INTERNATIONAL STANDARD

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Rigid cellular plastics — Determination of water vapour transmission properties

Plastiques alvéolaires rigides — Détermination des caractéristiques de transmission de la vapeur d'eau

Reference number
ISO 1663:1999(E)

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 1663 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 10, *Cellular plastics*.

This second edition cancels and replaces the first edition (ISO 1663:1981), which has been technically revised.

Annex A forms a normative part of this International Standard. Annex B is for information only.

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Rigid cellular plastics — Determination of water vapour transmission properties

1 Scope

This International Standard specifies a method of determining the water vapour transmission rate, water vapour permeance, water vapour permeability and water vapour diffusion resistance index for rigid cellular plastics.

The scope of this method provides for the testing of rigid cellular materials that have thicknesses from 10 mm upwards and which may, as an integral part of the material, contain natural skins or adhered facings of some different material.

Three different sets of temperature and humidity conditions are provided, as follows:

a) 38 °C and a relative-humidity gradient of 0 % to 88 %;

b) 23 °C and a relative-humidity gradient of 0 % to 85 %;

c) 23 °C and a relative-humidity gradient of 0 % to 50 %.

The results obtained by this method are suitable for design purposes and production control, and for inclusion in product specifications.

The method is suitable for materials which have water vapour transmission rates in the range 3 mg/(m^2·s) to 200 mg/(m^2·s).

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 291:1997, *Plastics — Standard atmospheres for conditioning and testing.*

ISO 483:1988, *Plastics — Small enclosures for conditioning and testing using aqueous solutions to maintain relative humidity at constant value.*

ISO 1923:1981, *Cellular plastics and rubbers — Determination of linear dimensions.*

3 Terms and definitions

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

3.1
water vapour transmission rate
the quantity of water vapour transmitted through unit area of a test specimen in unit time under specified conditions of temperature, humidity and thickness

It is expressed in micrograms per square metre per second ($\mu g \cdot m^{-2} \cdot s^{-1}$).

NOTE The values obtained for water vapour transmission rate are specific to the thickness of the test specimen.

3.2
water vapour permeance
the ratio of the water vapour transmission rate for a test specimen to the vapour pressure difference between the two specimen faces during the test

It is expressed in nanograms per square metre per second per pascal ($ng \cdot m^{-2} \cdot s^{-1} \cdot Pa^{-1}$).

NOTE Water vapour permeance values are specific of the thickness at which the specimen was tested.

3.3
water vapour resistance
the inverse of water vapour permeance

3.4
water vapour permeability
the numerical value of the product of permeance and thickness

It is the quantity of water vapour transmitted per unit time through a given area of the material per unit vapour pressure difference between its faces for a unit thickness.

It is expressed in nanograms per metre per second per pascal ($ng \cdot m^{-1} \cdot s^{-1} \cdot Pa^{-1}$).

NOTE For homogeneous materials, values obtained for water vapour permeability are a property of the material.

3.5
water vapour diffusion resistance index
the ratio of the water vapour permeability of air to that of the material concerned

It indicates how much less permeable the material is than an equally thick layer of stationary air at the same temperature.

It is dimensionless.

NOTE For homogeneous materials, values obtained for water vapour diffusion resistance index are a property of the material.

4 Principle

The test specimen is sealed to the open mouth of a test dish containing a desiccant. The assembly is then placed in an atmosphere whose temperature and humidity are controlled. Periodic weighings of the assembly are made to determine the rate of water vapour transmission through the specimen into the desiccant.

5 Apparatus and materials

5.1 Shallow circular open containers, made of a material impermeable to water vapour, such as glass or metal, of 65 mm minimum diameter and with tops slightly belled out to admit a wax seal. See annex A for typical assemblies and 5.3 for assemblies requiring a template.

5.2 Measuring instruments, capable of determining linear dimensions in accordance with the requirements of ISO 1923.

5.3 Circular template (with edge tapered to facilitate removal after use), to duplicate the exposed area of the specimen to the nearest 0,1 cm^2. The template shall have an area that is at least 90 % of the exposed surface of the specimen in order to reduce the edge effect due to a non-linear vapour seal.

5.4 Pot or dish, for melting the sealant wax (5.8).

5.5 Analytical balance, capable of weighing the test assembly to an accuracy of 0,1 mg.

5.6 Constant-temperature, constant-humidity chamber, capable of being maintained within ± 2 % of the required relative humidity and within ± 1 °C of the required temperature, and with a provision for continuous monitoring of the temperature and humidity during the test period. The chamber may be a room. Alternatively, if the chamber corresponds to that shown in Figure 1, then the air circulation shall be capable of being switched off to permit accurate weighings.

NOTE If a conditioned room is used for the test, then it is not necessary to use the chamber shown in Figure 1.

5.7 The following solutions can be used with non-injection-type humidity cabinets:

5.7.1 For testing at 38 °C and a relative-humidity gradient of 0 % to 88 %: **saturated potassium nitrate solution** containing a large excess of the undissolved salt at 38 °C.

5.7.2 For testing at 23 °C and a relative-humidity gradient of 0 % to 85 %: **saturated chloride solution** containing a large excess of the undissolved salt at 23 °C.

NOTE 1 For testing at 23 °C and a relative-humidity gradient of 0 % to 50 %, there is no suitable salt which would meet the tolerance required by 8.1.

NOTE 2 For laboratories which do not have a suitable humidity chamber, the following solutions are suggested as alternatives, although the user should be aware that they do not comply with this International Standard:

a) a saturated aqueous solution of magnesium nitrate hexahydrate containing a large excess of the undissolved salt at 23 °C;

b) a saturated aqueous solution of sodium dichromate dihydrate containing a large excess of the undissolved salt at 23 °C.

More information about constant-humidity solutions may be found in ISO 483.

5.8 Sealant wax, unaffected by the test conditions. The following are examples of suitable sealants:

5.8.1 A mixture of 90 % microcrystalline wax and 10 % of a plasticizer (for example low-molecular-mass polyisobutylene).

5.8.2 A mixture of 60 % microcrystalline wax and 40 % refined crystalline paraffin.

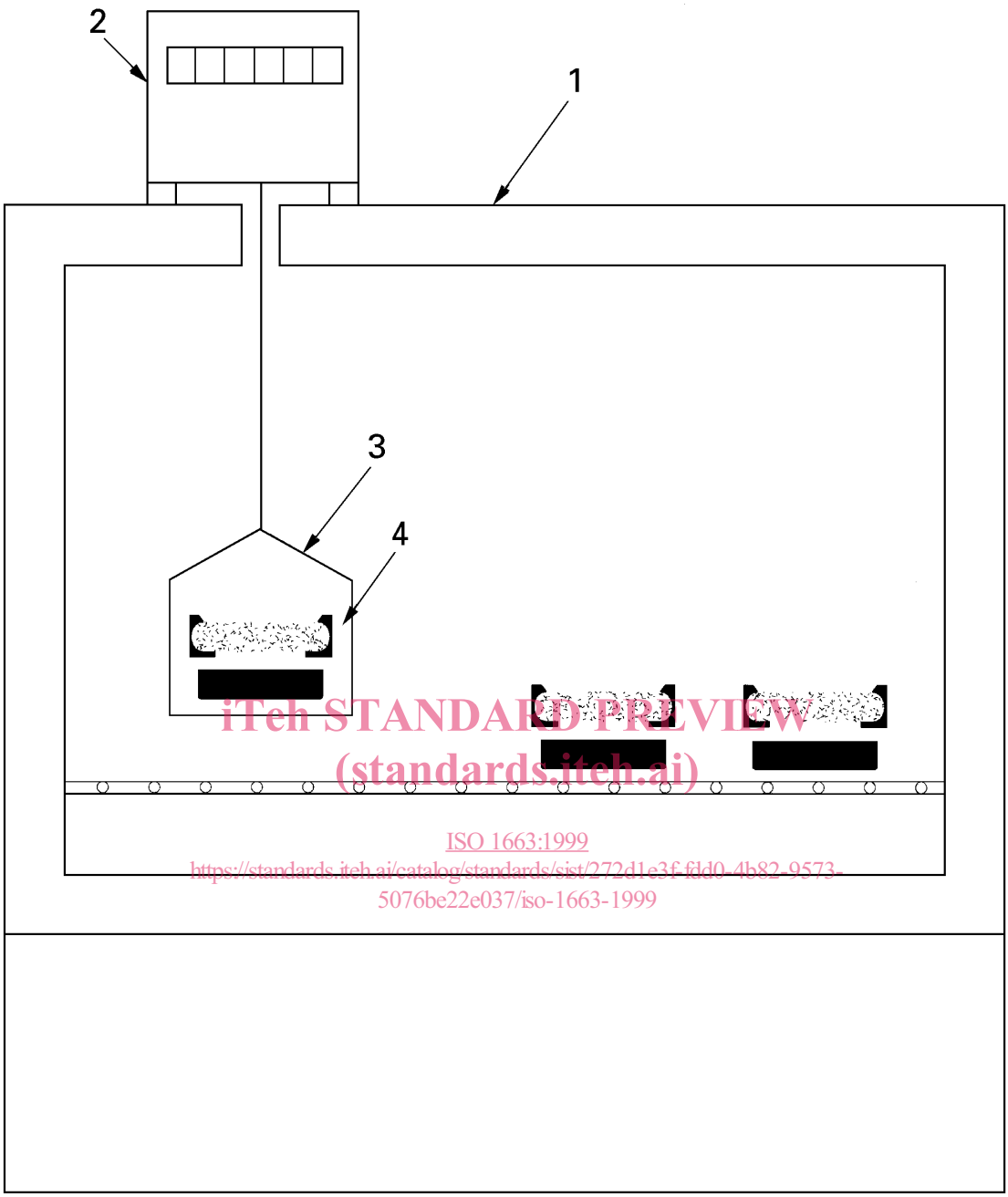
5.9 Anydrous calcium chloride desiccant, with particles about 5 mm in diameter, free from fines, which would pass a No. 30 (600 µm) sieve.

5.10 Limiting ring, for use with thin specimens (see Figure A.1).

6 Sample

The sample shall be representative of the material. It may contain the natural skin or facings adhered to it which constitute part of the material.

Some cellular plastics have skins of a density significantly different from that of the core material. If it is intended to determine the permeability of the material, the specimen shall be homogeneous and tested without the skin and facing.



Key

1 Controlled-environment test chamber with “glove box” type access door
2 Balance
3 Suspended weighing platform
4 Test assembly during weighing

Figure 1 — Recommended specimen exposure and measurement when operator cannot enter controlled environment

7 Test specimens

7.1 Dimensions

7.1.1 Shape and fit

Specimens shall be circular and cut to fit the dimensions of the test assembly in accordance with the appropriate drawing in Figure A.1.

7.1.2 Thickness

The thickness of specimens shall not be less than 10 mm, except for materials produced thinner than 10 mm which shall be tested at the manufactured thickness. A specimen thickness of 25 mm is preferred.

7.1.3 Exposed area

The diameter of specimens shall not be less than four times the specimen thickness. The minimum exposed area shall be 50 cm^2.

7.2 Number

A minimum of five specimens shall be tested.

When the material 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 through the product in its intended use.

When the material is faced with natural skins or adhered facings 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 vapour flow in the intended use is not known, a duplicate set of specimens shall be prepared so that tests can be made and reported for each direction of vapour flow.

7.3 Conditioning

For precise measurement, test specimens shall be conditioned in one of the atmospheres specified in ISO 291.

8 Procedure

8.1 Select the desired test environment from the three sets of conditions below:

a) (38 ± 1) °C and a relative-humidity gradient from 0 % to (88 ± 2) %;

b) (23 ± 1) °C and a relative-humidity gradient from 0 % to (85 ± 2) %;

c) (23 ± 1) °C and a relative-humidity gradient from 0 % to (50 ± 2) %;

NOTE A tolerance is not applied to the 0 % RH condition because it is the condition deemed to be generated by the use of the desiccant.

Because the values obtained under one set of test conditions may differ from the values obtained under a different set of conditions, the conditions selected shall be those most closely approaching the conditions of use.

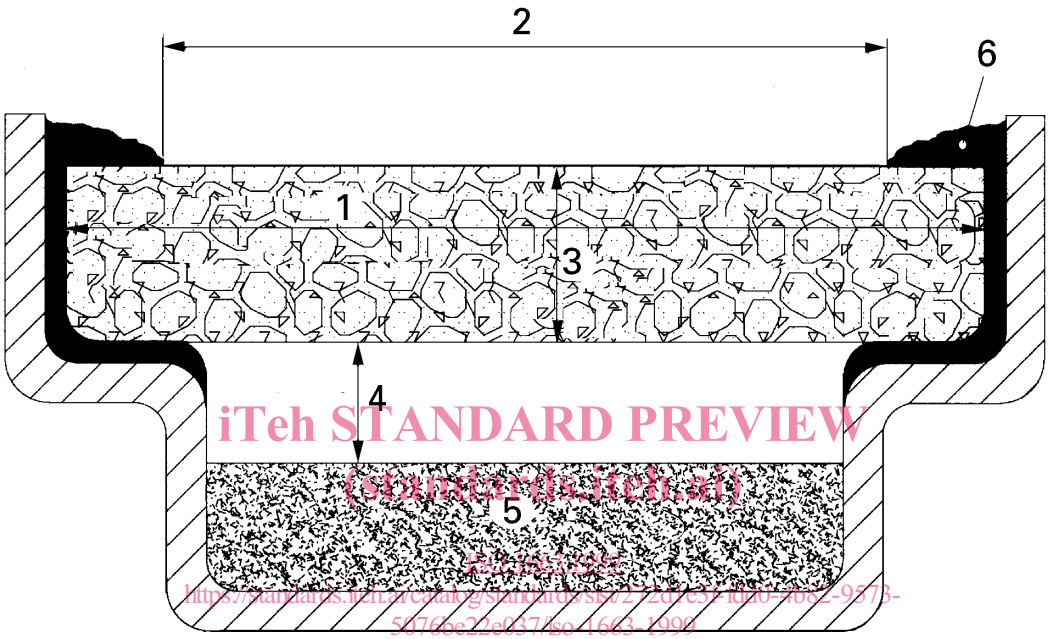
8.2 The environment in the test chamber (5.6) shall be monitored continuously and the temperature maintained within ± 2 °C of that of the test room.

8.3 Select a test assembly from the configurations given in Figure A.1.

8.4 Prepare circular test specimens such that they fit the selected test assembly configuration.

8.5 In accordance with ISO 1923, measure the thickness of the test specimens at each quadrant to the nearest 0,1 mm, or to an accuracy of 5 %, whichever is the more precise. Calculate the average result for each test specimen.

8.6 Place the desiccant (5.9) in a layer (20 ± 5) mm thick at the bottom of each container. Heat the sealant wax (5.8) in its container until liquid. Then follow the procedure in annex A which corresponds to the configuration selected. The air space between the desiccant and the specimen shall be (15 ± 5) mm. The diameter of the exposed area shall be at least 90 % of the diameter of the specimen. See Figure 2, which shows a typical test assembly.



Key

1 Specimen diameter d

2 Diameter of exposed area ($\geqslant 0{,}9\ d$)

3 Specimen thickness (>10 mm)

4 Air gap [width (15 ± 5) mm]

5 Desiccant [depth (20 ± 5) mm]

6 Sealant wax

Figure 2 — Typical test assembly

8.7 If it is intended to determine the water vapour diffusion resistance index, the atmospheric pressure shall be measured and recorded daily.

8.8 Condition each test assembly in the selected environment for a period of 24 h and weigh to the nearest 100 µg.

8.9 At regular intervals of 24 h, weigh each test assembly. If a test assembly is removed from the test environment for weighing, then it shall be returned to the test environment with a minimum delay.

8.10 Continue the weighings until five successive determinations of change in mass per unit time are constant, within ± 2 % of the mean value (see 9.1). A plot of mass change against time will indicate when the state of constant rate of change is reached.

9 Expression of results

9.1 Calculation of constant rate of change of mass

If $m_2 - m_1$ is the difference in mass between any two successive weighings of the test assembly, in µg,

and $t_2 - t_1$ is the time interval between two successive weighings of the test assembly, in h,

then $G_{12} = \frac{m_2 - m_1}{t_2 - t_1}$ = the change in mass per unit time for the two successive weighings, in µg/h.

Let G be the average of five successive values of G_{12}, in µg/h.

The test is completed when each of five successive values of G_{12} is within the range $0{,}980G - 1{,}020G$.

9.2 Calculation of water vapour transmission rate

The water vapour transmission rate g, in µg/(m^2·s), is given by the equation

$$g = \frac{G}{A} \times \frac{100}{36}$$

where A is the area of the side of the test specimen exposed to humidity, in cm^2.

9.3 Calculation of water vapour permeance

The water vapour permeance W_P, in ng/(m^2·s·Pa), is given by the equation

$$W_P = \frac{G}{AP} \times \frac{10^5}{36}$$

where P is the water vapour pressure difference, in pascals, and has one of the following values:

5 860 Pa at 38 °C and 0 to 88 % RH;

2 390 Pa at 23 °C and 0 to 85 % RH;

1 400 Pa at 23 °C and 0 to 50 % RH.

9.4 Calculation of water vapour permeability

The water vapour permeability δ, in ng/(m·s·Pa), is given by the equation

$$\delta = \frac{W_P \times s}{10^3}$$

where s is the specimen thickness, in mm.

9.5 Calculation of water vapour diffusion resistance index

Calculate the average daily atmospheric pressure for each period between weighings. Use these values to interpolate values for $\overline{H}$ (defined below) from Table 1.