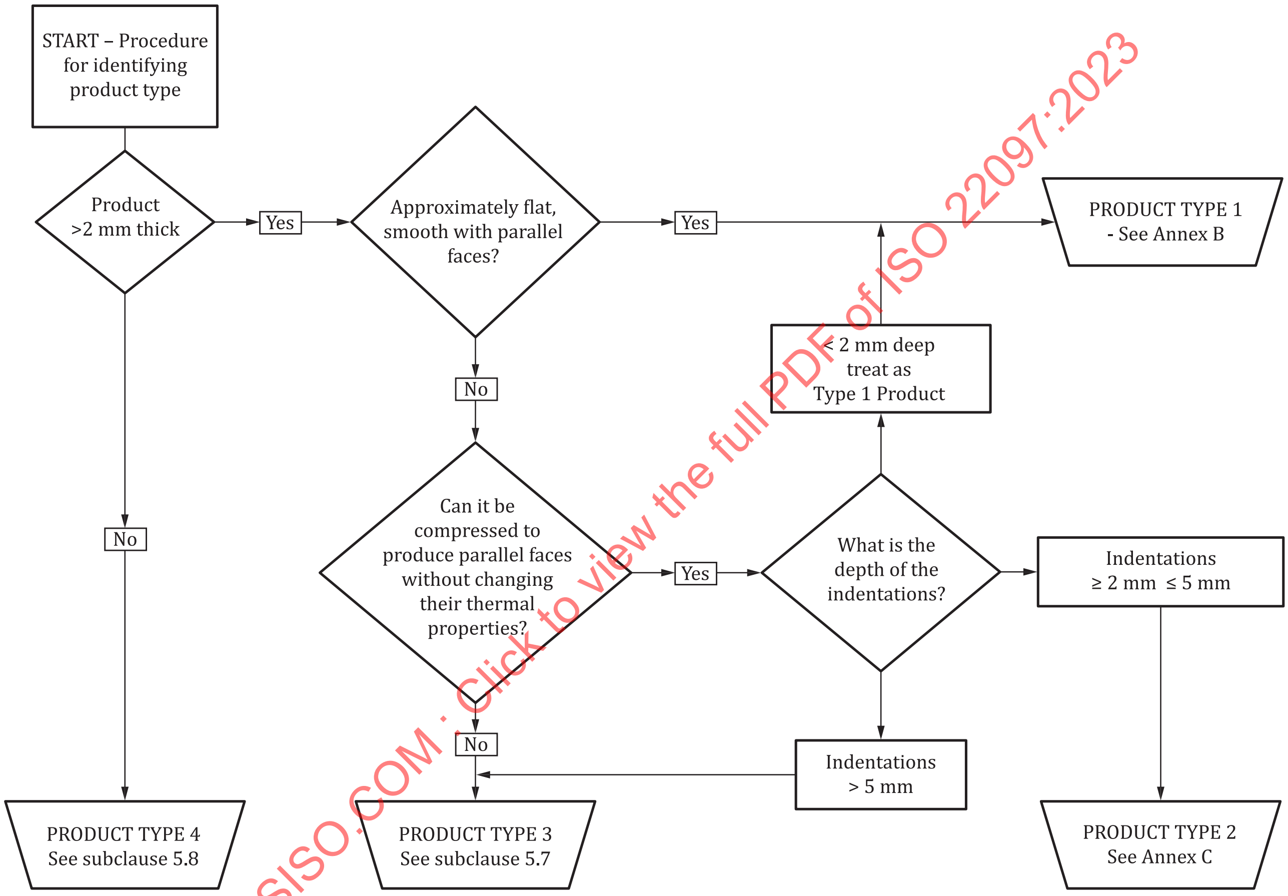


Figure A.1 — Flow chart for identification of product types

Annex B
(normative)

Selection of test methodology for product type 1 when using a hot plate method

The selection process outlined in Figure B.1 shall be followed when selecting a test methodology when using a hot plate method.

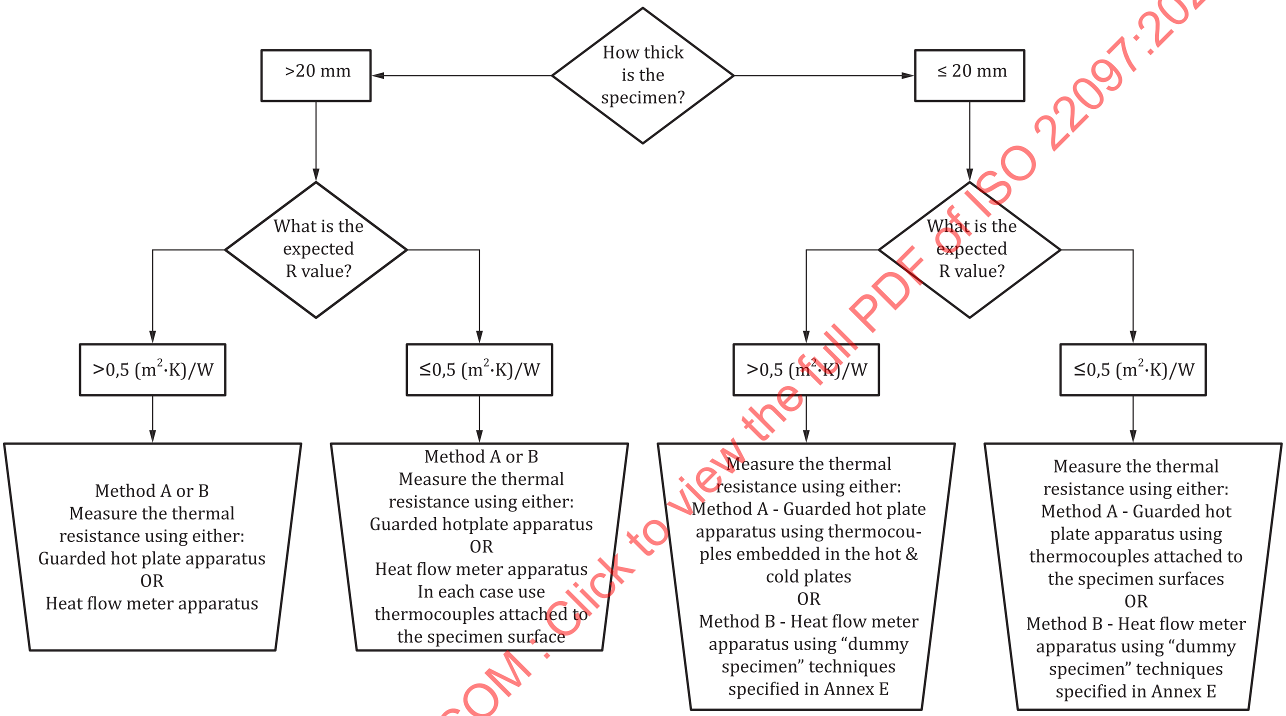


Figure B.1 — Selection of test methodology for product type 1 when using a hot plate method

Annex C
(normative)

Selection of the measurement technique for Product Type 2

The measurement technique for Product Type 2 shall be selected by following the process outlined in Figure C.1.

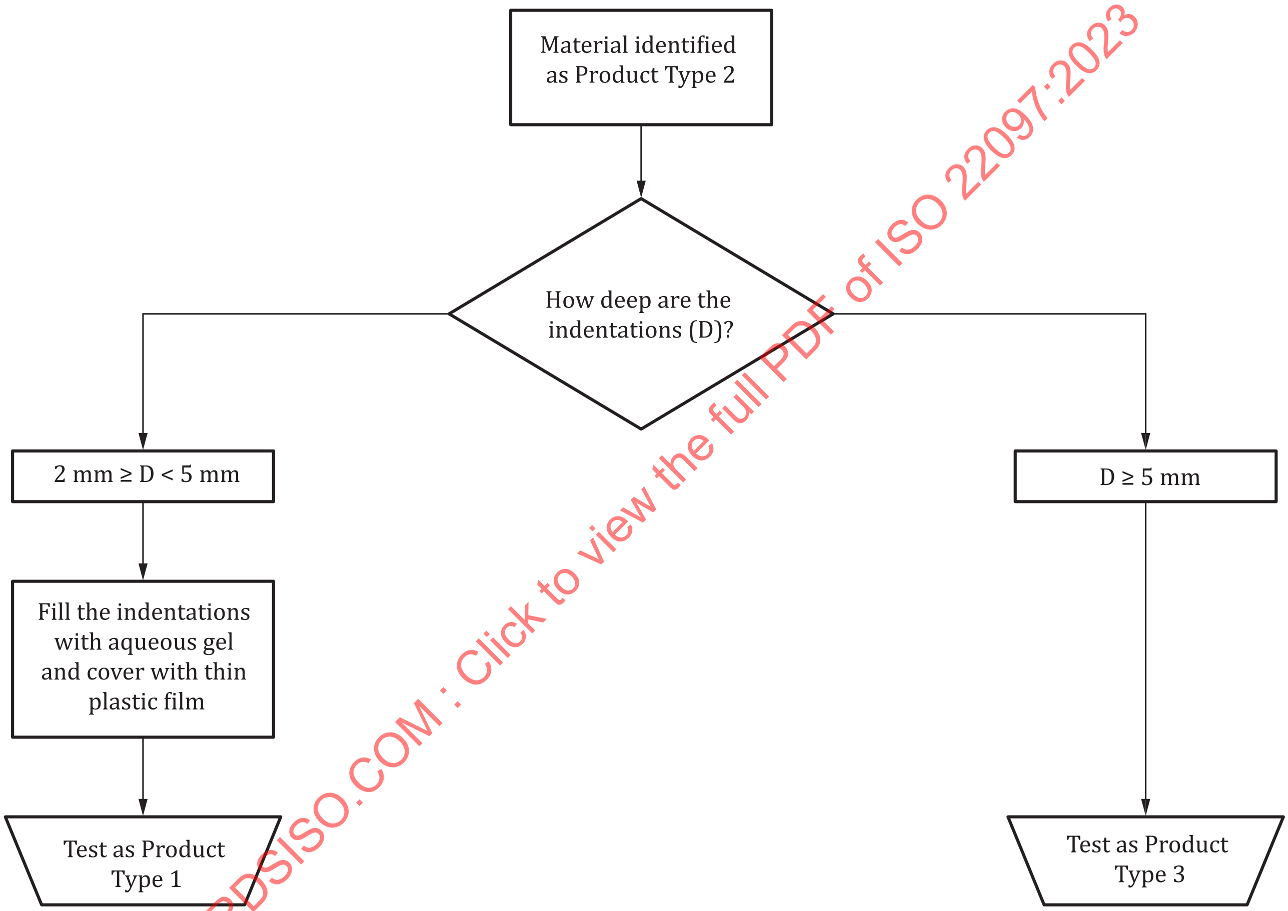


Figure C.1 — Selection of the measurement technique for Product Type 2

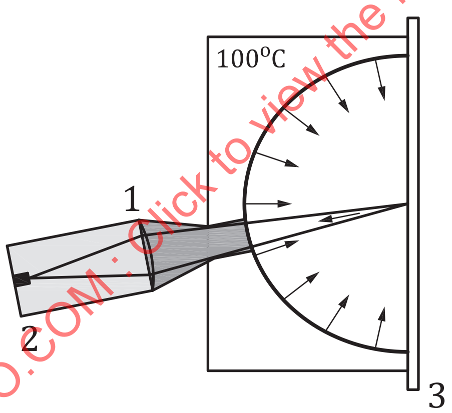
Annex D
(normative)

Measurement of emissivity using a thermal infra-red apparatus

D.1 Principle of the hemispherical blackbody radiator

The hemispherical radiator (half sphere) in the form of a blackbody uses the thermal infra-red radiation principle (TIR-principle). The temperature of the blackbody is set and controlled at 100 °C.

The hemispherical shape of the radiator is necessary in order to achieve a complete and homogenous illumination of the measurement surface allowing the emissivity of rough and structured surfaces to be measured correctly. Part of the energy reflected and emitted by the specimen passes through a small opening in the hemispherical radiator and is focussed onto an infra-red sensor by an infra-red lens. The infra-red sensor changes the incident thermal radiation into a voltage signal in a broad band and linear manner (the voltage signal is proportional to the reflected thermal energy). At any given temperature of a blackbody, the spectral distribution of the thermal radiation is given by Planck's law. The radiator's temperature has been chosen to be 100 °C so that the corresponding spectrum has its peak at a wavelength of circa 8 µm and more than 97 % of the radiant energy is in the wavelength range from 2,5 µm to 40 µm. A schematic of a typical arrangement is given in Figure D.1.



Key

1 IR lens

2 thermopile IR sensor

3 sensor

Figure D.1 — Schematic diagram of typical thermal infra-red apparatus

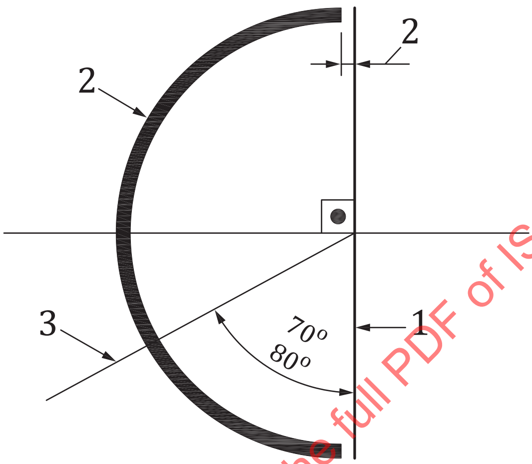
D.2 Description of suitable hemispherical blackbody radiator and specimen holder

In order to reduce errors related to the hemispherical blackbody radiator (henceforth referred to as "apparatus") to a minimum, the half sphere should have a diameter of not less than 70 mm. The distance of the specimen surface to the apparatus shall be approximately 2 mm. The axis of the infra-red sensor and infra-red lens assembly shall point at the centre of the specimen and shall be between 70° and 80° to the specimen surface. An example of this arrangement is shown in Figure D.2.

An adequate electronic method to evaluate the measuring signals should be applied. In order to avoid heating of the specimen, the measuring time should be limited to a maximum of 3 sec.

The specimen holder should have a solid flat front surface with a minimum of 140 mm × 140 mm. The fixing of the specimen onto the specimen holder should be adapted to the type of material being tested. The specimen shall be flat and wrinkle-free over the whole surface. Thin materials may be wrapped around the left and the right edges of the specimen holder and then fixed on both sides by magnetic strips. For metal foils, heat-sink coupling is very important (use heat conductance paste to couple to the heat sink) and a massive aluminium plate as a heat sink should be used. For thick and stiff materials, fixing should be adapted on a case-by-case basis (e.g. clamps, hooks). The specimen shall be maintained parallel to the apparatus during measurement. The distance of 2 mm between specimen and apparatus shall be predefined by spacers, which should also prevent any rocking of the specimen.

NOTE The TIR apparatus described in D.1 has previously been developed and specified in EN 15976[5].



Key

1 specimen

2 test equipment

3 IR beam

Figure D.2 — Arrangement of thermal infra-red apparatus and specimen

D.3 Calibration standards

The apparatus requires calibration against accurately defined low and high emissivity standards. Typical calibration standards for a low emitting surface should have $0,01 < \varepsilon_L < 0,02$. For a high emitting surface, the calibration standard should have $\varepsilon_H > 0,94$. The recommended reference standards should be based on:

— low emissive standard: polished aluminium surface;

— high emissive standard: black light trap surface.

Calibration standards shall be certified and accompanied by a certificate showing the measured emissivity. The calibration standards shall be recertified (or replaced by new certified standards) at least every two years.

D.4 Calculation of the emissivity

The emissivity is determined from comparing the measured result for the specimen with the two calibration documents. With the sensor signals (U, UH and UL) and the known emissivity of calibration documents (ε_L and ε_H), the emissivity, ε, of the specimen shall be calculated by Formula (D.1):

$$\varepsilon = \varepsilon_H - (\varepsilon_H - \varepsilon_L) \times (UH - U) / (UH - UL) \quad (D.1)$$

NOTE The measurement range of the apparatus is limited to values between those of the two calibration documents used, hence within the emissivity range of 0,02 to 0,94. However, there are practical limits to the measurement of very low values of emissivity, irrespective of the method used. Errors increase significantly below emissivity 0,05.

D.5 Sampling and preparation of the test specimens

D.5.1 Sampling

A sample of an undamaged reflective insulation product shall be selected at random from a batch of production material or from product placed on the market.

D.5.2 Dimensions and numbers of specimens

A minimum of three specimens should be taken from the sample to be representative of the length and width of the product to include a representative area of any printing or perforation where relevant. If the faces of the product differ then a minimum of three specimens shall be taken from each face. The specimen size should be adapted to the size of the specimen holder and to the fixing system of the specimen holder (see D.6), but shall be at least 250 mm × 250 mm. A similar number of specimens shall also be taken for testing after conditioning under UV light and after heat and humidity ageing as described below.

NOTE See also D.7.5 for alternative consideration of the effect of printed area on emissivity.

D.5.3 Conditioning of specimens for ageing

D.5.3.1 Ageing by UV Radiation.

One group of specimens shall be exposed to ageing with a fluorescent tube bench, using light in the UVA range (315 nm to 400 nm), with either UVA-340 (centred on 340 nm), UVA-368 (centred on 368 nm) or UVA-351 nm (centred on 351 nm).

The irradiance on the surface of the films in the 315 nm to 400 nm range shall be limited to 30 W/m^2. The reflective surface shall be positioned 50 mm from the tube. The duration of UV radiation depends on the nature of the product packaging:

— If the reflective product packaging protects the product from UV radiation (UVB 290-320 nm), the product should be subjected to UV radiation for 200 h at 45 °C and 90 % RH;

— Otherwise, the product should be subjected to UV radiation for 500 h at 45 °C and 90 % RH.

D.5.3.2 Ageing by temperature and humidity

Further specimens shall be exposed in a climatic chamber to 90 % RH and 70 °C temperature for a period of 28 days. The edges of the specimens shall be adequately protected by securing self-adhesive aluminium foil tape around each edge of the specimen from the upper surface to the lower surface, to prevent ingress of moisture through the cut edge. After the conditioning process, the specimens shall then be allowed to stabilize for a minimum of 2 h at a temperature of (23 ± 2) °C and (50 ± 20) % of RH.

D.6 Procedure for measurement of specimens

The apparatus shall be switched on at least 2 h before calibration and before commencing the taking of measurements. The apparatus shall be installed in a fixed position and shall not be moved during measurement. Special precautions should be taken to ensure that the calibration standards, the specimens and the apparatus are brought to equilibrium in the same standard climatic conditions. Air currents and draughts in the measuring area shall be avoided.

