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Hygrothermal performance of building materials and products — Determination of water vapour transmission properties — Cup method

Performance hygrothermique des matériaux et produits pour le bâtiment — Détermination des propriétés de transmission de la vapeur d'eau — Méthode de la coupelle

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Contents

Page

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).

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For an explanation on 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

ISO 12572 was prepared by the European Committee Standardization (CEN) Technical Committee CEN/TC 89, *Thermal performance of buildings and building components*, in collaboration with ISO Technical Committee ISO/TC 163, *Thermal performance and energy use in the built environment*, Subcommittee SC 1, *Test and measurement methods*, in accordance with the agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 12572:2001), which has been technically revised with the following changes:

— addition of insulation materials in the Scope;

— addition of e) humidity chamber in Clause 5;

— addition of requirements regarding thickness of test specimen to measure the permeability of core materials in 6.2.3;

— change of specimen area size in 6.3;

— addition of requirements for storage time and relative humidity for condition D in 6.4;

— new clause with requirements in 6.5;

— change of requirements for temperature and relative humidity for test conditions in 7.1;

— change of the calculation of mass change rate in 8.1;

— removal of 9.8.

Hygrothermal performance of building materials and products — Determination of water vapour transmission properties — Cup method

1 Scope

This document specifies a method based on cup tests for determining the water vapour permeance of building products and the water vapour permeability of building materials under isothermal conditions. Different sets of test conditions are specified.

The general principles are applicable to all hygroscopic and non-hygroscopic building materials and products, including insulation materials and including those with facings and integral skins. Annexes give details of test methods suitable for different material types.

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

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.

There are no normative references in this document.

3 Terms, definitions, symbols, units and subscripts

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 9346 and the following apply.

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

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

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

3.1.1
density of water vapour flow rate
mass of water vapour transferred through the specimen per area and per time

3.1.2
homogeneous material
material with properties likely to affect the transmission of water vapour which do not vary on a macroscopic scale

3.1.3
impermeable material
material with a measured *water vapour diffusion-equivalent air layer thickness* (3.1.8) greater than 1 500 m

3.1.4
water vapour permeance
density of water vapour flow rate (3.1.1) divided by the water vapour pressure difference between the two specimen faces

3.1.5
water vapour resistance
reciprocal of *water vapour permeance* (3.1.4)

3.1.6
water vapour permeability
product of the *water vapour permeance* (3.1.4) and the thickness of a homogeneous specimen

Note 1 to entry: Water vapour permeability can only be calculated for specimens of a *homogeneous material* (3.1.2).

3.1.7
water vapour resistance factor
water vapour permeability (3.1.6) of air divided by that of the material concerned

Note 1 to entry: The water vapour resistance factor indicates how much greater the resistance of the material is compared to an equally thick layer of stationary air at the same temperature.

3.1.8
water vapour diffusion-equivalent air layer thickness
thickness of a motionless air layer which has the same *water vapour resistance* (3.1.5) as the specimen

3.2 Symbols and units

Symbol	Quantity	Unit
A	area of specimen	m^2
G	water vapour flow rate through specimen	kg/s
R_v	gas constant for water vapour = 462	N·m/(kg·K)
S	hydraulic diameter of specimen	m
T	thermodynamic temperature	K
W_p	water vapour permeance with respect to partial vapour pressure	kg/(m²·s·Pa)
Z_p	water vapour resistance with respect to partial vapour pressure	m²·s·Pa/kg
d	mean thickness of specimen	m
g	density of water vapour flow rate	kg/(m²·s)
l	diameter of circle or side of square specimen	m
m	mass of specimen and cup assembly	kg
p	barometric pressure	hPa
p_0	standard barometric pressure = 1 013,25	hPa
S_d	water vapour diffusion-equivalent air layer thickness	m
t	time	s
Δp_v	water vapour pressure difference across specimen	Pa
δ_p	water vapour permeability	kg/(m·s·Pa)
δ_a	water vapour permeability of air	kg/(m·s·Pa)
μ	water vapour resistance factor	—
θ	celsius temperature	°C
φ	relative humidity	—

NOTE The above units comply with ISO 9346; a conversion table to other units commonly used in permeability measurements is given in Annex J.

3.3 Subscripts

Subscript	Denoting
I	interval
r	repeatability
a	air
c	corrected for air layer
f	film
j	joint
m	membrane
me	masked edge
s	specimen
t	total

4 Principle

The test specimen is sealed to the open side of a test cup containing either a desiccant (dry cup) or an aqueous saturated solution (wet cup). The assembly is then placed in a temperature and humidity controlled test chamber. Because of the different partial vapour pressure between the test cup and the chamber, a vapour flow occurs through permeable specimens. Periodic weighings of the assembly are made to determine the rate of water vapour transmission in the steady-state.

5 Apparatus

a) Test cups resistant to corrosion from the desiccant or salt solutions they contain; typically cups are made of glass or metal.

The design of cups suitable for testing various different types of materials is described in Annexes A to E.

NOTE Circular cups can be easier to seal and transparent cups allow better control of salt solutions.

b) For certain cups and sealing methods (see Annex A), a template, with shape and size corresponding to that of the test cup, is used when applying the sealant to give a sharply defined, reproducible test area. The template shall have an area of at least 90 % of the specimen to limit nonlinear vapour flow.

c) Measuring instruments capable of determining specimen thickness with accuracy required in 7.2.

d) Analytical balance, capable of weighing the test assembly with the repeatability needed for the required accuracy. Wherever possible, a balance of 0,001 g resolution shall be used. For heavy test assemblies, a balance resolution of 0,01 g may be sufficient (see Annex I for information linking the balance resolution to the duration of test).

NOTE The factors that affect the necessary accuracy of measurement are discussed in Annex I.

e) Constant temperature, constant humidity chamber, capable of being maintained within ±5 % relative humidity around the set point relative humidity and ±1,0 K around the set point temperature. In order to ensure uniform conditions throughout the chamber, the air shall be stirred so as to obtain velocities between 0,02 m/s and 0,3 m/s. If highly permeable materials are being tested, means should be provided to measure the air speed directly over the upper surface of the specimen (see Annex G).

f) Suitable sensors and a logging system to continuously record the temperature, relative humidity and, if necessary, the barometric pressure within the test chamber. The sensors shall be calibrated at regular intervals.

g) Sealant, which is impermeable to water vapour, does not undergo physical or chemical changes during the test and does not cause physical or chemical changes to the specimen.

NOTE Examples of sealants suitable for specific materials, if necessary, are listed in the appropriate Annex.

6 Test specimens

6.1 General principles for preparation of test specimens

The test specimens shall be representative of the product. If the product has natural skins or integral facings, these may be included in the test specimen, but they shall be removed if it is intended to measure the permeability of the core material. If the skins or facings are different on the two sides, specimens shall be tested with vapour flow in the direction of the intended use. If the direction of flow is not known, duplicate specimens shall be prepared and tests carried out for each direction of flow. Unless the product to be tested is isotropic, the test specimens shall be cut so that the parallel faces are normal to the direction of vapour flow of the product in use.

Specimen preparation shall not involve methods which damage the surface in ways which affect the flow of water vapour.

6.2 Dimensions of test specimens

6.2.1 Shape and fit

Test specimens shall be cut to correspond with the dimensions of the chosen test assembly (see Annexes A to E).

6.2.2 Exposed area

The diameter of a circular specimen or the side of a square specimen shall be at least twice the specimen thickness. The exposed area (the arithmetic mean of the upper and lower free surface areas) shall be at least 0,005 m^2. The upper and lower free surface areas shall not differ by more than 3 % of the mean in the case of homogeneous materials and by no more than 10 % in the case of other materials.

6.2.3 Thickness of test specimens

Whenever possible, the thickness of the specimen shall be that of the product in use. In the case of homogeneous materials, if the thickness exceeds 100 mm, this may be reduced by cutting. In the case of non-homogeneous materials, such as concrete containing aggregates, the thickness should be at least three times (and preferably five times) the largest particle size.

If a material contains macroscopic formed voids, the solid material should be tested and the resistance of the whole material calculated from the proportions of solid to air space assuming one dimensional vapour flow.

If it is necessary to test a product so thick that the available test cups do not have an area large enough to comply with 6.2.2, the product may, only as a last resort, be sliced. In this case, all slices shall be tested and the results reported.

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.

NOTE There is a risk that this procedure leads to significant inaccuracies, especially when wet cup tests are carried out on hygroscopic materials.

6.3 Number of test specimens

If the specimen area is less than 0,05 m^2, a minimum of five specimens shall be tested, otherwise a minimum of three specimens shall be tested.

6.4 Conditioning of test specimens

Before testing, the test specimens shall be stored at (23 ± 5) °C, (50 ± 5) % relative humidity for a period long enough for their weight to stabilize so that three successive daily determinations of their weight agree to within 5 %; a storage time of at least 6 h is necessary. If condition D in Table 1 is to be used, the specimens should be conditioned at (38 ± 5) °C, (50 ± 5) % relative humidity.

NOTE This period will vary from a few hours in the case of some insulating materials to three to four weeks, or more, for massive hygroscopic materials and products.

Wet field specimens may be dried before conditioning using the methods specified in ISO 12570.

A period of conditioning is not necessary in the case of plastic membranes.

6.5 Testing low resistance specimens

When testing low vapour resistance specimens with Sd < 0,1 m, use a wet cup, with distilled water in the cup, giving a relative humidity of 100 % in the cup. The high flow rate through the specimen prevents the occurrence of condensation on the underside of the specimen that is a risk with higher resistance specimens. In this case, the size of the air gap between the water in the cup and the base of the specimen shall be known to the nearest mm, and it is essential to maintain sufficient airspeed over the top surface of the specimen (see Annex G).

NOTE Testing low vapour resistance specimens, with Sd < 0,1 m, can be difficult with either a wet cup or a dry cup, because the water flow out of or into the cup can be large enough to affect the performance of the saturated salt solution or desiccant before the test is complete. It is not therefore possible to carry out "dry cup"" tests with this type of material.

7 Procedure

7.1 Test conditions

Select the desired test environment from the conditions given in Table 1.

Table 1 — Test conditions

Set	Condition °C - % RH	Tolerances				
		Temperature °C	Relative humidity[a] %			
			Dry state		Wet state	
			Set point	Tolerance	Set point	Tolerance
A	23 – 0/50	23 ± 1	0	+5	50	±5
B	23 – 0/85	23 ± 1	0	+5	85	±5
C	23 – 50/93	23 ± 1	50	±5	93	±5
D	38 – 0/93	38 ± 1	0	+5	93	±3
E	23 – 50/100	23 ± 1	50	±5	100	

NOTE 1 "Dry cup" tests (condition A) give information about the performance of materials at low humidities when moisture transfer is dominated by vapour diffusion. "Wet cup" tests (condition C) give guidance about the performance of materials under high humidity conditions. At higher humidities, the material pores start to fill with water; this increases the transport of liquid water and reduces vapour transport. Tests in this area therefore give some information about liquid water transport within materials. This is discussed further in ISO 15148.

NOTE 2 Condition E is used for low resistance specimens ($S_d \leq 0{,}1$ m).

[a] Saturated salt solutions, which regulate the relative humidity in the cup at some value less than 100 %, are used because, with many materials, there is a danger of condensation occurring on the underside of the sample, which disrupts the vapour flow. In the case of very low resistance materials with Sd < 0,1 m, the vapour flow rates are so high that a) condensation is unlikely and b) the saturated salt solution might not remain in equilibrium for the duration of the test. In this case, that distilled water should be used in the test cup. Further information about the use of saturated salt solutions is given in 9.6.

Other sets of temperature and relative humidity may be agreed between the parties when needed for special application conditions.

EXAMPLE 1 This is an example of desiccants which produce the specified air relative humidities at 23 °C.

Desiccants

Calcium chloride, $CaCl_2$ - particle size < 3 mm	0 %
Magnesium perchlorate, $Mg(ClO_4)_2$	0 %
Phosphorus pentoxide, P_2O_5	0 %
Silicagel	0 %

EXAMPLE 2 This is an example of saturated aqueous solutions which produce the specified air relative humidities at 23 °C.

Aqueous solutions

Sodium dichromate, $Na_2Cr_2O_7 \cdot 2H_2O$	52 %
Magnesium nitrate, $Mg(NO_3)_2$	53 %
Potassium chloride, KCl	85 %
Ammonium dihydrogen phosphate, $NH_4H_2PO_4$	93 %
Potassium nitrate, KNO_3	94 %

Further details of suitable solutions can be found in ISO 12571:2013, Annexes A and B.

Regular checks shall be made, especially during long tests, to ensure that saturated solutions remain as a mixture of liquid with a large amount of undissolved substance.