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Hygrothermal performance of building materials and products — Determination of hygroscopic sorption properties

*Performance hygrothermique des matériaux et produits pour le
bâtiment — Détermination des propriétés de sorption hygroscopique*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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

This third edition cancels and replaces the second edition (ISO 12571:2013), which has been technically revised.

The main changes compared to the previous edition are as follows:

- [Table A.1](#) was revised.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Hygrothermal performance of building materials and products — Determination of hygroscopic sorption properties

1 Scope

This document specifies two alternative methods for determining hygroscopic sorption properties of porous building materials and products:

- a) using desiccators and weighing cups (desiccator method);
- b) using a climatic chamber (climatic chamber method).

The desiccator method is the reference method.

This document does not specify the method for sampling.

The methods specified in this document can be used to determine the moisture content of a sample in equilibrium with air at a specific temperature and humidity.

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 9346, *Hygrothermal performance of buildings and building materials — Physical quantities for mass transfer — Vocabulary*

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

3 Terms and definitions, symbols and units

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:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1 Terms and definitions

3.1.1

equilibrium moisture content

moisture content of a porous material in equilibrium with the environment and the relative humidity of the ambient air, at a specified temperature

3.1.2

moisture content mass by mass

mass of evaporable water divided by mass of dry material

3.1.3

moisture content volume by volume

volume of evaporable water divided by volume of dry material

3.1.4

moisture content mass by volume

mass of evaporable water divided by volume of dry material

Note 1 to entry: The mass of water is determined by weighing the specimen before and after drying at the appropriate drying temperature until constant mass is reached.

3.1.5

sorption curve

curve established at a series of increasing equilibrium relative humidities at a given temperature

3.1.6

desorption curve

curve established at a series of decreasing equilibrium relative humidities at a given temperature

3.2 Symbols and units

Symbol	Quantity	Unit
m	mass of test specimen	kg
m_0	mass of dried test specimen	kg
u	moisture content mass by mass	kg/kg
ψ	moisture content volume by volume	m^3/m^3
w	moisture content mass by volume	kg/m^3

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4 Principle

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4.1 Sorption curve

The specimen is dried to constant mass. While maintaining a constant temperature, the specimen is placed consecutively in a series of test environments, with relative humidity increasing in stages. The moisture content is determined when equilibrium with each environment is reached. At this point, a uniform moisture distribution in the sample is assumed. Equilibrium with the environment is established by weighing the specimen until constant mass is reached. A minimum of four test atmospheres shall be selected in the humidity range under consideration.

After establishing the moisture content at each relative humidity, the sorption curve can be drawn.

4.2 Desorption curve

The starting point for desorption is a relative humidity of at least 95 %. See 7.2.3 for the procedure to define a consistent initial condition. While maintaining a constant temperature, the specimen is placed consecutively in a series of test environments, with relative humidity decreasing in stages. The moisture content is determined when equilibrium with each environment is reached. Equilibrium with the environment is established by weighing the specimen until constant mass is reached. A minimum of four test atmospheres shall be selected in the humidity range under consideration. Finally, the specimen is dried to constant mass.

After establishing the moisture content at each relative humidity, the desorption curve can be drawn.

5 Apparatus

5.1 Desiccator method

The test apparatus shall include:

- a) **weighing cups**, which do not absorb water and with tight-fitting lids;
- b) **balance**, capable of weighing to an accuracy of $\pm 0,01$ % of the mass of the test specimen;

NOTE If larger weighing cups are used, the weighing accuracy can be determined with respect to the total mass and the required accuracy of the test results.
- c) **drying oven**, in accordance with ISO 12570;
- d) **desiccator**, capable of maintaining the relative humidity within ± 2 % relative humidity;
- e) **constant-temperature chamber**, capable of maintaining the specified test temperature to an accuracy of $\pm 0,5$ K.

5.2 Climatic chamber method

The test apparatus shall include:

- a) **weighing cups**, which do not absorb water;
- b) **balance**, capable of weighing to an accuracy of $\pm 0,01$ % of the mass of the test specimen;

NOTE If larger weighing cups are used, the weighing accuracy can be determined with respect to the total mass and the required accuracy of the test results.
- c) **drying oven**, in accordance with ISO 12570;
- d) **climatic chamber**, capable of maintaining the relative humidity within ± 5 % relative humidity and the temperature within ± 2 K over the whole test area.

6 Test specimens

6.1 Specification of the test specimens

A test specimen shall be representative of the product and have a mass of at least 10 g. Specimens of materials with a dry density less than 300 kg/m^3 shall have an area of at least $100 \text{ mm} \times 100 \text{ mm}$. And the selected sample size shall take into account any heterogeneity of the materials. If it can be demonstrated from other references that the result will not be affected, a test specimen may be cut or crushed into smaller pieces to reduce the time to reach equilibrium with the environment.

6.2 Number of test specimens

A minimum of three specimens shall be tested. The procedure in [Clause 7](#) shall be applied to each specimen.

7 Procedure

7.1 Test conditions

Reference sorption curves shall be established at a temperature of $(23 \pm 0,5) ^\circ\text{C}$ or $(27 \pm 0,5) ^\circ\text{C}$ in tropical countries. If agreed between the parties, sorption curves can be established at other temperatures for specific applications.

7.2 Desiccator method

7.2.1 General

Make up the appropriate saturated aqueous solution to achieve the necessary relative humidity in the desiccator.

Standard air relative humidities to be selected for measuring sorption curves are shown in [Table 1](#). Choose five or more conditions that include No.2, No.4 and No.6 in [Table 1](#).

NOTE [Annex A](#) gives the air relative humidities of various saturated solutions in equilibrium, and [Annex B](#) describes the preparation of various solutions.

Place the desiccator in the constant-temperature chamber (see [Figure 1](#)). The depth of saturated aqueous solution shall be 30 mm to 50 mm.

Table 1 — Standard air relative humidities above saturated solutions in equilibrium

No.	Substance	Relative humidity (%) ^a	
1	KOH	9	8
2	MgCl ₂ ·6H ₂ O	33	33
3	Mg(NO ₃) ₂ ·6H ₂ O	53	52
4	NaCl	75	75
5	KCl	85	84
6	KNO ₃	94	93
7	K ₂ SO ₄	97	97

^a Relative humidities are calculated by rounding off the values in [Table A.1](#). The left column corresponds to air temperature 23 °C. The right column corresponds to air temperature 27 °C.

7.2.2 Sorption curve

Weigh the weighing cup and lid when empty and dry. Put the test specimen into the weighing cup without the lid and dry it until it has reached constant mass in the drying oven at the temperature specified in ISO 12570.

Constant mass is reached if the change of mass between three consecutive weighings, each made at least 24 h apart, differs by less than 0,1 % of the total mass.

Put the test specimen in the weighing cup, with the lid beside it, into the desiccator containing the salt solution needed to give the appropriate relative humidity.

Periodically weigh the specimen until it is in equilibrium with the environment (constant mass). Immediately after removing the lid of the desiccator, put on the lid of the weighing cup, and move the weighing cup to the balance. After weighing the cup, return it to the desiccator with the lid beside it.

NOTE 1 [Annex C](#) gives an example of a detailed weighing procedure.

Repeat the procedure for increasing humidities. A minimum of four approximately evenly spaced humidities in increasing order shall be selected in the range of 30 % to 95 % relative humidity.

NOTE 2 It is possible that mould and mildew can grow on specimens of wood-based materials in atmospheres with relative humidities over 80 %. This can invalidate the test and can be prevented by adding a few drops of an appropriate fungicide to the solution.

7.2.3 Desorption curve

The starting point for desorption is a relative humidity of at least 95 %. This can be the last point of the sorption curve or it can be reached by sorption from the dried test specimen.

Reaching hygroscopic saturation by adsorption as a starting point for the desorption assumes there is little or no hysteresis of the adsorption and desorption processes. Also, it is possible that a uniform moisture distribution as expected by the desorption experiment is not reached at the end of adsorption, which can take very long for some materials. Hence, the alternative procedure described below can be used to accelerate the initial condition process. It is recommended for hysteretic materials.

An alternative procedure to obtain a consistent initial condition for the desorption experiment is the use of a pressure-plate apparatus [12]. A moisture-saturated specimen is desorbed at the highest pressure (recommended 11 000 Pa). The resulting moisture content will be already close to hygroscopic saturation and fairly uniform. The remaining access moisture is removed by placing the specimen into the desiccator at the highest possible relative humidity (preferably at 97 %). When three consecutive weighings no longer show weight reduction, the initial condition for the desorption has been reached. This procedure will generally yield a better reproducibility of the results, especially for hysteretic materials.

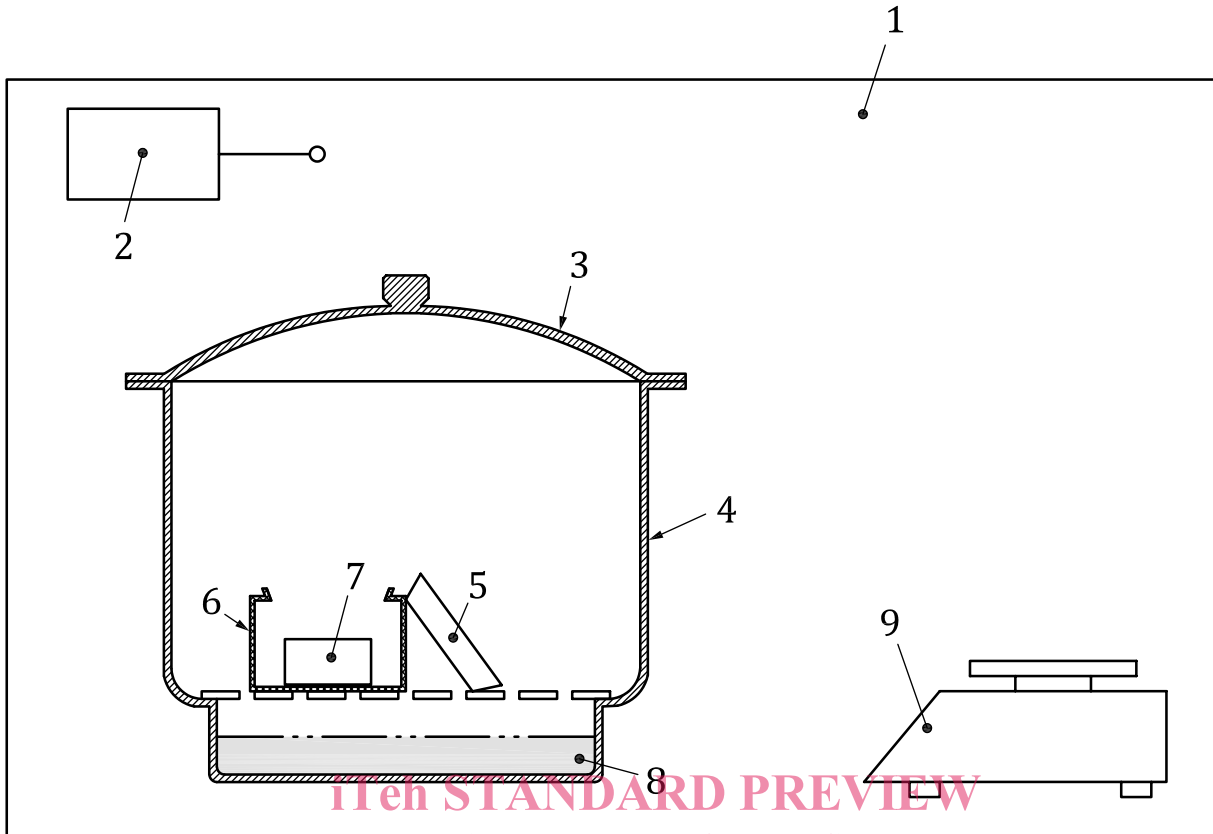
Put the test specimen in the weighing cup, with the lid beside it, into the desiccator containing the solution needed to give the appropriate relative humidity.

Periodically weigh the specimen until it is in equilibrium with the environment (constant mass). Immediately after removing the lid of the desiccator, put on the lid of the weighing cup, and move the weighing cup to the balance. After weighing the cup, return it to the desiccator with the lid beside it. Constant mass is reached if the change of mass between three consecutive weighings, each made at least 24 h apart, is less than 0,1 % of the total mass.

NOTE 1 [Annex C](#) gives an example of a detailed weighing procedure.

Repeat the procedure for decreasing humidities. A minimum of four approximately evenly spaced humidities in decreasing order shall be selected in the range of 95 % to 30 % relative humidity.

NOTE 2 [Annex D](#) gives an example of the method using a glass jar.



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Key

- 1 constant temperature chamber
- 2 thermometer
- 3 lid of desiccator
- 4 desiccator
- 5 lid of weighing cup
- 6 weighing cup
- 7 test specimen
- 8 saturated salt solution
- 9 electronic balance

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Figure 1 — Desiccator method

7.3 Climatic chamber method

7.3.1 Sorption curve

Put the test specimen, if necessary, in the weighing cup, in the drying oven and dry it until it has reached constant mass at the temperature specified in ISO 12570. Constant mass is reached if the change of mass between three consecutive weighings, each made at least 24 h apart, is less than 0,1 % of the total mass.

Put the test specimen in the climatic chamber. At first the humidity in the climatic chamber is the lowest of the range of values chosen for the test (see below).

Periodically weigh the specimen in the climatic chamber until it is in equilibrium with the environment (constant mass).

Repeat the procedure for increasing humidities. A minimum of four approximately evenly spaced humidities in increasing order shall be selected in the range of 30 % to 95 % relative humidity.

7.3.2 Desorption curve

The starting point for desorption is at a relative humidity of at least 95 %. This can be the last point of the sorption curve or can be reached by sorption from dried test specimen.

Put the test specimen, if necessary, in the weighing cup, in the climatic chamber.

Periodically weigh the specimen in the climatic chamber until it is in equilibrium with the environment (constant mass). Constant mass is reached if the change of mass between three consecutive weighings, each made 24 h apart, is less than 0,1 % of the total mass.

Repeat the procedure for decreasing humidities. A minimum of four approximately evenly spaced humidities in decreasing order shall be selected in the range of 95 % to 30 % relative humidity.

8 Calculation and expression of results

8.1 Hygroscopic sorption

The moisture content, u , is calculated in [Formula \(1\)](#) as follows for each specimen:

$$u = \frac{m - m_0}{m_0} \quad (1)$$

For the sorption curve or for the desorption curve, take the mean of the calculated moisture contents for a minimum of three specimens at each relative humidity.

After calculation of the mean moisture content of the various test specimens at each relative humidity, the sorption and desorption curves can be drawn by joining the data points with straight lines.

NOTE Curve fitting techniques can be used to fit functional relations to the data; see the references in [Annex D](#) for further information.

ISO 12570 gives methods for converting the values of u calculated from [Formula \(1\)](#) into the moisture content volume by volume ψ or moisture content mass by volume w .

8.2 Equilibrium moisture content curves

The sorption curve and the desorption curve are respectively drawn by using four or more air relative humidity conditions.