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Solar energy — Collector components and materials —

Part 5: Insulation material durability and performance

Énergie solaire — Composants et matériaux du collecteur —
Partie 5: Durabilité et performance des matériaux isolants

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Foreword

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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 on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 180, *Solar Energy.*

A list of all parts in the ISO 22975 series can be found on the ISO website.

Introduction

The insulation material is a component of a solar collector, which is placed behind the panel in a flat plate solar collector or in the header of an evacuated tube solar collector through a specific filling process and is used as a heat insulation element.

This document provides test methods for measuring the common properties on insulation materials, including apparent density, apparent volume percentage of open cells of PU and PF, and dimension, bulk density of MW and mineral fibre. For each test, this document specifies sampling, apparatus and acceptance test procedure.

This document also provides test methods for determining the durability of insulation materials, including compression properties, water absorption, hygroscopic sorption properties, water vapor transmission properties, flammability, accelerated aged value of thermal resistance of PU and PF, and compression behaviour, water absorption, moisture content, water vapor transmission properties, maximum use temperature, non-combustibility of MW and mineral fibre. For each durability test, this document specifies principle, apparatus, sampling, acceptance test procedure, calculation and expression of results, or evaluation.

This document also provides test methods and acceptance test procedure for measuring performance of insulation materials, including thermal resistance and thermal conductivity.

This document also provides test methods and acceptance test procedure for measuring outgassing of insulation materials in solar flat-plate collector.

Solar energy — Collector components and materials —

Part 5: Insulation material durability and performance

1 Scope

This document specifies the requirements on insulation materials for solar collectors and test methods for durability and performance of insulation materials used in solar collectors.

This document is applicable to all types of insulation material used in solar collectors, such as rigid polyurethane foam (PU), phenolic foam (PF), mineral wool (MW) and mineral fibre.

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 291, *Plastics — Standard atmospheres for conditioning and testing*

ISO 844, *Rigid cellular plastics — Determination of compression properties*

ISO 845, *Cellular plastics and rubbers — Determination of apparent density*

ISO 1182:2010, *Reaction to fire tests for products — Non-combustibility test*

ISO 1663, *Rigid cellular plastics — Determination of water vapour transmission properties*

ISO 2796, *Cellular plastics, rigid — Test for dimensional stability*

ISO 2896, *Rigid cellular plastics — Determination of water absorption*

ISO 4590, *Rigid cellular plastics — Determination of the volume percentage of open cells and of closed cells*

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

ISO 9050, *Glass in building — Determination of light transmittance, solar direct transmittance, total solar energy transmittance, ultraviolet transmittance and related glazing factors*

ISO 11561:1999, *Ageing of thermal insulation materials — Determination of the long-term change in thermal resistance of closed-cell plastics (accelerated laboratory test methods)*

ISO 11925-2, *Reaction to fire tests — Ignitability of products subjected to direct impingement of flame — Part 2: Single-flame source test*

ISO 12570, *Hygrothermal performance of building materials and products — Determination of moisture content by drying at elevated temperature*

ISO 12571, *Hygrothermal performance of building materials and products — Determination of hygroscopic sorption properties*

ISO 29469, *Thermal insulating products for building applications — Determination of compression behaviour*

3 Terms and definitions

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

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

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

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

3.1
bulk density
mass per unit volume of uncompact filling insulation material

Note 1 to entry: Bulk density is expressed in kilograms per cubic metre (kg/m^3).

3.2
water vapour transmission rate
g
quantity of water vapour transmitted through unit area in unit time under specified conditions of temperature, humidity and thickness

3.3
water vapour permeance
W
quotient of the *water vapour transmission rate* (3.2) of the test specimen and the water vapour pressure difference between the two specimen faces during the test

3.4
water vapour resistance
Z
inverse of *water vapour permeance* (3.3)

3.5
water vapour permeability
δ
quantity of water vapour transmitted per unit of time through a unit area of the product per unit of vapour pressure difference between its faces for a unit thickness

3.6
water vapour diffusion resistance factor
μ
quotient of the *water vapour permeability* (3.5) of air and the *water vapour permeability* (3.5) of the material or the homogeneous product concerned

Note 1 to entry: μ indicates the relative magnitude of the water vapour resistance of the product and that of an equally thick layer of stationary air at the same temperature.

3.7
water vapour diffusion equivalent air layer thickness
S_d
thickness of a motionless air layer which has the same water vapour resistance as the test specimen with the thickness, *d*

3.8
maximum use temperature
highest temperature that can be borne by the material under the normal usage condition

Note 1 to entry: Maximum use temperature is expressed in degrees Celsius (°C).

4 Requirements

4.1 General

Product properties of the insulation materials used in solar collectors shall be given by the manufacturers. Product properties should be assessed in accordance with Clause 5. To comply with this document, products should meet the situation of 4.2 as appropriate.

4.2 For specific application

For specific application and quality control, in the cases of being agreed by the purchaser and seller, acceptable performance of insulation materials may be considered as the recommended performance levels provided in Annex B.

5 Test methods

5.1 Rigid polyurethane foam and phenolic foam

5.1.1 Standard atmospheres for conditioning and testing

They shall be in accordance with ISO 291.

5.1.2 Apparent density

It shall be in accordance with ISO 845.

5.1.3 Apparent volume percentage of open cells

It shall be in accordance with ISO 4590.

5.1.4 Dimensional stability

It shall be in accordance with ISO 2796.

5.1.5 Compression properties

They shall be in accordance with ISO 844.

5.1.6 Water absorption

It shall be in accordance with ISO 2896.

5.1.7 Hygroscopic sorption properties

They shall be in accordance with ISO 12571.

5.1.8 Water vapor transmission properties

They shall be in accordance with ISO 1663.

5.1.9 Thermal resistance and thermal conductivity

They shall be in accordance with ISO 8301.

5.1.10 Flammability

It shall be in accordance with ISO 11925-2.

5.1.11 Accelerated aged value of thermal resistance

It shall be in accordance with ISO 11561.

5.2 Mineral wool and mineral fibre

5.2.1 Dimension

5.2.1.1 Sampling

The number of specimens and sampling shall be as follows:

1) A test sample shall consist of one representative roll or package of insulation.

2) Sampling of packages — For packages which contain 20 or more batts, five batts shall be selected. For packages which contain less than 20 batts, either the three-batt or five-batt selection technique may be used. Batts which are folded in half shall count as two batts for purposes of choosing and employing the selection method.

   a) Three-Batt Method — Select the centre batt and the second batt from each end of the package.

   b) Five-Batt Method — Divide the package sequentially into five groups of batts as equal in number as possible. Select the first batt from each group. Be careful to select one and only one batt from the two end batts within the package.

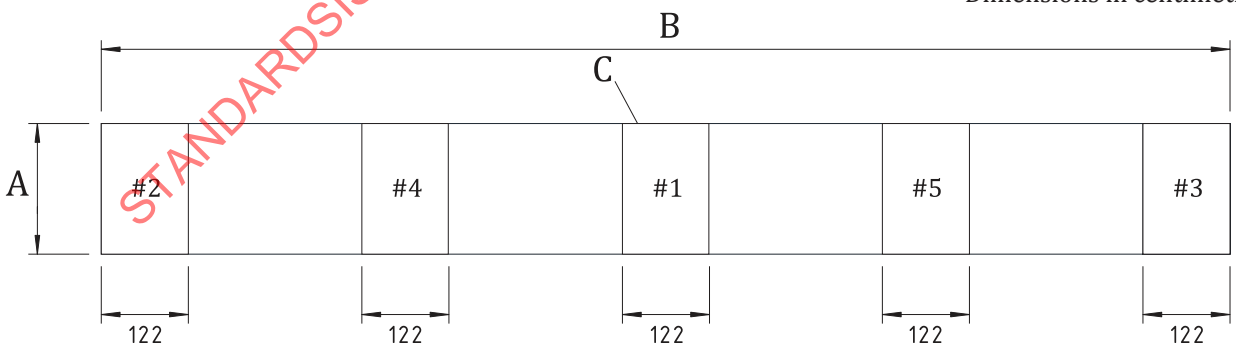
   c) Cut batts which are longer than (122 ± 0,63) cm in length.

3) Sampling of cut rolls — Five batts shall be cut of roll-width by (122 ± 0,63) cm in length.

   a) Cut one batt from the centre of the roll, two batts from the ends of the roll, and the fourth and fifth from the quarter points along the length. See Figure 1.

   b) For blankets wider than 61 cm, cut each of the five batts (61 ± 0,63) cm wide by (122 ± 0,63) cm long.

Dimensions in centimetres



Key

A nominal roll width
B nominal roll length
C batt

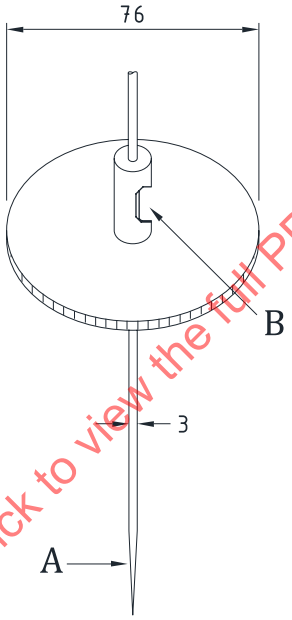
Figure 1 — Sampling of cut rolls

4) Sampling for Full Roll Method — This method can be used in place of sampling of cut rolls when the roll is wider than 61 cm or longer than 16,4 m. Prior to unrolling the material, weigh the entire roll to the nearest 0,11 kg. Two methods may be used to obtain the full roll weight. The first method removes the insulation product from the packaging prior to weighing. The material will expand and can unroll slightly, care shall be taken to ensure that the full roll is weighed accurately. The second method weighs the packaged insulation product, then weighs the packaging material only. The packaging material weight is subtracted from packaged product weight to obtain the net material weight.

5.2.1.2 Apparatus

5.2.1.2.1 Depth gauge, to be used for dimension testing meeting the following requirements and of the type shown in Figure 2.

Dimensions in millimetres



Key

A taper to a sharp point

B thumb grip

Figure 2 — Depth gauge for thickness measurements

5.2.1.2.2 Disk, fabricated of a suitable plastic material. The disk shall have a mass of (9,3 ± 0,3) g and shall exert a pressure of 20 Pa. The disk shall be 76 mm ± 2 mm in diameter. The disk shall be perpendicular to the pin at all times and shall have a friction device or thumb grip to secure the pin unless purposely moved.

5.2.1.2.3 Pin, made at a maximum of 3 mm in diameter and of sufficient length for the material to be measured.

5.2.1.2.4 Steel rule, graduated in 1 mm intervals.

5.2.1.3 Procedure

5.2.1.3.1 General

The test specimens shall be cut by methods that do not change the structure relative to that of the original product and the test procedure shall be as follows:

5.2.1.3.2 Expansion of packages and cut roll

a) Hold the first batt vertically off the floor by grasping it with both hands on its long dimension so that the lower edge is (460 ± 25) mm above a solid horizontal surface. Release the batt, allowing it to strike the surface.

b) Repeat the actions of a) for a second time. Next, hold the batt by the other long edge, drop twice as a). Place the specimen on the flat, hard surface.

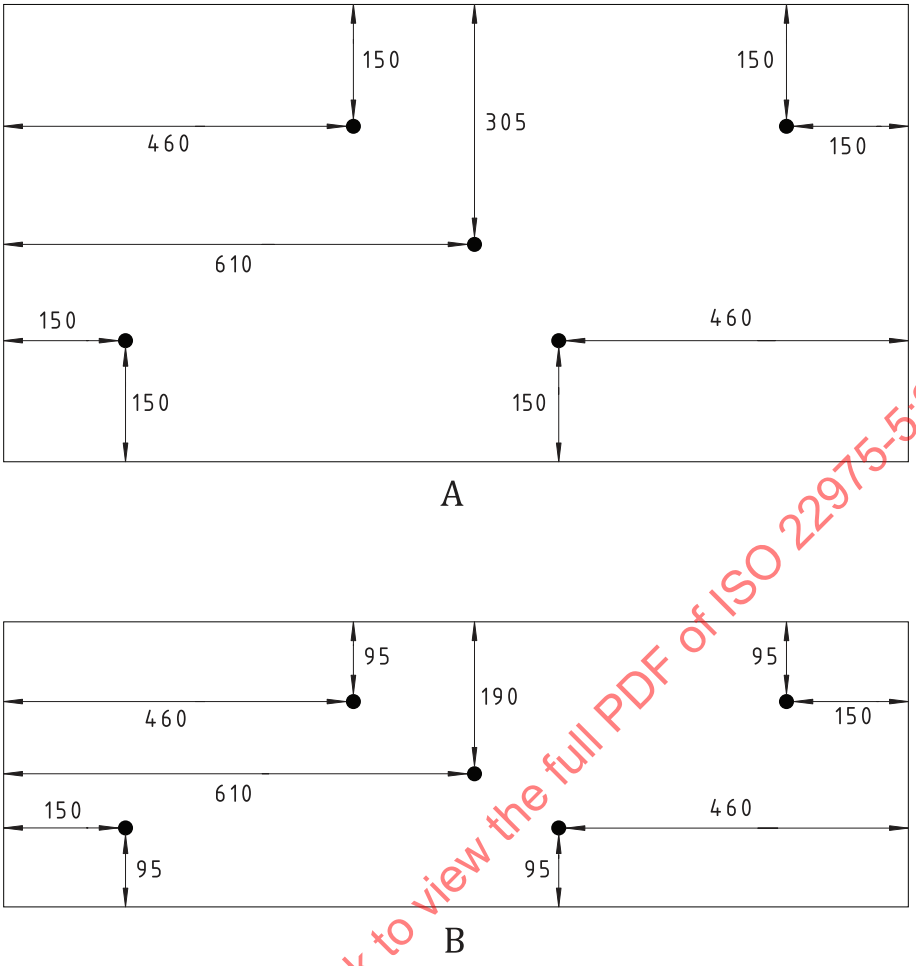
c) Repeat the actions of a) and b) for the remaining four specimens.

d) Allow specimens to reach equilibrium by waiting at least 5 min before making thickness measurements within 25 mm in any direction of five points as indicated in Figure 3.

If 580 mm-wide samples are tested, use a quarter or half of that dimension to establish the test points.

NOTE 1 Some materials can require 4 h or more to reach equilibrium.

Dimensions in millimetres



Key

A 600 mm by 1 200 mm specimen

B 375 mm by 1 200 mm specimen

Figure 3 — Thickness measurement locations

5.2.1.3.3 Expansion of full roll

a) Unroll the insulation. Flip the test roll over its entire length so the bottom surface is now on top. Next grasp one end and pull the material over itself until the original surface is again facing up.

b) If there is insufficient room to pull the material over itself (less than twice the unrolled length), the material may be repositioned by sliding the partially pulled roll to the end of the testing space and continue to pull the material over itself.

c) Use 5.2.1.3.1 if the sampling of cut rolls procedure in 3) of 5.2.1.1 is used.

5.2.1.3.4 Measurement of packages and cut roll

a) Insert the pin of the thickness gauge vertically into the material at the first measuring point with a twisting motion until it contacts the hard surface beneath. Lower the disk until it lightly and uniformly contacts the specimen.

b) An alternative procedure is to use a disk whose mass exerts a specified pressure of at least 20 Pa on the specimen. With the gauge disk locked against the pin, lift the gauge unit from the test specimen.

c) While holding the gauge in locked position, place the disk against the zero end of the rule with the pin projecting along the calibrated surface of the rule.

d) Observe and record the reading at the pointed end of the pin to the nearest 1 mm.

e) Repeat the actions of a), b), c), d) for each of the remaining measuring points as shown in Figure 3.

5.2.1.3.5 Measurement of full roll

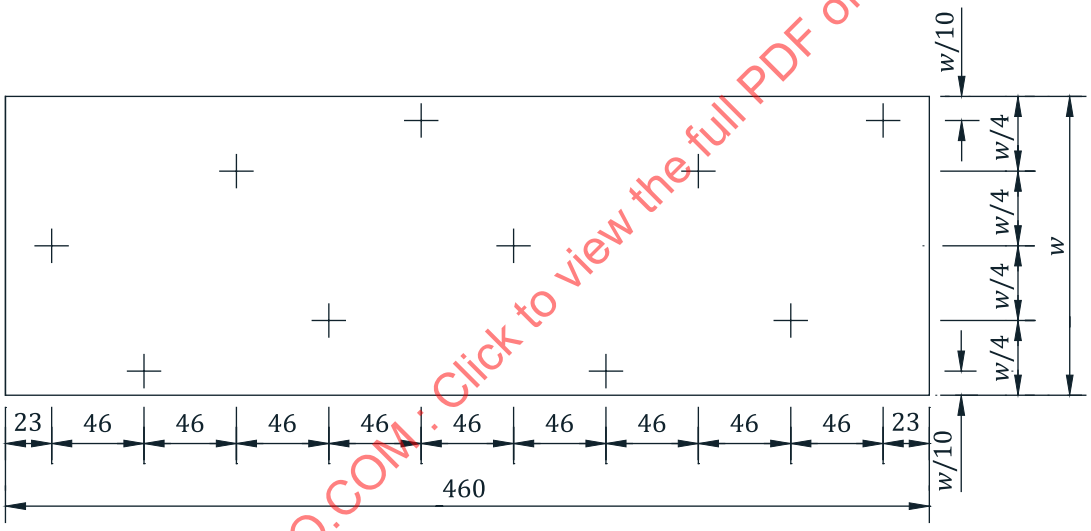
a) Record the roll length to the nearest 2,54 cm. Take measurements on each side of the roll. If the roll has been cut in half, take a third roll length measurement along the midpoint of the roll width.

b) Record roll width at three locations to the nearest 0,32 cm. Width measurements will be taken 3,05 m from each end, and in the middle of the roll length.

c) Using a pin gauge, record thickness to the nearest 1 mm as shown in Figure 4. Refer to 5.2.1.3.4 for use of pin gauge. Two 4,57 m long sections shall be measured. These sections shall be 3,05 m from each end. A total of twenty thickness measurements shall be taken for each roll.

d) Use 5.2.1.3.5 if the sampling procedure in 4) of 5.2.1.1 is used.

Dimensions in centimetres



Key

w roll width

Figure 4 — Thickness measurement locations — Full roll

5.2.1.4 Thickness calculation

Take the average of the thickness measurements made in accordance with 5.2.1.3 as the thickness of the specimen.

5.2.2 Bulk density

5.2.2.1 Sampling

Same as 5.2.1.1.

5.2.2.2 Apparatus

Balance to be used for bulk density testing meeting the following requirements:

a) Scales of sufficient capacity to weigh the test specimen to an accuracy of ±0,5 %.

b) Sensitivity to weigh the test specimen to an accuracy of ±0,5 %

5.2.2.3 Procedure

The procedure for bulk density of the specimen shall be as follows:

a) Weigh the weight of the specimen with facings and the weight of the specimen without facings.

b) Calculate the density of the specimen with facings and the density of the specimen without facings by using Formula (1) and Formula (2):

$$D_a = \frac{M_1}{L_1 w_1 H_1} \quad (1)$$

where

D_a is the density of the specimen with facings in kilograms per cubic metre (kg/m^3);

M_1 is the total weight of test specimen with facings in kilograms (kg);

L_1 is the length of test specimen with facings in metres (m);

w_1 is the width of test specimen with facings in metres (m);

H_1 is the thickness of test specimen with facings in metres (m).

$$D_b = \frac{M_2}{L_2 w_2 H_2} \quad (2)$$

where

D_b is the density of the specimen without facings in kilograms per cubic metre (kg/m^3);

M_2 is the total weight of test specimen without facings in kilograms (kg);

L_2 is the length of test specimen without in metres (m);

w_2 is the width of test specimen without in metres (m);

H_2 is the thickness of test specimen without in metres (m).

5.2.3 Compression behaviour

It shall be in accordance with ISO 29469.

5.2.4 Water absorption

5.2.4.1 Principle

There are two methods to get water absorption which is related to different situations. The principle shall be as follows:

a) Partial immersion (Method 1):

The long-term water absorption by partial immersion is intended to simulate the water absorption caused by long-term water exposure.

The long-term water absorption by partial immersion is determined by measuring the change in mass of a test specimen, the lower part of which is in contact with water for a period of 28 days.

The excess water adhering to the surface, not absorbed by the test specimen, is removed by drainage in Method 1A (see 5.2.4.4.3.1) or taken into account by deduction of the initial water uptake in Method 1B (see 5.2.4.4.3.2).

b) Total immersion (Method 2):

The long-term water absorption by total immersion is not directly related to the conditions on site, but has been recognised as a relevant condition of test for some products in some applications.

The long term water absorption by total immersion is determined by measuring the change in mass of the test specimen, totally immersed in water, over a period of 28 days.

The excess water adhering to the surface, not absorbed by the test specimen, is removed by drainage in Method 2A (see 5.2.4.4.4.1) or taken into account by deduction of the initial water uptake in Method 2B (see 5.2.4.4.4.2).

5.2.4.2 Apparatus

The examples of test devices for water absorption testing are given in the Figures 5, 6 and 7, Equipment for drainage is given in Figure 8. Following requirements shall be met:

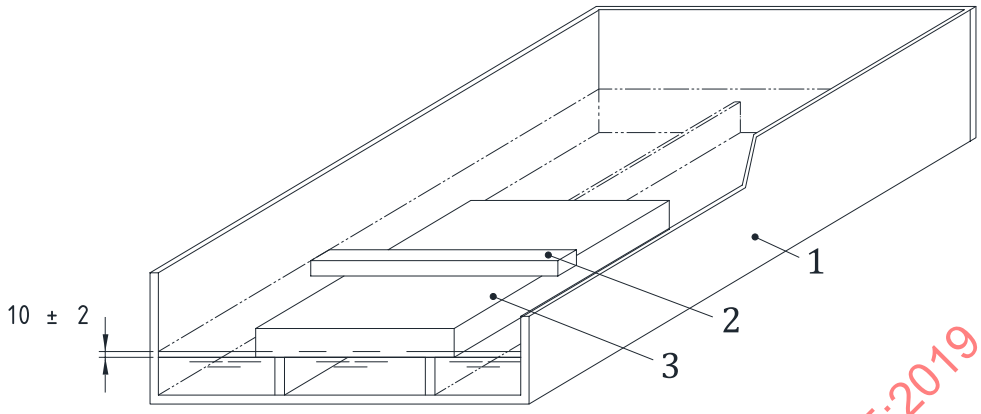
5.2.4.2.1 Balance, which allows the determination of the mass of a test specimen to 0,1 g.

5.2.4.2.2 Water tank, with a device for keeping the water level constant to within ±2 mm, and a device to keep the test specimen in the required position. The device to keep the test specimen in position shall not cover more than 15 % of the cross-section area of the test specimen, which is exposed to water. It shall be such that the original form of the test specimen is maintained.

5.2.4.2.3 Tap water, adjusted to a temperature of (23 ± 5) °C. In case of dispute, deionised water shall be used.

The principle for Methods 1A (see 5.2.4.4.3.1) and 2A (see 5.2.4.4.4.1) is illustrated in Figures 8 a) and b).

Dimensions in millimetres

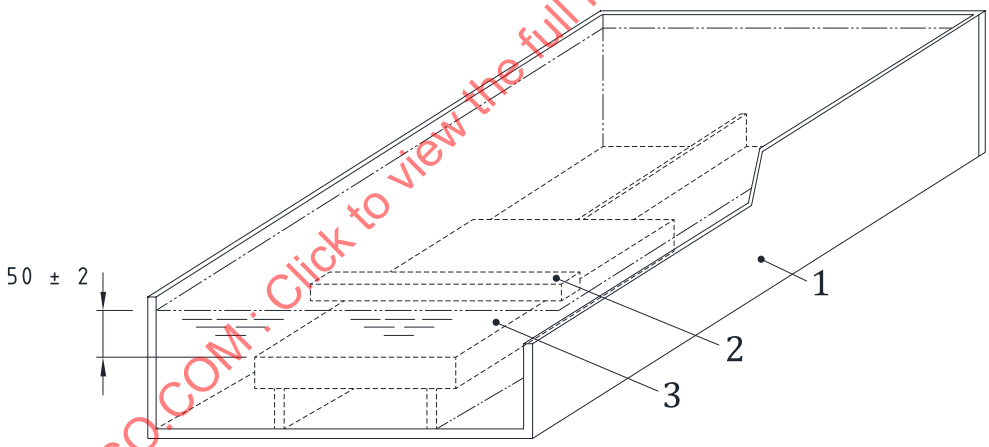


Key

1 water tank
2 load to keep the test specimen in position
3 test specimen

Figure 5 — Example of partial immersion test device (Method 1A and 1B)

Dimensions in millimetres

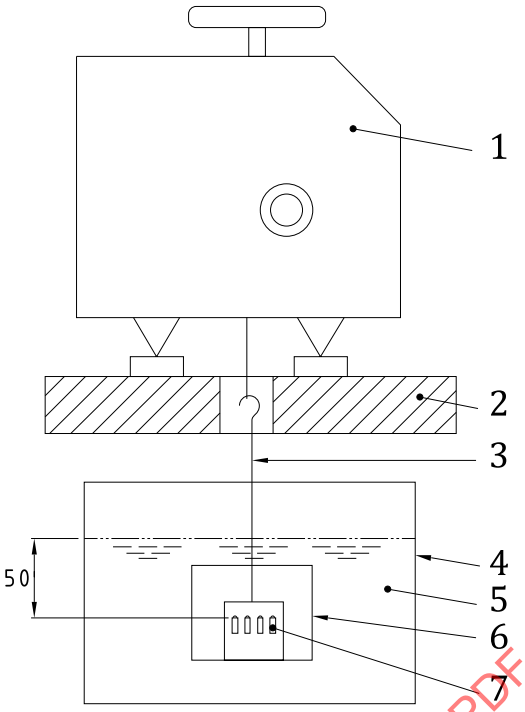


Key

1 water tank
2 load to keep the test specimen in position
3 test specimen

Figure 6 — Example of equipment for the determination of water absorption by total immersion (Method 2A and 2B)

Dimensions in millimetres



Key

1 balance
2 weighing table
3 linkage
4 water container
5 water
6 mesh cage made of stainless material with fixing rods or a sinker large enough in mass to compensate for the upthrust of the test specimen
7 test specimen

Figure 7 — Example of equipment for determination of water absorption by total immersion (Method 2C)

a) **b)**

Key

1 stainless steel mesh
2 test specimen
3 perforated stainless steel

Figure 8 — Examples of equipment for drainage

5.2.4.3 Sampling

5.2.4.3.1 Dimensions of test specimens

The thickness of the test specimens shall be the original product thickness.

The test specimens shall be squares with squarely cut edges having sides of (200 ± 1) mm.

5.2.4.3.2 Number of test specimens

The number of test specimens shall be as specified in the relevant ISO standard. In the absence of such a specification, at least four test specimens shall be used.

5.2.4.3.3 Preparation of test specimens

The test specimens shall be cut so that they do not include original product edges.

Test specimens shall be prepared by methods that do not substantially change the original structure of the product. Any skins, facings and/or coatings shall be retained.

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

5.2.4.3.4 Conditioning of test specimens

The 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 for the time stated in the relevant standard with a minimum of 6 h.

5.2.4.4 Procedure

5.2.4.4.1 Test conditions

The test shall be carried out at (23 ±5) °C. In case of dispute it shall be carried out at (23 ±2) °C.

5.2.4.4.2 General

The method shall be as specified in the relevant ISO standard. In the absence of such a specification, the method may be agreed between parties.

The long-term water absorption is determined after 28 days immersion.

If requested, readings can be made at shorter time periods, e.g. after 7 days and 14 days immersion periods.

The dimensions of the test specimens shall be measured in accordance with 5.2.1 to the nearest 0,5 mm before the test.

If any dimensional changes are noticed after the immersion period, the dimensions of the test specimens should be measured again.

5.2.4.4.3 Long term water absorption by partial immersion (Method 1)

5.2.4.4.3.1 Method 1A (drainage)

Weigh the test specimen to the nearest 0,1 g to determine its initial mass, m_0.

The test is conducted with half of the test specimens with one major face upwards and with the other half with the same major face downwards.

Place the test specimen in the empty water tank and apply a sufficient load to keep it partially immersed when water is added. Carefully add the water to the tank until the bottom face of the test specimen is (10 ± 2) mm below the surface of the water (see example in Figure 5). Ensure that the water level remains constant during the test.

After 28 days remove the test specimen; drain it for (10 ± 0,5) min by placing it vertically on a mesh, inclined at 45°, as shown in Figure 8 a) or b). Weigh the test specimen again to determine its mass, m_{28}.

5.2.4.4.3.2 Method 1B (deduction of initial water uptake)

Weigh the test specimen to the nearest 0,1 g to determine its initial mass, m_0.

The test is conducted with half of the test specimens with one major face upwards and with the other half with the same major face downwards.

Place the test specimen in the water tank in such a position that it is partially immersed in water with the bottom face of the test specimen (10 ± 2) mm below the water level. Remove the test specimen; after 10 s, hold it horizontally and place it, within 5 s, in a plastic tray of known mass. Reweigh this tray with the test specimen to determine the mass, m_1, of the test specimen including the initial water uptake.

Replace the test specimen in the water tank and apply a sufficient load to keep the test specimen partially immersed in water with the bottom face of the test specimen (10 ± 2) mm below the water level (see example in Figure 5). Ensure that the water level remains constant during the test.

The test is conducted with half of the test specimens with one major face upwards and with the other half with the same major face downwards.

After 28 days remove the test specimen holding it horizontally and place it, within 5 s, in the plastic tray of previously determined mass to determine its mass, m_{28}.

Method 1B is only applicable if the initial water uptake is less than or equal to 0,5 kg/m^2, where this is calculated using Formula (3).

$$\frac{m_1 - m_0}{A_p} \tag{3}$$

where

m_0 is the initial mass of the test specimen as determined in Method 1B in kilograms (kg);

m_1 is the mass of the test specimen including the initial water uptake in Method 1B in kilograms (kg);

A_p is the bottom surface area of the test specimen in square metres (m^2).

5.2.4.4.4 Long term water absorption by total immersion (Method 2)

5.2.4.4.4.1 Method 2A (drainage)

Weigh the test specimen to the nearest 0,1 g to determine its initial mass, m_0.

Place the test specimen in the empty water tank and apply a sufficient load to keep the test specimen totally immersed in water. Carefully add water to the tank until the top face of the test specimen is (50 ± 2) mm below the surface of the water (see Figure 6). Ensure that the water level remains constant during the test.

After 28 days remove the test specimen; drain it for (10 ± 0,5) min by placing it vertically on a mesh, inclined at 45°, as shown in Figure 8 a) or b). Then weigh the test specimen again to determine its mass, m_{28}.

5.2.4.4.4.2 Method 2B (deduction of initial water uptake)

Weigh the test specimen to the nearest 0,1 g to determine its initial mass, m_0.

Place the test specimen in the water tank in such a position that it is totally immersed in water with the top face of the test specimen (50 ± 2) mm below the water level. Remove the test specimen, after 10 s, hold it horizontally and place it, within 5 s, in a plastic tray of known mass. Reweigh this tray with the test specimen to determine the mass of the test specimen, m_1, including the initial water uptake.

Replace the test specimen in the water tank and apply a sufficient load to keep the test specimen totally immersed in water, with the top face of the test specimen (50 ± 2) mm below the water level (see example in Figure 6). Ensure that the water level remains constant during the test.

After 28 days remove the test specimen, holding it horizontally, and place it within 5 s in the plastic tray of previously determined mass to determine its mass, m_{28}.

Method 2B is only applicable if the initial water uptake is less than or equal to 0,5 kg/m^2, where this is calculated using Formula (4):

$$\frac{m_1 - m_0}{A_t} \tag{4}$$

where

m_0 is the initial mass of the test specimen as determined in method 2B in kilograms (kg);

m_1 is the mass of the test specimen including the initial water uptake in method 2B in kilograms (kg);

A_t is the total surface area of the test specimen exposed to water in square metres (m^2).

5.2.4.4.4.3 Method 2C

Weigh the test specimen to the nearest 0,1 g to determine its initial mass, m_0.

Determine the linear dimensions of the test specimen according to 5.2.1 to the nearest 0,5 mm. Fill the water container with tap water. Weigh the immersed empty cage to the nearest 0,1 g (mass m_1).

Remove the cage and attach the test specimen horizontally in the cage so that the distance between the surface of the water and the top surface of the test specimen will be (50 ± 2) mm. Ensure that this distance remains constant during the test. Immerse the assembled cage and attach it to the balance.

Remove obvious air bubbles from the test specimen with a brush or by agitation.

Ensure that the cage remains at the same level relative to the surface of the water for all weighings.

After 28 days determine the apparent mass, m_{28}, of the submerged cage containing the test specimen, to the nearest 0,1 g.

Re-measure the linear dimensions of the test specimen as before to the nearest 0,5 mm.

5.2.4.5 Calculation and expression of results

5.2.4.5.1 General

The test result shall be the mean value of the individual values [for products having different faces (facings) on each side two mean values are calculated in Method 1].

Results shall not be extrapolated to other thicknesses.

Results obtained by different water absorption test methods are not comparable.

5.2.4.5.2 Long-term water absorption by partial immersion

Calculate the long-term water absorption by partial immersion for each test specimen, W_{lp}, kg/m^2 using Formula (5) or (6):

Method 1A

$$W_{lp} = \frac{m_{28} - m_0}{A_p} \tag{5}$$

Method 1B

$$W_{lp} = \frac{m_{28} - m_1}{A_p} \tag{6}$$

where

m_0 is the initial mass of the test specimen as determined in Method 1A in kilograms (kg);

m_1 is the mass of the test specimen including the initial water uptake in Method 1B in kilograms (kg);

m_{28} is the mass of the test specimen after partial immersion for 28 days (Method 1A and 1B) in kilograms (kg);

A_p is the bottom surface area of the test specimen in square metres (m^2).

5.2.4.5.3 Long-term water absorption by total immersion

Calculate the long-term water absorption by total immersion, W_{lt}, in volume percent using Formula (7) or (8):

Method 2A

$$W_{lt} = \frac{m_{28} - m_0}{V \rho_w} \tag{7}$$

Method 2B

$$W_{lt} = \frac{m_{28} - m_1}{V \rho_w} \tag{8}$$

where

m_0 is the initial mass of the test specimen as determined in Method 2A in kilograms (kg);

m_1 is the mass of the test specimen including the initial water uptake in Method 2B in kilograms (kg);

m_{28} is the mass of the test specimen after total immersion for 28 days in method 2A and 2B in kilograms (kg);

V is the initial volume of the test specimen in cubic metres (m^3);

ρ_w is the density of water, assumed to be 1 000 kg/m^3.

Method 2C

Calculate the water absorption after the immersion time of 28 days, W_{28}, in percent volume using Formula (9):

$$W_{28} = \frac{m_{28} + V_1 \rho_w - m_0 - m_1}{V_0 \rho_w} \quad (9)$$

where

m_0 is the initial mass of the test specimen in kilograms (kg);

m_1 is the mass of the empty cage immersed in kilograms (kg);

m_{28} is the mass of the test specimen and the cage submerged after 28 days of immersion in kilograms (kg);

V_0 is the initial volume of the test specimen in cubic metres (m^3);

V_1 is the volume of the test specimen after 28 days of immersion in cubic metres (m^3);

ρ_w is the density of water, assumed to be 1 000 kg/m^3.

5.2.4.6 Accuracy of measurement

Following the experience of a "round robin test" where comparable test equipment and test specimen preparation were used, the accuracy for long-term water absorption by partial immersion W_{ip} for Methods 1A and 1B, can be estimated as given below:

a) 95 % reproducibility limit for Method 1A: approximately 0,15 kg/m^2;

b) 95 % reproducibility limit for Method 1B: approximately 0,20 kg/m^2.

5.2.5 Moisture content

It shall be in accordance with ISO 12570.

5.2.6 Water vapor transmission properties

5.2.6.1 Principle

The test specimen is sealed to the open side of a test dish containing a desiccant or an aqueous saturated salt solution. The assembly is then placed in a test atmosphere whose temperature and humidity are controlled. Because of the difference between the partial water vapour pressures in the test assembly and in the test atmosphere, water vapour flows through the test specimen. Periodic weighings of the assembly are conducted to determine the rate of water vapour transmission when the steady state is reached.

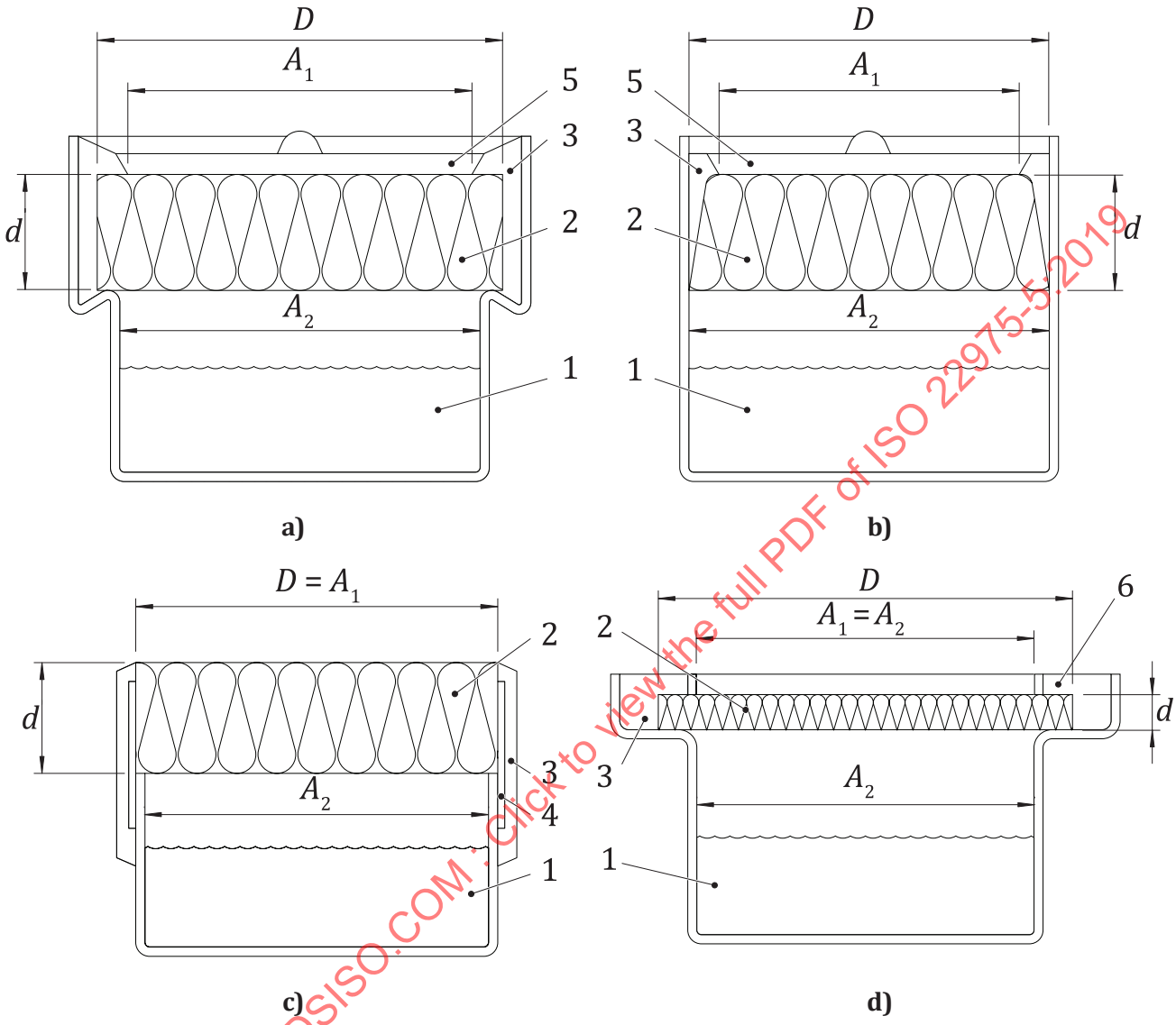
5.2.6.2 Apparatus

The apparatus for water vapour transmission properties testing and its related requirements are the following:

5.2.6.2.1 Test dishes

a) The examples of test dishes are shown in Figure 9. Test dishes, preferably of circular shape and which are (corrosion) resistant to any desiccant or to the salt solution which they may be required to contain and impermeable to water or water vapour.

b) These dishes are typically made of glass or metal. The size of the dishes depends on the size of the test specimen to be tested. The difference in size between the upper exposed area and the lower exposed area of the test specimen shall be less than 3 %.



Key

1 desiccant/aqueous saturated salt solution
2 test specimen
3 sealant
4 tape
5 template
6 limiting ring
A_1 upper exposed area
A_2 lower exposed area; the mean exposed area
D area of the test specimen
d thickness of the test specimen

Figure 9 — Examples of test assemblies

5.2.6.2.2 Measuring instruments

Measuring instruments, capable of determining linear dimensions in accordance with 5.2.1.

5.2.6.2.3 Template

a) Template (with edge tapered to facilitate removal after use) with a shape and size corresponding to that of the test dish to duplicate the exposed area of the specimen.

b) The template shall have an area that is at least 90 % of the test specimen's surface in order to limit the edge effect due to non-linear vapour flow.

5.2.6.2.4 Analytical balance

a) Analytical balance, capable of weighing the test assembly to an accuracy of ±1 mg or better.

b) If larger test assemblies are used, the weighing accuracy may be determined with respect to the total weight and the required accuracy of the test results.

5.2.6.2.5 Chamber

a) Chamber, capable of being maintained within ±3 % of the required relative humidity and within ±1 °C of the required temperature.

b) In order to maintain the required conditions throughout the chamber it may be necessary to use air circulation with an air speed of between 0,02 m/s to 0,3 m/s.

c) If a non-injection type humidity chamber is used, saturated salt solutions may then be used.

5.2.6.2.6 Sealant

a) Sealant, unaffected by test conditions.

b) The following are examples of suitable sealants:

1) Mixture of 90 % micro crystalline wax and 10 % of plasticiser (e.g. low molecular weight polyisobutylene).

2) 60 % micro crystalline wax with 40 % refined crystalline paraffin.

5.2.6.3 Sampling

5.2.6.3.1 Dimensions of test specimens

a) Shape and fit

The test specimens shall be representative of the product and shall include any natural surface skins or facings of different material(s).

If it is intended to measure the permeability of the core material, all skins and facings shall be removed and the test specimens shall have a thickness of at least 20 mm.

For faced and/or coated products with a water vapour diffusion resistance index $\mu \leq 3$, for the core material, the permeability may be determined from measurements made on the facing/coating itself, after separation from the product.

The test specimens shall be cut to correspond to the dimensions of the chosen test assembly (see examples in Figure 9).

b) Thickness of test specimens

The thickness of the test specimen shall be the thickness of the product. If this exceeds 100 mm, the specimen thickness may be reduced by cutting.

c) Exposed area

The exposed area A of the test specimen (arithmetic mean of the upper and lower exposed areas) shall be at least 50 cm^2. The diameter of circular test specimens or the equivalent diameter of rectangular test specimens (calculated from the area) shall be at least twice the test specimen thickness.

5.2.6.3.2 Number of test specimens

A minimum of five test specimens shall be tested. If the test specimen area is >500 cm^2, a minimum of three test specimens shall be tested.

If the test specimens have been cut, all pieces shall be tested.

If the product to be tested is suspected of being anisotropic, the test specimens shall be cut such that the parallel faces are normal to the direction of vapour flow of the product in its application.

If the product is faced with natural skins or adhered facing which are different for the two sides, the test specimens shall be tested with the vapour flow in the same direction as that in the intended use. If the direction of intended use relative to the facings is not known, a duplicate set of test specimens shall be prepared so that tests can be made and reported for each direction of vapour flow.

5.2.6.3.3 Conditioning of test specimens

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

5.2.6.4 Procedure

5.2.6.4.1 Test conditions

a) Select the test atmosphere from the three sets of conditions given in Table 3:

Table 3 — Test conditions

Set	Condition	Temperature °C	Relative humidity %	
			Dry state[a]	Humid state
A	23-0/50	23 ± 1	0	50 ± 3
B	23-0/85	23 ± 1	0	85 ± 3
C	23-50/93	23 ± 1	50 ± 3	93 ± 3

[a] A tolerance is not applied to the 0 % relative humidity condition because it is the condition deemed to be generated by the use of the desiccant.

b) For hygroscopic products the result depends on the set of conditions and both sets A and C should be used.

c) Other test conditions (temperature and relative humidity) can be agreed between the parties when needed to simulate special application conditions.

d) The following desiccants and saturated aqueous salt solutions may be used to produce the specified relative humidities at 23 °C; a large excess is necessary.

Desiccants	relative humidity, in %
1) P_2O_5 (phosphorus pentoxide):	0
2) $CaCl_2$ (calcium chloride), particle size: e.g. 2 mm to 8 mm:	0
3) $Mg(ClO_4)_2$ (magnesium perchlorate):	0
Aqueous salt solutions (saturated salt solutions in contact with a large content of undissolved salt)	relative humidity, in %
1) $Na_2Cr_2O_7 . 2H_2O$ (sodium dichromate):	52
2) KCl (potassium chloride):	85
3) $NH_4H_2PO_4$ (ammonium dihydrogen phosphate):	93
4) KNO_3 (potassium nitrate):	94

5.2.6.4.2 Test procedure

Monitor the test chamber to ensure that test conditions are kept constant.

Select a test assembly. Examples of suitable configurations are given in Figure 9.

Prepare test specimens in accordance with 5.2.6.3.

Measure the thickness of the test specimen to the nearest 0,2 mm, or to an accuracy of 0,5 %, whichever is the smaller.

Place the desiccant or the aqueous saturated salt solution at the bottom of each dish in a layer of appropriate thickness, with a minimum of 15 mm. Use melted wax to seal the test specimen to the open side of the dish. The air space between the desiccant and the test specimen shall be (15 ± 5) mm.

Condition the test assemblies in the test chamber for a period between 1 h and 24 h. Weigh the test assembly to the nearest milligram or in the case of larger assemblies with an accuracy depending on the total weight and the required accuracy of the test results.

Weigh the test assemblies at regular intervals of not less than 24 h. If the temperature of the room where the balance stands is within ±2 °C of the nominal test temperature, then test assemblies can be weighed either inside or outside of the test chamber.

If the measurement is made outside the chamber, return the test assemblies as soon as possible. Care shall be taken that the duration outside the chamber does not affect the result.

If the temperature of the balance is outside of the ±2 °C range, then the test assemblies shall be weighed in the test atmosphere.

Continue weighing until five successive determinations of change in mass per unit time for each test specimen are constant within ±5 % of the mean value for this test specimen (see 5.2.6.5.1). Plot a curve of change in mass against time to help recognise the condition of constant change (steady state).

5.2.6.5 Calculation and expression of results

5.2.6.5.1 Change in mass of test assembly

Calculate for each test specimen the change in mass for the selected time interval, $G_{1,2}$, in milligrams per hour using Formula (10):

$$G_{1,2} = \frac{m_2 - m_1}{t_2 - t_1} \tag{10}$$

where

m_1 is the mass of the test assembly at time t_1 in milligrams (mg);

m_2 is the mass of the test assembly at time t_2 in milligrams (mg);

t_1 and t_2 are successive times of weighings in hours (h).

Calculate G, the mean of five successive determinations of $G_{1,2}$, in milligrams per hour, for each test specimen.

The final value of G is obtained when each of the last five successive determinations of $G_{1,2}$ is within ±5 % of G.

5.2.6.5.2 Water vapour transmission rate

Calculate the water vapour transmission rate, g, in milligrams per square metre times hours using Formula (11):

$$g = \frac{G}{A} \tag{11}$$

where A is the exposed area (arithmetic mean of the upper and lower exposed areas) of the test specimen in square metres (m^2).

5.2.6.5.3 Water vapour permeance

Calculate the water vapour permeance, W, in milligrams per square metre times hours times pascals using Formula (12):

$$W = \frac{G}{A\,\Delta p} \tag{12}$$

where Δp is the water vapour pressure difference in pascal and has one of the following values, depending on the set of test conditions (see Table 3):

Test condition: 23-0/50 Δp = 1 400 Pa

23-0/85 Δp = 2 390 Pa

23-50/95 Δp = 1 210 Pa

5.2.6.5.4 Water vapour resistance

Calculate the water vapour resistance, Z, in square metres times hours times pascals per milligrams using Formula (13):

$$Z = \frac{1}{W} \tag{13}$$

5.2.6.5.5 Water vapour permeability

Calculate the water vapour permeability, δ, in milligrams per metre hours pascals using Formula (14):

$$\delta = Wd \tag{14}$$

where d is the test specimen thickness in metres (m).

5.2.6.5.6 Water vapour diffusion resistance factor

Calculate the water vapour diffusion resistance factor, μ, dimensionless using Formula (15):

$$\mu = \frac{\delta_{\text{air}}}{\delta} \tag{15}$$

where δ_{air} is the water vapour permeability of air [depending on the mean barometric pressure during the test, the calculation can be made by using Formulae (16) or (17) of Schirmer];

$$\delta_{\text{air}} = \frac{D}{R_{\text{D}} T} \tag{16}$$

$$\delta_{\text{air}} = \frac{0{,}083\, p_0}{R_{\text{D}} T p} \left(\frac{T}{273} \right)^{1{,}81} \tag{17}$$

where

D is the water vapour diffusion coefficient in square metres per hour (m^2/h);

R_{D} is the gas constant of water vapour: 462×10^{-8} Nm/(mg. K);

T is the test temperature in kelvins (K);

p is the mean barometric pressure during the test in hectopascals (hPa);

p_0 is the normal barometric pressure: 1 013,25 hPa.

NOTE The barometric pressure can be measured with a barometer or ascertained from a meteorological service.

Since the water vapour permeability of air and the material are assumed to depend equally on the barometric pressure, their quotient, the factor μ, can be considered independent from the barometric pressure. When calculating water vapour transmission rate at different locations, the actual barometric pressure may be taken into account using Formula (18):

$$g = \frac{\Delta p \delta_{\text{air}}}{\mu d} \tag{18}$$

5.2.6.5.7 Water vapour diffusion equivalent air layer thickness

Calculate the water vapour diffusion equivalent air layer thickness, S_d, in metres using Formulae (19) or (20):

$$S_d = \mu \times d \tag{19}$$

$$S_d = \delta_{\text{air}} \times Z \tag{20}$$

where d is the test specimen thickness in metres (m).

5.2.7 Thermal resistance and thermal conductivity

They shall be in accordance with ISO 8301.

5.2.8 The maximum use temperature

5.2.8.1 Principle

The criteria necessary to establish acceptable performance by any of the methods described shall be as provided in the material specification or as agreed upon between the purchaser and seller. For example, the specification of a maximum percent dimensional change as criterion for estimating the maximum use temperature.

Since soaking heat exposure seldom occurs under "as installed" conditions, and such exposure often produces misleading results, test specimens shall be conditioned using hot-face/cold-face methods. Limit soaking heat exposure to preliminary evaluation and quality control testing.

If required, testing shall begin at the hot-face temperature of the desired application or the maximum use temperature that is claimed. When there has been significant deterioration of the properties tested during or after exposure at the maximum hot-face temperature, additional specimens will be exposed at lower temperatures (third or quarter points of the temperature range from ambient to maximum) to establish the maximum hot-face temperature. Additional tests shall be made until enough data have been obtained to establish acceptable performance.

5.2.8.2 Apparatus

Two suitable types of heating plates for maximum use temperature testing are shown in Figure 10 and Figure 11.

a) The heating plate shall consist of a corrosion-resistant and heat-resistant plate with a preferred exposed test area of 900 mm by 450 mm, but having a minimum test area of 450 mm by 450 mm.

b) The heated area shall have an insulated, heated guard area having a minimum width of 75 mm around the entire periphery of the test area.

c) The plate shall be supported in a horizontal plane at a sufficient number of points to prevent sagging. It shall be heated on the under side by gas or electricity.

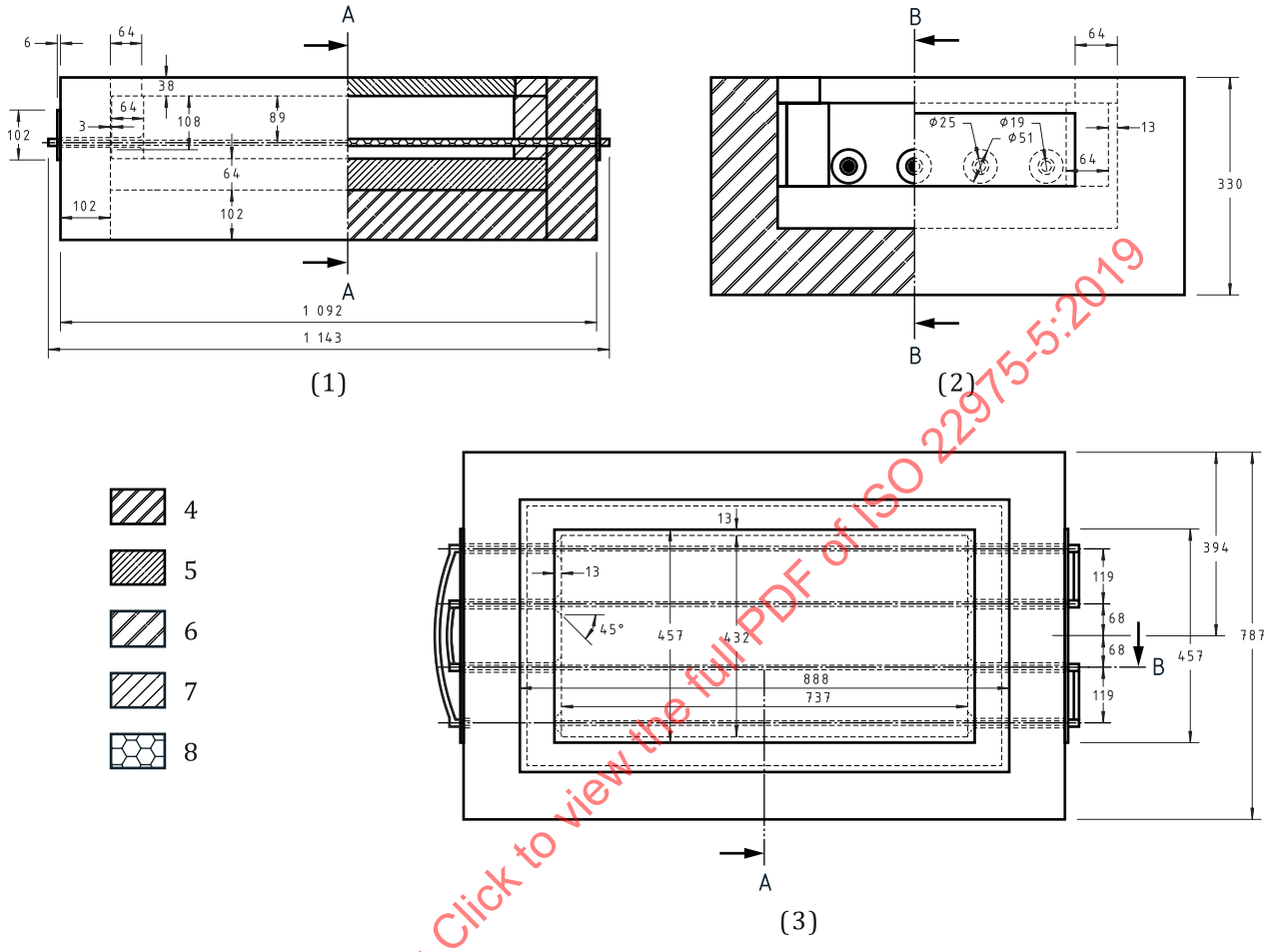
d) The surface temperature of the plate shall be measured by not less than five thermocouples. Four of the thermocouples shall be located along the diagonals that extend from the corners of the exposed area of the plate and at a distance of 150 mm from each corner. A fifth thermocouple shall be located near the centre of the test plate area.

e) The temperature at no point of measurement shall vary more than ±5 % or ±14 °C, whichever is less, from the desired temperature.

f) A heating chamber beneath the heating plate shall be formed to retain the heat generated by the heating means.

g) A 152 mm thickness of insulation shall form the bottom and the sides, and the heating plate shall form the top of the chamber.

Dimensions in millimetres

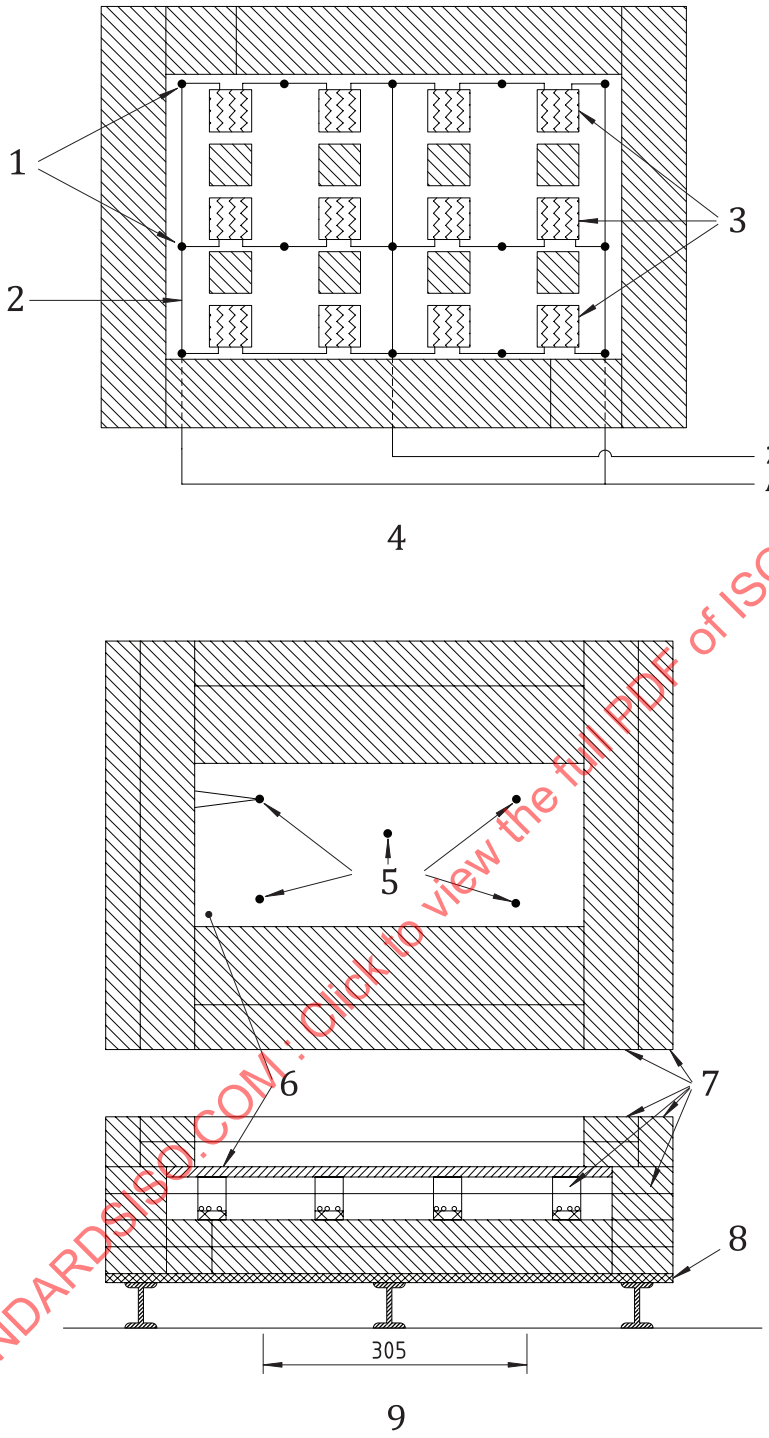


Key

1 side view
2 end view
3 top view
4 silicon carbide refractory plate
5 1 400 °C insulating brick
6 1 000 °C insulating block
7 6 mm asbestos — cement board
8 19 mm × 762 mm × 1 143 mm silicon carbide resistors
A cutaway view
B cutaway view

Figure 10 — Type A heating plate for hot-surface performance test

Dimensions in millimetres



Key

1	18-8 stainless steel connectors	6	hot plate 1 067 mm × 610 mm 4,8 mm No. 309 stainless steel
2	14-gauge nichrome lead wires	7	1 000 °C insulating block
3	600 W, 110 V, 21-gauge nichrome heating units	8	asbestos cement board
4	plan section (below hot plate)	9	plan section (above hot plate)
5	thermocouples		

NOTE Thermocouple leads to temperature controller.

Figure 11 — Type B heating plate for hot-surface performance test

5.2.8.3 Sampling

The test specimens shall be selected to be representative of the material under evaluation. Original surfaces shall be retained at least on the hot face of the specimens.

Where further fabrication of the specimen after exposure is not practical, additional specimens, pre-cut to the required size, shall be exposed separately.

All samples that are required to complete the tests shall be selected at one time and in such a manner so as to be fully representative of the average of the material. Test specimens for any one test condition shall be selected from the original sample lot so as to be as representative as possible. The test specimens shall be commercial pieces.

5.2.8.4 Procedure

The procedure for maximum use temperature of the specimen shall be as follows:

a) The thickness of the layers in multilayer insulation and the total thickness of insulation applied to the hot surface for a test shall be that recommended by the manufacturer for the temperature of the hot surface in question, or as agreed between the manufacturer and the purchaser. When multi-layer applications are to be tested, stagger each joint between adjacent test pieces in the same layer with respect to the joint in the next layer. Equally dispose about that joint the test piece in the next layer that covers a joint of the preceding layer.

b) Assembly of specimen on heating plate — specimens for testing on a heating plate shall be 150 mm by 450 mm with the thickness as described in 5.2.8.4 a). Check each block for flatness and measure and record any initial warpage. Cover the test area of the heating plate with the test blocks. If any blocks have initial warpage, place the concave face toward the hot side. Apply additional layers to the first layers when necessary to give the total required thickness.

c) The hot-face temperature shall be the service temperature being evaluated. Ambient conditions on the exposed surface of the test insulation shall be at room temperature. Start the test with the heating surface at room temperature. Follow the time-temperature recommendations of the manufacturer for heat-up. The average temperature rise shall not exceed 167 °C/h.

d) The cold-face temperature shall be representative of the intended application or a maximum of 93 °C.

e) During the heating period, make qualitative observations to detect visible evidence of flaming, glowing, smouldering and smoking. After the hot surface has reached the desired test temperature, begin a period of exposure of 96 h. At the completion of the test period, turn off the source of heat and allow the assembly to cool to about room temperature before any specimens are removed.

f) After test and prior to removal, examine the specimens very carefully to detect any tendency toward cracking. Note the number of cracks and the extent or depth of cracking. Also note any tendency toward delamination. Record other discernible changes, such as any evidence of melting, flaming, glowing, smouldering or smoking that can be observed by visual inspection.

5.2.8.5 Evaluation for maximum use temperature

The hot-face temperature shall be the service temperature being evaluated.

If, after testing specimens exposed to the maximum service temperature, additional tests are made of specimens exposed to intermediate temperatures (third or quarter points in the full service temperature range), the results of such tests, when plotted with proper curve-fit techniques, give indications of changes in product characteristics throughout the service range. These results are used to bracket the temperature range within which a change has occurred (for example, significant change in slope of curve).

5.2.9 Non-combustibility

It shall be in accordance with ISO 1182.

5.3 Outgassing of insulation materials in solar flat-plate collectors

5.3.1 General

This general method provides a laboratory method for the rating of outgassing of insulation materials. It is important and applicable for insulation manufacturers who want to supply their product to different collector manufacturers. Furthermore, the method is suitable to collector manufacturers for incoming goods quality control.

Representative test samples of the insulation material are used for testing. The test samples are heated up to a well-defined maximum temperature in a test apparatus as described in 5.3.2. The amount of outgassing is then checked and rated according to a clearly defined key.

5.3.2 Apparatus

The test device consists of a temperature-controlled heating plate, a metallic cylinder and a glass cover as illustrated in Figure 12.

Key

1 sample glass
2 aluminium disc
3 temperature sensor
4 heating plate
5 ventilation
6 upper polytetrafluoroethylene ring
7 ventilation
8 test cylinder
9 lower polytetrafluoroethylene ring

Figure 12 — Test device for laboratory testing of outgassing

a) A heating plate (a conventional cooking device is appropriate) to heat an aluminium disc of approximately 5 mm thickness. The heating plate shall be controlled by an electronic temperature controller.

b) In this aluminium disc, a PT100 temperature sensor is inserted using a borehole to measure the temperature in the centre of the disc. This temperature sensor is used to control the heating plate.

c) The temperature shall be controlled to a precision better than ±1 °K of the intended test temperature.

d) This aluminium disc simulates the hot absorber in a solar collector. The test sample will be placed directly on this disc to simulate direct contact with an absorber.

e) A metallic cylinder containing the test sample is placed on the aluminium disc. The metallic cylinder shall have an inner diameter of 100 mm, a height of 100 mm and a thickness of about 1 mm.

f) The outside of the cylinder shall be insulated with some EPDM foam of about 5 mm thickness to prevent excessive cooling of the device.

g) Two small ventilation holes (diameter 2 mm) are required to allow for a certain airflow through the test cylinder, one at the bottom and one at the upper end on the opposite side of the cylinder.

h) A clear glass sample for the assessment of the outgassing is placed on top of the cylinder. Two polytetrafluoroethylene rings of approximately 2 mm to 3 mm thickness are required to seal the test chamber on top and on the bottom.

i) It is essential that all materials used for the setup of the test device are resistant against solvents/cleaning detergents required to clean the whole apparatus. The modular setup of the test device allows for easy cleaning, furthermore, single parts of the device can be easily replaced if soiled to such an extent that they cannot be cleaned anymore.

j) The surrounding air humidity during the testing shall be in the range of 0,006 kg/kg_{Air} to 0,012 kg/kg_{Air}.

5.3.3 Sampling

The test specimens shall be selected to be representative of the material under evaluation and a minimum of two test specimens shall be selected.

The test specimens shall have a size of approximately 75 mm × 75 mm and a height of maximum 50 mm. If the material submitted for testing is less than 50 mm, it shall be tested as delivered. Materials with higher thickness shall be cut down to a maximum height of 50 mm. The test specimen is then cut 15 mm × 15 mm (in 45 degrees) at each corner to give an octagonal-like shape and placed directly on the aluminium disc (see Figure 13 and Figure 14). Care shall be taken that the specimen is not touching the test cylinder and that the ventilation holes are not closed by the test specimen.

If the material is covered with some fleece or aluminium foil, this side shall be placed towards the heating plate. Two test specimens, by preference taken from different production batches, shall be tested.

Figure 13 — Typical test specimen prepared for testing

Figure 14 — Test specimen placed on the aluminium disc

NOTE The black fleece is placed on the heating plate to simulate direct contact with a hot absorber.

5.3.4 Procedure

The specimens are heated up on one side, in accordance to real use. The surface temperature T_0 on the heated side of specimen is selected according to instructions of the customer. Recommended temperatures for standard flat plate collectors are 200 °C or more, and for flat plate collectors with AR glass and evacuated tube collectors, 220 °C or more. The test is thermostatically controlled, within a tolerance of ±1 °C.

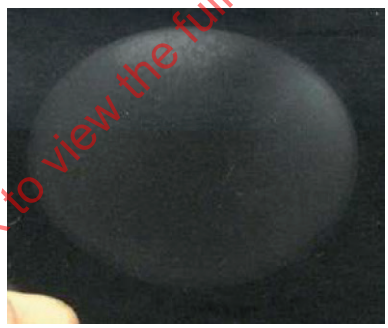
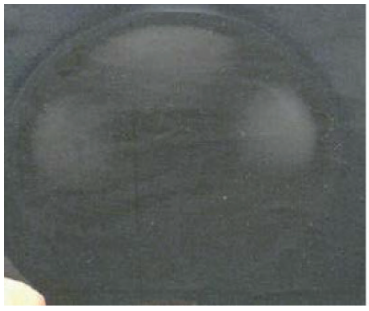
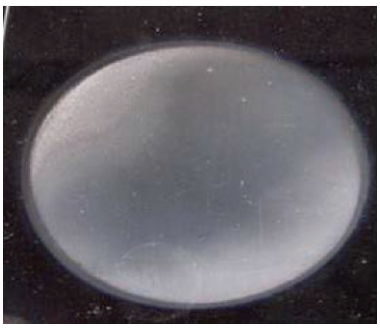
The test chamber shall be cleaned thoroughly. To check whether cleaning was successful, the device should be operated at the intended temperature without test specimen and without glass cover for at least one hour to make sure that possible outgassing on the test glass is not caused by some residuals of the cleaning process or, even worse, by remains of a precedent test of another product. The test device is then cooled to laboratory temperature and the test specimen is placed in the metallic container. The metallic container is covered with the cleaned sample glass. This glass is either clear glass or structured glass, depending on the intended test class. The heating plate is then heated up to the test temperature and then kept at this temperature for at least 150 h. Within one day after completion of the test cycle, the glass is inspected visually for deposits/outgassing and fogging. This inspection shall be done indoor by viewing the glass sample against a very dark, homogeneous and clean mat black surface (for example black felt or similar). The fogging shall be rated according to the key given in the examples. The result of the rating shall be indicated together with the picture in the test report. Pictures shall be taken to illustrate the amount of fogging. The test sample should also be compared to a new and clean glass. Gloves should be worn to avoid fingerprints.

If the insulation material is tested for the use with AR glass, the above described test method is applicable as well. The only difference is that the test glass shall be an AR treated glass. The AR side shall be placed facing downwards. In addition to the visual inspection, the solar transmission, τ_{sol}, of the glass shall be determined before and after the test procedure according to ISO 9050. The results shall be indicated in the test report, see Annex A.

5.3.5 Analysis and criteria

In every case, the condensation traps are checked visually by eye, and pictures are taken. Based on this, a classification falls into one of the four categories v1 to v4 (see Table 4).

Table 4 — Categories for visual classification of the condensation traps

Category	Description	Example of pictures	
v1	No visible condensate precipitation is to be expected		
v2	Only few visible condensate precipitation is to be expected		
v3	Markedly visible condensate precipitation is to be expected		
v4	Strong visible condensate precipitation is to be expected		

Before and after the exposition for the transmittance of the glass is measured by spectrometer. The resulting change of values decides the classification into one of four categoriest1 to t4 (see Table 5).

Table 5 — Change of transmittance of the condensation traps

Category	Change of the single value of τ_{sol}	Judgment
t1	Up to 0,003	Acceptable
t2	Up to 0,010	Acceptable
t3	Up to 0,015	Acceptable
t4	More than 0,015	Not acceptable

An insulation material is assumed acceptable for the use in solar collectors without creating troublesome amounts of fogging if both ratings of the visual inspection are between v1 and v3. If the material is to be used with AR treatment, the difference in solar transmission shall furthermore be less than or equal to 0,015 (i.e. $\tau_{sol,after} - \tau_{sol,before} \leq 0{,}015$). The test temperature is the maximum application temperature ϑ_{max}. If a material did not pass without outgassing, a maximum application temperature ϑ_{max} of 0 °C is assigned.

Annex A
(normative)

Test report for insulation material

A.1 General

The test report shall give the following information:

a) reference number of the insulation material;

b) test facility;

c) starting date and duration of the test;

d) address and correspondence of the test facility.

A.2 Description of insulation material

The description of insulation material shall give following information:

a) name of manufacturer;

b) name of brand;

c) name and other identification of the material tested;

d) production code number;

e) kind of insulation tested, sectional, segmental or block;

f) number of layers of insulation applied;

g) details of application;

h) year of production;

i) date and details of specimen preparation;

j) dimension of the specimens.

A.3 Test results for common and durability property of rigid polyurethane foam or phenolic foam

A.3.1 Common property test

A.3.1.1 Apparent density

The test results for apparent density shall include the following information:

a) the temperature and humidity at which the test specimens were conditioned;

b) the presence or absence of surface skins and whether skins were removed for testing;

c) the presence of densification, striations or other defects of the test specimens;

d) the individual test results, stating details of the test specimen shape, test specimen dimensions and the location from which they were taken;

e) the mean value of the density (apparent overall density or apparent core density) and the standard deviation;

f) whether any allowance was made for buoyancy and, if so, the size of the correction and details of the temperature, pressure and relative humidity of the ambient air during the test;

g) any deviation from the procedure specified in ISO 845.

A.3.1.2 Apparent volume percentage of open cells

The test results for apparent volume percentage of open cells shall include the following information:

a) the test method used for the determination of impenetrable volume V_i, i.e. Method 1 (pyknometer) or Method 2 (volume expansion);

b) the individual results and the mean values of the corrected volume percentage of open cells ω_0 and of closed cells ψ_0;

c) when applicable, the direction of the greatest dimension A of the test specimens in relation to any anisotropy of the material;

d) any deviation from the method specified;

e) all details necessary to identify the test facility.

A.3.2 Durability property test

A.3.2.1 Dimensional stability

The test results for dimensional stability shall include the following information:

a) the conditioning procedure used;

b) the test conditions employed;

c) for each exposure period, the individual percentage change in length, width and thickness of each test specimen after test;

d) for each exposure period, the average of the percentage changes in length, width and thickness after test;

e) for each exposure period, comments on any visual distortion of the test specimens;

f) any deviation, by agreement or otherwise, from the procedure specified.

A.3.2.2 Compression property

The test results for compression property shall include the following information:

a) the direction in which the force was applied in relation to anisotropy or product geometry;

b) the procedure (A or B) used;

c) the average of the test results, to three significant figures, expressed as:

   1) compressive strength σ_m and corresponding relative deformation ε_m, or

   2) compressive stress at 10 % relative deformation σ_{10}, or

