
**Hygrothermal performance of
building materials and products —
Determination of moisture
adsorption/desorption properties
in response to periodic temperature
variation**

*Performance hygrothermique des matériaux et produits pour le
bâtiment — Détermination des propriétés d'adsorption/désorption de
l'humidité en réponse à une fluctuation périodique de la température*

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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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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 163, *Thermal performance and energy use in the built environment*, Subcommittee SC 1, *Test and measurement methods*.

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 moisture adsorption/desorption properties in response to periodic temperature variation

1 Scope

This document specifies the test method of moisture-adsorption/desorption efficiency (or capacity) of building materials, when there are changes in temperature in sealed boxes containing building materials.

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*

3 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:

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

3.1

moisture-adsorption/desorption amount

amount of moisture which is adsorbed in or desorbed from materials in a moisture-adsorption/desorption process, calculated as:

$$m = m_4 \cdot V / A$$

$$m_4 = (\sum |v - \bar{v}|) / (\sum |\theta - \bar{\theta}|)$$

4 Specimen

A specimen shall be extracted from the test product. The size, the thickness, and the number of sheets shall be as follows.

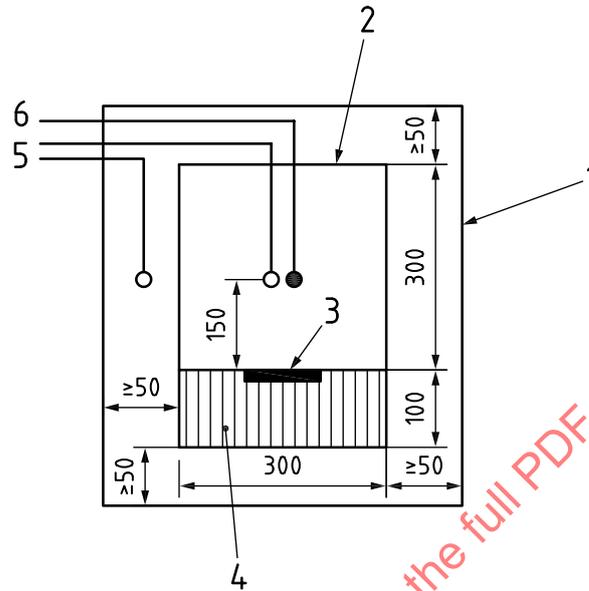
- a) Size: the standard size of the specimen shall be 100 mm x 100 mm.
- b) Thickness: the thickness shall, as a rule, be the thickness of the product. However, the upper limit of thickness is 20 mm.
- c) The number of sheets: the number of sheets shall, as a rule, be one for each test condition.

5 Test apparatus

5.1 General

A test apparatus shall be principally comprised of a sealed box, a box or chamber with thermostat, a thermometer and a hygrometer, and be constructed as given in [Figure 1](#).

Dimension in millimetres



Key

- 1 chamber
- 2 sealed box
- 3 specimen
- 4 thermal insulation
- 5 thermometer
- 6 hygrometer

Figure 1 — Apparatus

5.2 Sealed box

A sealed box shall have dimensions as given in [Figure 2](#) when dimensions of the specimen are 100 mm x 100 mm, and shall be comprised of a container for storing a specimen, the packing for keeping airtightness, and shall conform to the following:

- a) The material of a container and a cover shall be non-hygroscopic and non-permeable.
- b) The volume of the container shall conform to the following conditions:

$$V / A = 2,7 \text{ m}^3 \cdot \text{m}^{-2}$$

where

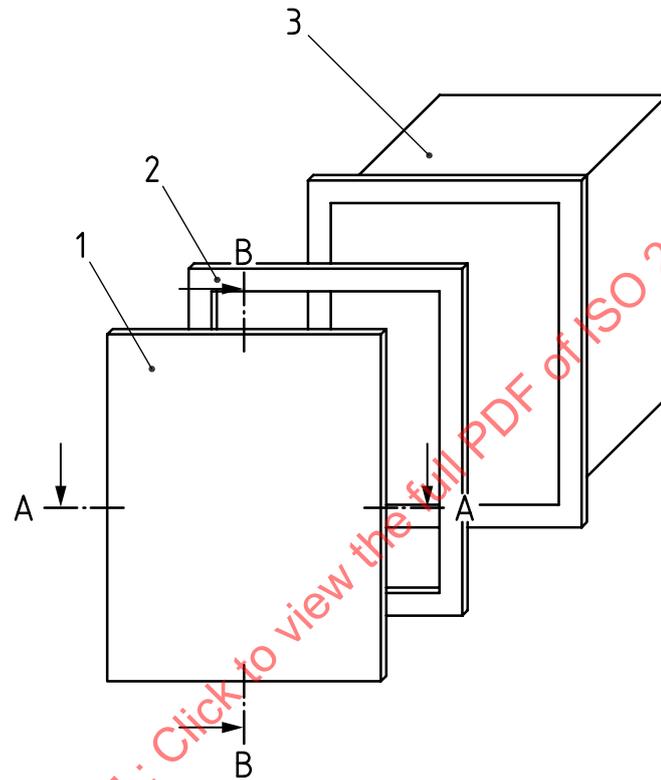
V is the volume of space in the sealed box (m^3);

A is the moisture-adsorption/desorption area of the specimen (m^2).

NOTE When the moisture-adsorption/desorption area is 100 mm x 100 mm, the inside dimensions are 300 mm x 300 mm x 400 mm as given in [Figure 2](#).

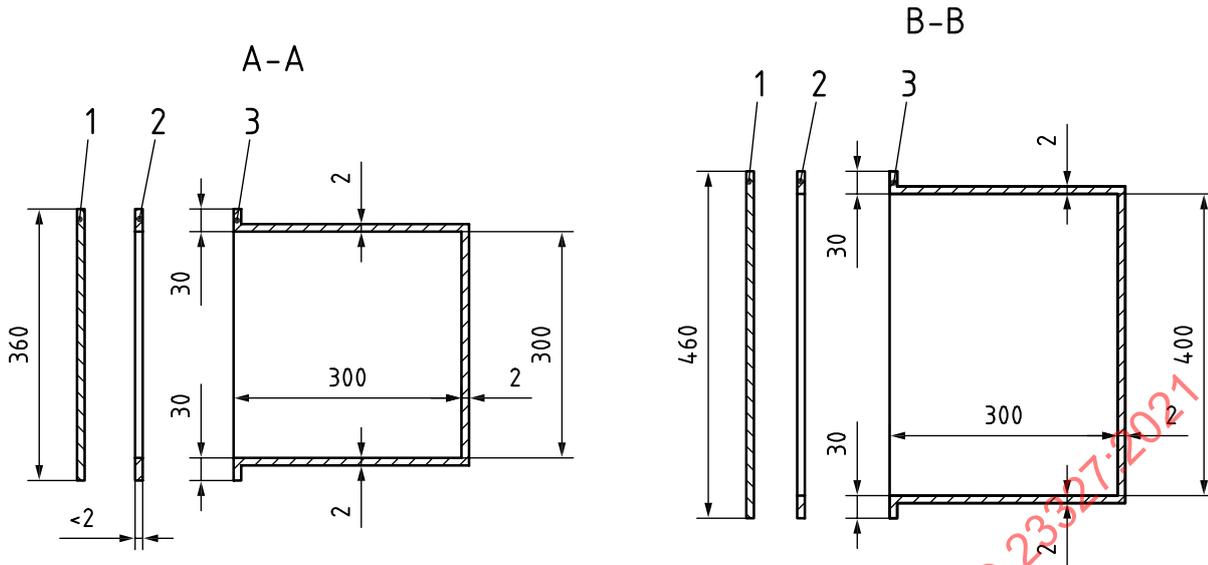
- c) The temperature and humidity in a sealed box are measured 150 mm above the upper surface of a specimen.
- d) The sealed box shall be as airtight as possible, and the amount of water vapour leakage from the sealed box shall be less than or equal to the value specified in [Clause 8](#).

Dimensions in millimetres



a) Projection drawing

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b) Cross-section drawing

Key

- 1 cover
- 2 packing
- 3 container

Figure 2 — Sealed box

5.3 Box or chamber with thermostat

A box or chamber with thermostat shall be maintained at a prescribed temperature and shall conform to the following conditions:

- a) The size of the box or chamber shall be sufficiently large for housing a sealed box.
- b) The temperature in the box or chamber with thermostat shall be measured at a position approximately 20 mm apart from the centre of a side surface of the sealed box, and is able to be kept constant within $\pm 0,5$ °C of the set temperature.
- c) The box or chamber with thermostat shall have a temperature control device providing automatic temperature variation.

5.4 Thermometer

The thermometer shall have a precision of $\pm 0,1$ °C.

5.5 Hygrometer

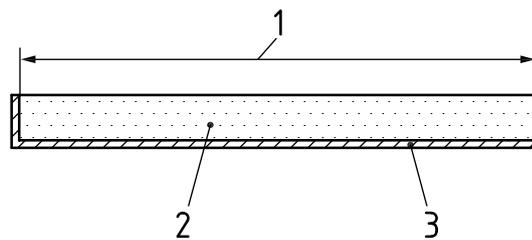
The hygrometer shall have a precision of ± 2 %.

6 Curing and thermal insulation of specimen

6.1 Damp-proofing of specimen

The side surface of a specimen shall be damp-proofed as given in [Figure 3](#).

Dimensions in millimetres

**Key**

- 1 moisture adsorption/desorption area (100 × 100) mm
- 2 specimen
- 3 damp-proofing

Figure 3 — Damp-proofing of specimen (example of standard dimensions)**6.2 Curing of specimen**

A specimen shall be cured until it reaches a constant weight in the atmosphere of relative humidity as given in [Table 1](#).

For a tropical zone, the temperature condition given in [Table 1](#) can be changed to 27 °C.

A specimen shall be preliminarily dried in order to adsorb moisture in the atmosphere up to a constant weight. Constant weight shall be obtained when an increase in mass of the specimen becomes 0,1 g or less per 24 h.

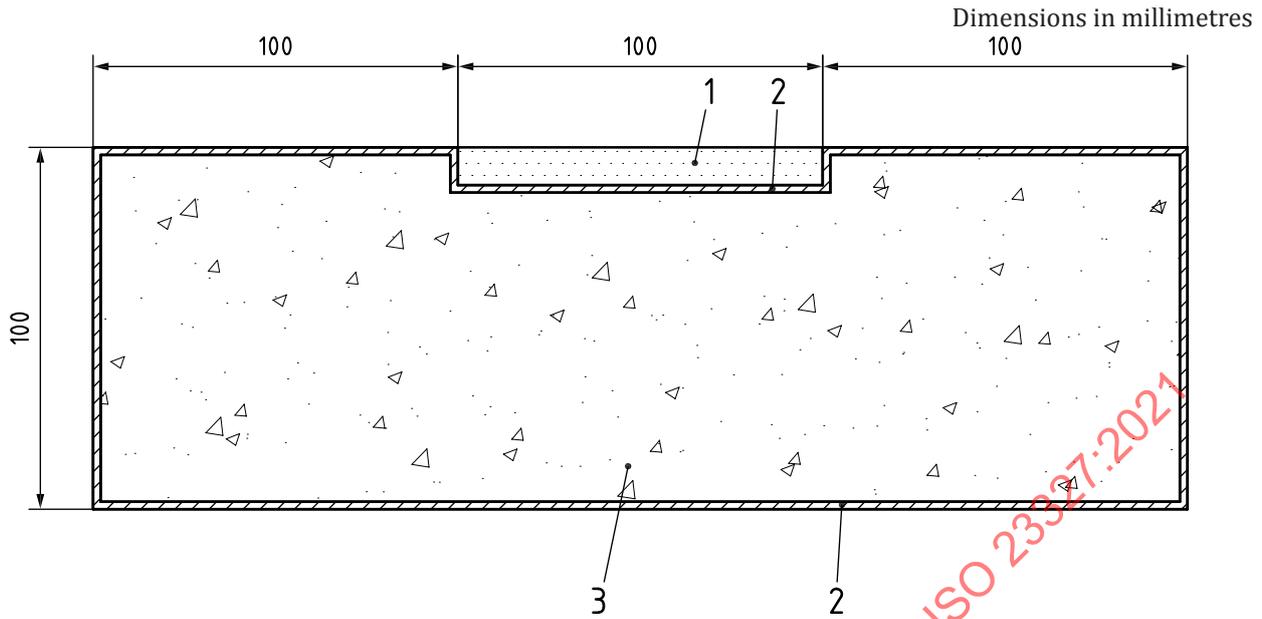
Table 1 — Conditions for curing specimen

Curing condition	
Temperature	Relative humidity
°C	%
23	50

6.3 Thermal insulation of specimen

A specimen shall be thermally insulated with a thermal insulation material (except the moisture-adsorption/desorption surface of a specimen prepared in [6.1](#)) as shown in [Figure 4](#). The thickness of the thermal insulation material shall be 100 mm. The thermal insulation shall be rigid cellular plastics with stable thermal conductivity not greater than 0,04 W·m⁻¹·K⁻¹.

A gap between the side surface of the specimen and the thermal insulation material shall be sealed as occasion demands.



- Key**
- 1 specimen
 - 2 damp-proofing
 - 3 thermal insulation material

Figure 4 — Thermal insulation of specimen (example of standard dimensions)

7 Test method

7.1 Cleaning inside the sealed box

Prior to installing a specimen, clean the inside of a sealed box and the surface of the packing and remove any oil or other stains.

7.2 Initial relative humidity inside the sealed box

Initial temperature and relative humidity inside the sealed box shall be the same as given in [Table 1](#), i.e. the same conditions as the curing conditions of the specimen.

If it is necessary to use other conditions according to a request from a user, or depending upon the characteristics of the materials, it is possible to use another relative humidity inside the sealed box, e.g. low humidity (30 % RH), or high humidity (70 % RH), unless it causes condensation inside the sealed box.

7.3 Installation of specimen

Place a specimen on the bottom the sealed box container kept under conditions of [7.2](#) (as shown [Figure 1](#)). Then, hermetically seal the container with packing, and a cover.

7.4 Placement of sealed box

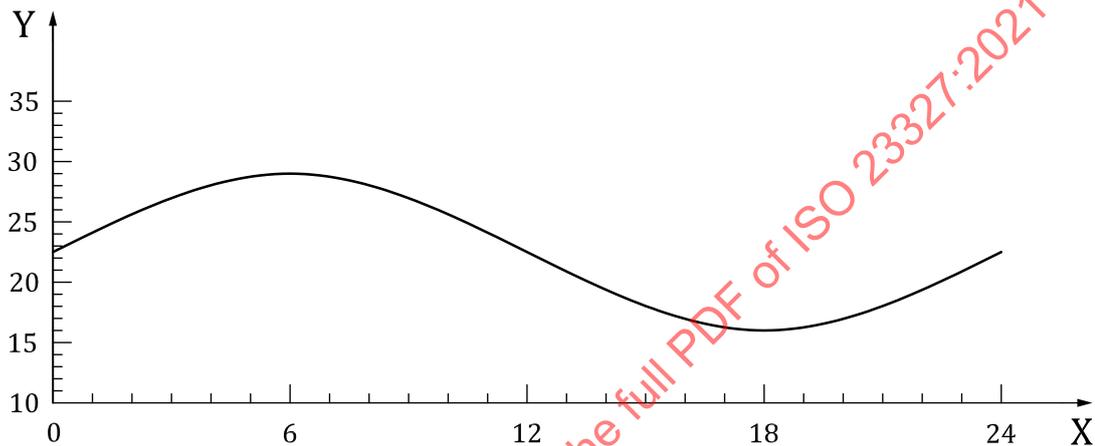
Place the sealed box in a box or chamber with a thermostat. Separate each surface of the sealed box by 50 mm or more from each surface of the box or chamber with the thermostat.

NOTE When legs are attached to the sealed box, the contact area with the bottom surface of the sealed box is made as small as possible.

7.5 Temperature conditions

After keeping the temperature of the box or chamber at 22,5 °C, the temperature of the box or chamber is changed so that it becomes a sine wave with an amplitude of 7,5 °C and a period of 24 h. [Annex A](#) shows the temperature for each step as an example when using a program temperature controller that can set 12 steps. However, the temperature and time can be changed depending on the situation in which the material is used. The temperature in the box or chamber with the thermostat shall be varied imitating a sine wave as given in [Figure 5](#). The temperature cycle shall be repeated 4 turns (4 cycles).

NOTE Assuming a typical building material as a test specimen and calculating under the conditions of this document, the moisture-adsorption/desorption amount of the test specimen becomes a sufficiently steady state after repeating the temperature cycle four turns.



Key

X time (h)
Y temperature (°C)

Figure 5 — Temperature conditions in a box or chamber with thermostat (Example: in the case of 24 h for one cycle)

7.6 Measurement

Measure the temperature and the relative humidity of the air in the sealed box, and the temperature of the air in the box or chamber with a thermostat. Measure the temperature and humidity in the sealed box at 10 min intervals. Measure the temperatures to the nearest 0,1 °C and relative humidity to the nearest 0,1 %.

NOTE The temperature of the air in the box or chamber with a thermostat is for monitoring.

8 Water vapour leakage from sealed box

8.1 Calibration of sealed box for vapour leakage

Prior to measurement with a specimen inside the sealed box, calibrate the sealed box. In the sealed box, a thermal insulation material of 300 mm x 300 mm x 100 mm in size is set without containing a specimen. Measure the temperature and humidity in the sealed box in accordance with [7.1](#) to [7.6](#).

8.2 Calculation of calibration value

Calculate humidity by volume from an air temperature and a relative humidity in the sealed box on the fourth cycle measured in 8.1, and calculate a calibration value of the sealed box (CVSB) in the case of no specimen, i.e. an amount of moisture-adsorption/desorption, according to Formula (1):

$$C_{\text{VSB}} = (\sum |v_{\text{SB}} - \bar{v}_{\text{SB}}|) / (\sum |\theta_{\text{SB}} - \bar{\theta}_{\text{SB}}|) \tag{1}$$

where

- C_{VSB} is the moisture-adsorption/desorption amount CVSB of no specimen ($\text{g}\cdot\text{m}^{-3}\cdot^{\circ}\text{C}^{-1}$);
- v_{SB} is the volume absolute humidity at each time in the sealed box on the fourth cycle ($\text{g}\cdot\text{m}^{-3}$);
- \bar{v}_{SB} is the average volume absolute humidity in the sealed box on the fourth cycle ($\text{g}\cdot\text{m}^{-3}$);
- θ_{SB} is the temperature at each time in the sealed box on the fourth cycle ($^{\circ}\text{C}$);
- $\bar{\theta}_{\text{SB}}$ is the average temperature in the sealed box on the fourth cycle ($^{\circ}\text{C}$).

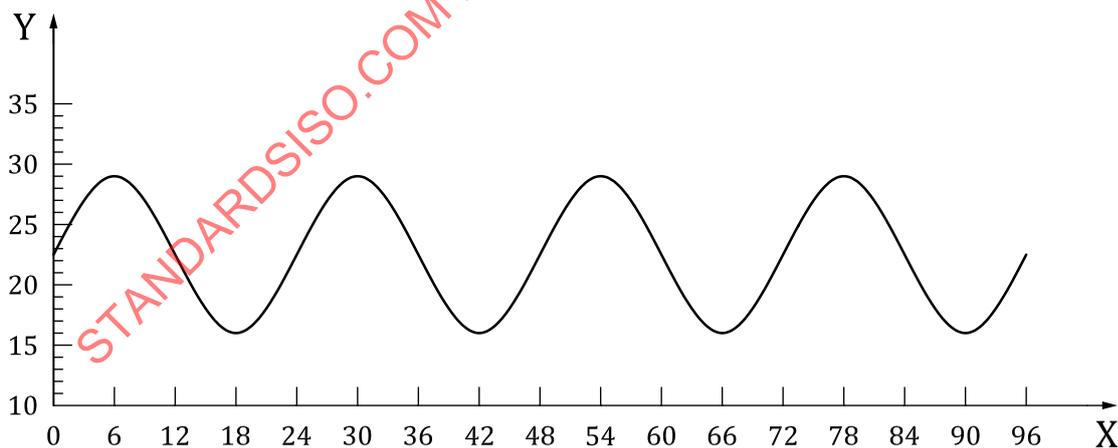
8.3 Tolerance calibration value

The CVSB shall be $0,06 \text{ g}\cdot\text{m}^{-3}\cdot^{\circ}\text{C}^{-1}$ or less. When CVSB exceeds the tolerable value, the performance of the box shall be examined again or the box shall be manufactured again.

9 Calculation of results

9.1 Temperature and humidity in sealed box

The air temperature and the relative humidity in the sealed box measured in 7.1 to 7.6 shall be given in relation to time as shown in Figures 6 and 7. Furthermore, humidity by volume shall be obtained from the air temperature and relative humidity and the relation with time shall be given as in Figure 8.



Key

- X time (h)
- Y temperature ($^{\circ}\text{C}$)

Figure 6 — Example for measurement of temperature variation in sealed box