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

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

Reference number
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Foreword

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ISO 24353 was prepared by Technical Committee ISO/TC 163, *Thermal performance and energy use in the built environment*, Subcommittee SC 1, *Test and measurement methods*.

Introduction

This International Standard describes a test method that is applicable to materials used to inhibit fluctuation of indoor relative humidity. Testing of sorption/desorption efficiency permits the evaluation of materials for applications such as adjusting the relative humidity of museum storage and exhibition spaces.

Materials selected for their adsorption/desorption efficiency have recently come to be used in homes and medical care facilities in the interest of creating healthy and comfortable indoor environments.

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

1 Scope

This International Standard specifies a test method for determining moisture adsorption/desorption properties of building materials in response to humidity variation. This International Standard also defines the adsorption/desorption efficiency of building materials, measured as the change in mass of a specimen moved from a given space to another one of different relative humidity and equal temperature.

Moisture adsorption/desorption properties of materials are measured under conditions of a single cycle and several cycles.

2 Normative references

The following referenced documents are indispensable for the application 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 12571:2000, *Hygrothermal performance of building materials and products — Determination of hygroscopic sorption properties*

ISO 12572:2001, *Hygrothermal performance of building materials and products — Determination of water vapour transmission properties*

3 Terms, definitions and symbols

3.1 Terms and definitions

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

3.1.1
moisture adsorption/desorption property
property of a material related to its capacity for and efficiency in moisture adsorption/desorption

3.1.2
moisture adsorption process
process by which moisture is adsorbed into a material from ambient air until equilibrium is reached

3.1.3
moisture desorption process
process by which moisture is desorbed from a material into ambient air until equilibrium is reached

3.1.4
moisture adsorption content
amount of moisture adsorbed into a specimen of a given material per unit of surface area of that material

3.1.5
moisture desorption content
amount of moisture desorbed by a specimen of a given material per unit of surface area of that material

3.1.6
water vapour surface resistance
resistance against the transfer of water vapour across the boundary layer between the ambient air and the surface of a building component such as a wall

3.1.7
resistance of water vapour transmission
resistance against the transfer of water vapour through a building component, such as wall, from one surface in contact with the water vapour in the air to the other

3.1.8
moisture adsorption rate
rate of adsorbing moisture of the material from the ambient air

3.1.9
moisture desorption rate
rate of desorbing moisture of the material to the ambient air

3.2 Symbols and units

Symbol	Description	Unit
A	Surface area of adsorption/desorption	m^2
G_n	Adsorption/desorption rate at time n	$kg/(m^2·h)$
m_0	Mass of the specimen after preconditioning	kg
m_a	Mass of the specimen at the time of completion of moisture adsorption process	kg
m_{a4}	Mass of the specimen at the time of completion of moisture adsorption process of the 4th adsorption/desorption cycle	kg
m_d	Mass of the specimen at the time of completion of moisture desorption process	kg
m_{d3}	Mass of the specimen at the time of completion of moisture desorption process of the 3rd adsorption/desorption cycle	kg
m_{d4}	Mass of the specimen at the time of completion of moisture desorption process of the 4th adsorption/desorption cycle	kg
m_n	Mass of specimen at time n	kg
m_{n-1}	Mass of specimen at time $n-1$	kg
R_1	Resistance of water vapour on single-layered specimen	$m^2·h·Pa/μg$
R_2	Resistance of water vapour on double-layered specimen	$m^2·h·Pa/μg$
Δt	Elapsed time	h
$1/\beta$	Water vapour surface resistance of specimen	$m^2·h·Pa/μg$
$\rho_{A,a}$	Change of moisture content at the time of completion of adsorption process	kg/m^2
$\rho_{A,ac}$	Moisture adsorption content at the time of completion of moisture adsorption process of the 4th sorption/desorption cycle	kg/m^2
$\rho_{A,d}$	Moisture desorption content at the time of completion of desorption process	kg/m^2
$\rho_{A,dc}$	Moisture desorption content at the time of completion of moisture desorption process of the 4th adsorption/desorption cycle	kg/m^2
$\rho_{A,s}$	Difference between moisture adsorption/desorption content at the time of completion of the test	kg/m^2
$\rho_{A,sc}$	Difference between moisture adsorption/desorption content at the time of completion of the 4th adsorption/desorption cycle	kg/m^2

4 Test specimens

4.1 General

The specimen shall be representatives of the product. The size, the thickness and the number of specimens shall be as specified in 4.2 to 4.4, or otherwise selected ensuring that their moisture adsorption/desorption properties are properly evaluated.

4.2 Size

The size of a specimen shall be at most 250 mm × 250 mm but shall not be less than 100 mm × 100 mm.

4.3 Thickness

The thickness of a specimen shall be the same as the thickness of the product.

4.4 Number of specimens

The number of specimens shall be one piece for each test condition.

5 Test apparatus

The test apparatus consists of an electronic balance, a moisture-proof box with a programmable air conditioner and a thermometer, as shown in Figure 1. An apparatus of any structure may be used as long as the criteria of measurement precision described for the different pieces of equipment (5.1 to 5.4) are satisfied.

5.1 Electronic balance, capable of weighing to the nearest 0,01 g for test specimens up to 6 kg.

For test specimens exceeding 6 kg, an electronic balance capable of weighing to the nearest 0,1 g may be used.

5.2 Moisture-proof box with thermostat and/or hygrostat, equipped with a programmable air conditioner capable of being set at a specific temperature and humidity, having sufficient capacity to accommodate the specimen and containing the elements listed in 5.2.1 to 5.2.4.

5.2.1 Temperature sensor, positioned about 50 mm from the centre of the adsorption/desorption surface of the specimen and enabling the temperature to be maintained throughout the moisture-proof box to within ± 0,5 °C.

5.2.2 Humidity gauge, of which the sensor of the hygrometer is positioned about 50 mm from the centre of the moisture adsorption/desorption surface of the specimen and enables the humidity to be maintained throughout the moisture-proof box to within ± 3 % at any position.

5.2.3 Humidifier, using water vapour as the humidification source.

Humidification methods that involve spraying water with an ultrasonic humidifier, or similar devices, shall not be employed. When humidity is changed stepwise, the desired humidity shall be reached quickly (as a rule, in less than 10 min).

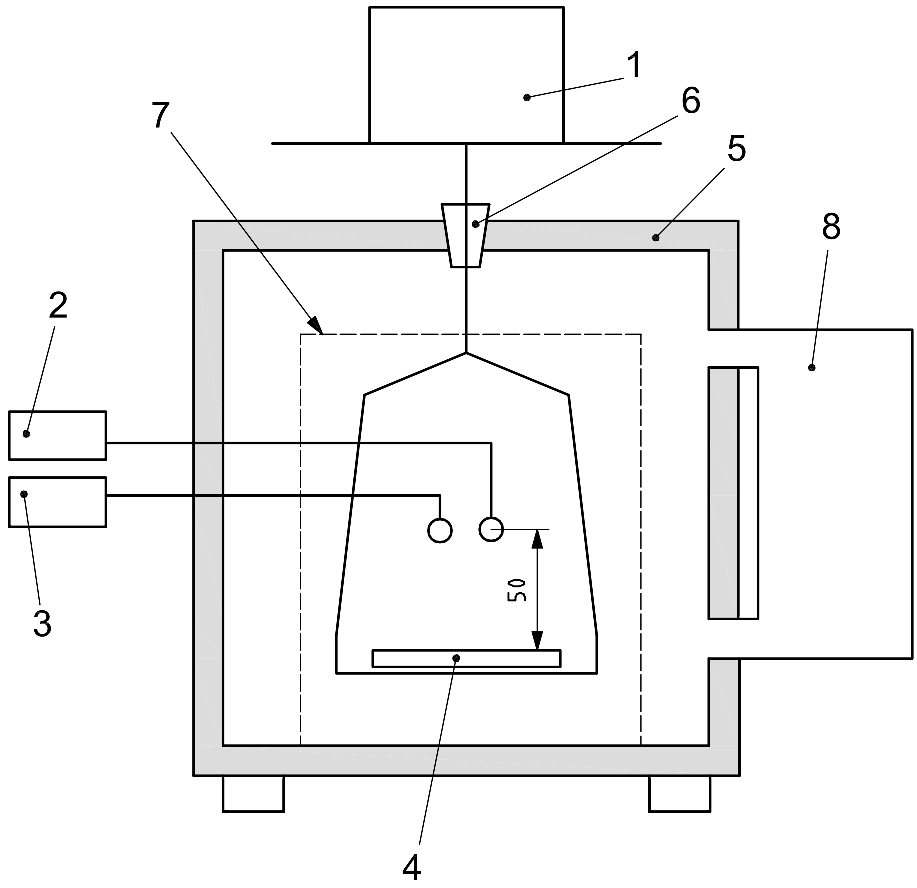
NOTE Salt saturated solutions can be used to adjust the relative humidity as indicated in Annex B.

5.2.4 Windscreen, set up to prevent any influence from airflow of the air conditioner.

5.3 Thermometer, capable of measuring the temperature to within ± 0,1°C.

5.4 Hygrometer, capable of measuring the humidity to within ± 2 %.

Dimensions in millimetres



Key

1 electronic balance
2 hygrometer
3 thermometer
4 specimen
5 moisture-proof box
6 rubber plug
7 windscreen
8 programmable air conditioner

Figure 1 — Typical test apparatus

6 Setting of water vapour surface resistance

Air flow a along the surface of a specimen should be adjusted using a fan to stir the air inside the moisture-proof box (see Annex A) so as to obtain water vapour surface resistance, as measured in A.5, equal to (13,3 ± 1,3) $m^2 \cdot h \cdot Pa/\mu g$.

7 Test method

7.1 Test conditions

For preconditioning and testing of a specimen, set the ambient temperature to (23 ± 0,5) °C, then maintain the ambient relative humidity to within ± 1 % of the value of relative humidity selected for testing.

7.2 Single cycle test of moisture adsorption/desorption content

7.2.1 Preconditioning of the specimen

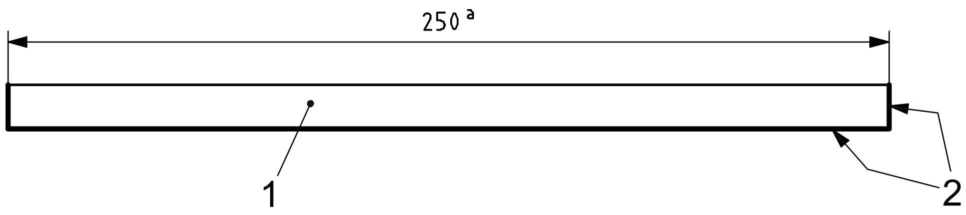
Precondition the specimen until it reaches constant mass, m_0, at a given ambient relative humidity as specified in Table 1.

A specimen shall be considered as having reached constant mass during the moisture adsorption process when the rate of increase in mass of adsorbed moisture is less than 0,01 g in 24 h.

7.2.2 Moisture barrier of test specimen

Provide a moisture barrier consisting of aluminium foil or other appropriate material and cover the entire surface of the specimen except for a single adsorption/desorption face.

Dimensions in millimetres



Key

1 test specimen

2 moisture barrier (aluminium sheet or the like)

a Length of moisture adsorption/desorption area.

Figure 2 — Moisture barrier of test specimen

7.2.3 Test procedure

The test shall be carried out in two steps:

a) Step 1: with relative humidity set at one value for the moisture adsorption process;

b) Step 2: with relative humidity set at a lower value for the desorption process.

Typical humidity values are given for reference in Table 1.

Place the preconditioned test specimen into the test apparatus and quickly bring the water vapour surface resistance of the test specimen to the same value as that set for the calibration specimen.

With water vapour surface resistance thus adjusted, maintain the relative humidity at the Step 1 value for 12 h, then lower it to the Step 2 value and maintain it at this value for 12 h.

Measure the change in mass of the test specimen over a consecutive 24 h period. Take the mass at the beginning of the 12 h Step 1 period to be zero, then measure the mass of the test specimen (m_n) at 10 min intervals to the nearest 0,01 g. Record the mass at the end of the first 12 h period, the moisture adsorption process, as m_a, and at the end of the second 12 h period, the moisture adsorption process, as m_d.

Table 1 — Relative humidity levels to be set for preconditioning and moisture adsorption/desorption process

Humidity conditions	Relative humidity %		
	Preconditioning	Moisture adsorption process	Moisture desorption process
		Step 1	Step 2
Low humidity level	30	55	30
Middle humidity level	50	75	50
High humidity level	70	95	70

Other values may be selected in accordance with the needs of users and characteristics of the materials tested.

7.3 Cyclic test of regular moisture adsorption/desorption content

7.3.1 Preconditioning of the test specimen

Precondition the specimen until it reaches constant mass at the desired relative humidity specified in Table 2 (or other appropriate relative humidity).

After preliminary drying, allow the test specimen to adsorb moisture from the ambient air until it reaches constant mass. A test specimen shall be considered as having reached constant mass during this process when the rate of increase in mass of adsorbed moisture is less than 0,01 g in 24 h.

7.3.2 Moisture barrier of test specimen

Provide a moisture barrier consisting of aluminium foil or other appropriate material and cover the entire surface of the specimen except for a single adsorption/desorption face as shown in Figure 2.

7.3.3 Test procedure

Conduct the test as specified in 7.2.3 using the relative humidity values given in Table 2. Maintain the relative humidity at the Step 1 value for 12 h, then lower it to the Step 2 value and maintain it at this value for 12 h. This process constitutes one cycle. Repeat this process to obtain a total of four cycles. Measure the mass, temperature and humidity as specified in 7.2.3.

Table 2 — Setting relative humidity for the periodic test of moisture adsorption/desorption processes

Humidity conditions	Relative humidity %		
	Preconditioning	Moisture adsorption process	Moisture desorption process
		Step 1	Step 2
Low humidity level	43	55	30
Middle humidity level	63	75	50
High humidity level	83	95	70

8 Calculation

8.1 Moisture adsorption/desorption content and the differences between them

8.1.1 Moisture adsorption content

Calculate the moisture adsorption content, $\rho_{A,\mathrm{a}}$, using Equation (1) from the values obtained in 7.2.

$$\rho_{A,\mathrm{a}} = \frac{m_\mathrm{a} - m_0}{A} \tag{1}$$

NOTE The results obtained in 7.2 can be also be used to calculate the moisture infiltration coefficient, which indicates the degree of change of moisture within the specimen. The procedure for calculating the moisture infiltration coefficient is described in Annex C.

8.1.2 Moisture desorption content

Calculate the moisture desorption content, $\rho_{A,\mathrm{d}}$, using Equation (2) from the values obtained in 7.2.

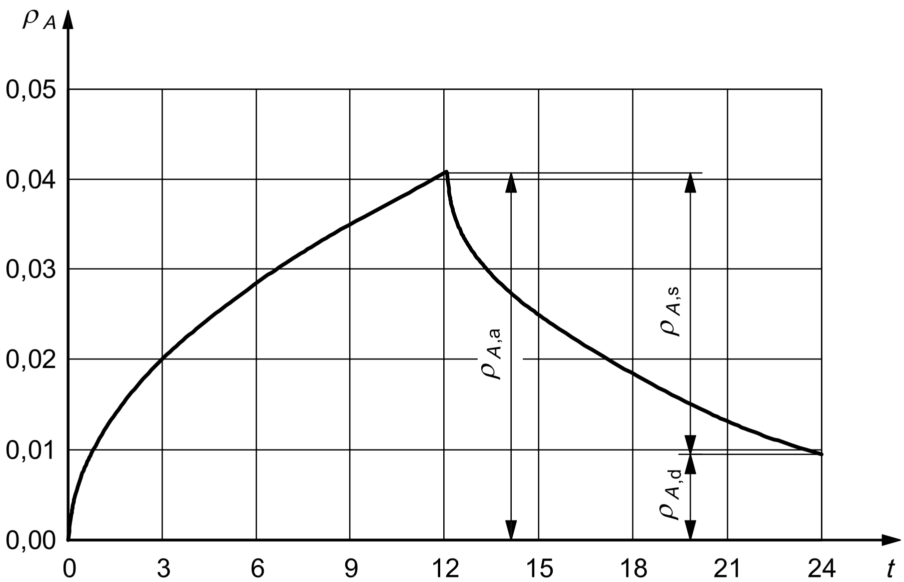
$$\rho_{A,\mathrm{d}} = \frac{m_\mathrm{a} - m_\mathrm{d}}{A} \tag{2}$$

8.1.3 Moisture content difference between adsorption and desorption

Calculate the difference of moisture content, $\rho_{A,\mathrm{s}}$, between adsorption and desorption using Equation (3).

$$\rho_{A,\mathrm{s}} = \rho_{A,\mathrm{a}} - \rho_{A,\mathrm{d}} \tag{3}$$

Figure 3 shows a typical graph of moisture adsorbed/desorbed content over time. The test specimen thickness shall be clearly indicated in any such graph of observed adsorbed/desorbed moisture values.



Key

t time, expressed in hours

ρ_A adsorption/desorption content, expressed in kg/m^2

$\rho_{A,\mathrm{a}}$ moisture adsorption content

$\rho_{A,\mathrm{d}}$ moisture desorption content

$\rho_{A,\mathrm{s}}$ difference of moisture content between adsorption and desorption

d = 5,0 mm test specimen thickness

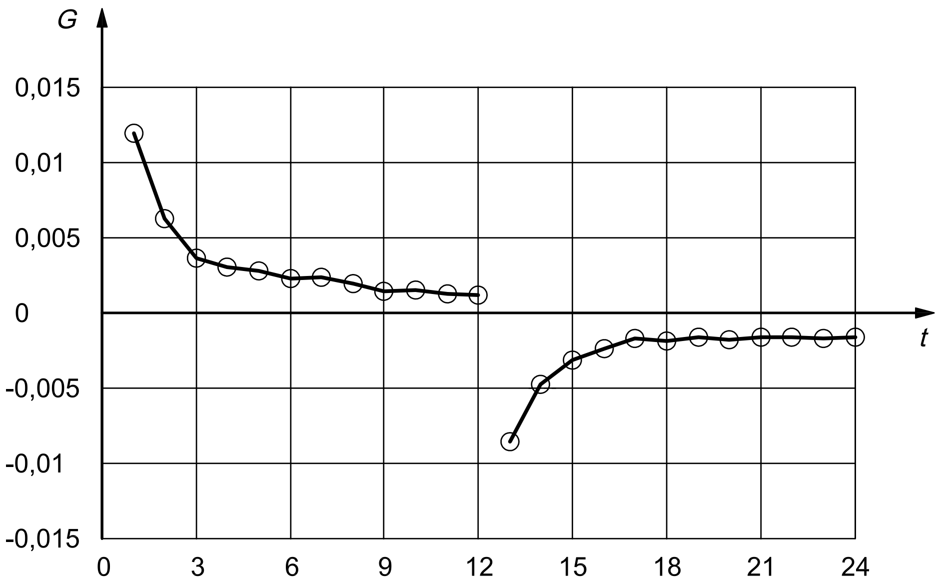
Figure 3 — Typical graph showing moisture adsorption/desorption content over time

8.2 Moisture adsorption/desorption rates

Calculate the moisture adsorption/desorption rate, G_n, from results of moisture adsorption/desorption obtained as specified in 7.2 using Equation (4).

$$G_n = \frac{m_n - m_{n-1}}{\Delta t} \tag{4}$$

Plot the moisture adsorption/desorption rate calculated from Equation (4) as shown in Figure 4.



Key

t time, expressed in hours

G moisture adsorption/desorption rate, expressed in kg/(m²·h)

d = 5,0 mm test specimen thickness

Figure 4 — Typical plot of moisture adsorption/desorption rate

8.3 Fourth cycle moisture adsorption/desorption content

8.3.1 Moisture adsorption content

Calculate the cyclic value of the moisture adsorption content, $\rho_{A,\mathrm{ac}}$, using Equation (5) from the values obtained in 7.3 for mass values determined at the end of the third desorption period and the fourth adsorption period.

$$\rho_{A,\mathrm{ac}} = \frac{m_{\mathrm{a4}} - m_{\mathrm{d3}}}{A} \tag{5}$$

8.3.2 Moisture desorption content

Calculate the cyclic value of the moisture desorption content, $\rho_{A,\mathrm{dc}}$, using Equation (6) for mass values obtained in 7.3 for mass values determined at the end of the fourth adsorption period and at the end of the fourth desorption period.

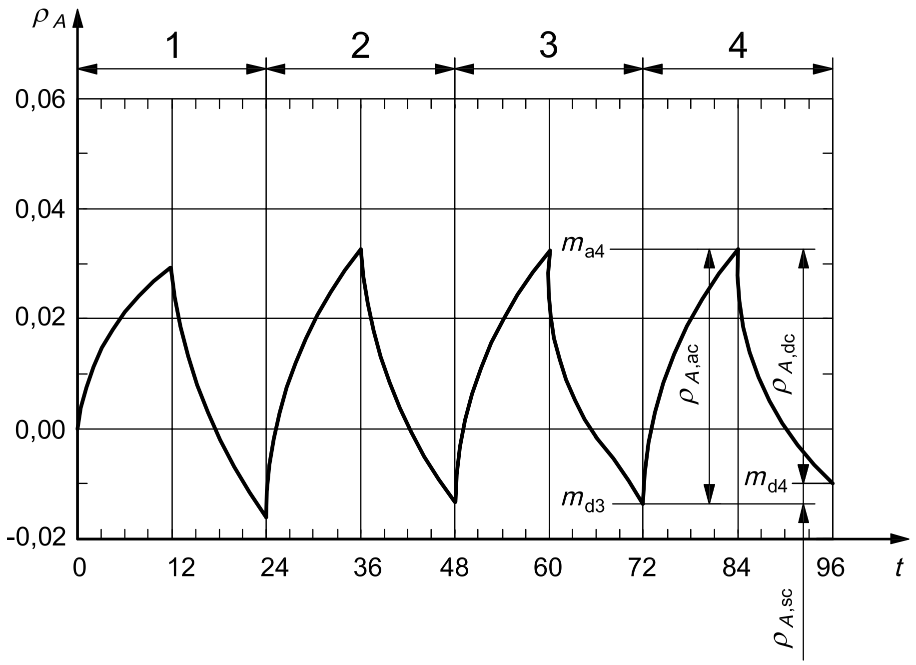
$$\rho_{A,\mathrm{dc}} = \frac{m_{\mathrm{a4}} - m_{\mathrm{d4}}}{A} \tag{6}$$

8.3.3 Moisture content difference between adsorption and desorption

Calculate the cyclic difference of moisture content, $\rho_{A,\text{sc}}$, between adsorption and desorption using Equation (7).

$$\rho_{A,\text{sc}} = \rho_{A,\text{ac}} - \rho_{A,\text{dc}} \quad (7)$$

Figure 5 shows a typical graph of the variation of moisture adsorbed/desorbed content over time.



Key

t time, expressed in hours

ρ_A moisture adsorption/desorption content, expressed in kg/m^2

1 first cycle

2 second cycle

3 third cycle

4 fourth cycle

m_{a4} mass value determined at the end of the fourth adsorption period

m_{d3} mass value determined at the end of the third desorption period

m_{d4} mass value determined at the end of the fourth desorption period

$\rho_{A,\text{ac}}$ moisture adsorption content for the fourth cycle

$\rho_{A,\text{dc}}$ moisture desorption content for the fourth cycle

$\rho_{A,\text{sc}}$ difference of moisture content between adsorption and desorption for the fourth cycle

Figure 5 — Typical example of moisture adsorption/desorption content for four adsorption/desorption cycles

9 Test report

The test report shall include the following:

a) reference to this International Standard (ISO 24353:2008);

b) product identification:

   1) product name, manufacturer or supplier; manufacturer's classification of test specimen,

   2) type of test specimen,

   3) size and thickness of test specimen,

   4) density of test specimen (before the start of test);

c) test procedure:

   1) single cycle test,

   2) cyclic test;

d) test conditions:

   1) temperature,

   2) relative humidity levels (low, middle and/or high humidity levels),

   3) preconditioning of the test specimen,

   4) relative humidity in the moisture adsorption/desorption process,

   5) number of cycles,

   6) type of salts, if salt saturated aqueous solution has been used;

e) test results:

   1) values of moisture content for adsorption and desorption for single cycle (see Figure 3) or for the fourth cycle (see Figure 5),

   2) difference of moisture content between adsorption and desorption of a single cycle or of the fourth cycle [see Equations (1), (2) and (3) or Equations (5), (6) and (7)],

   3) values of variation of moisture adsorption/desorption rates of single cycle or fourth cycle process (see Figure 4),

   4) moisture adsorption/desorption rates of a single cycle or of a fourth cycle process [see Equation (4)];

f) date of the test;

g) information concerning the operator and the laboratory.

Annex A
(normative)

Setting of air flow on test specimen surface

A.1 General

In order to adjust the conditions of air flow on a test specimen surface, the water vapour surface resistance on the moisture adsorption/desorption surface of a test specimen shall be set according to the following procedure before the test.

A.2 Calibration specimen

For the calibration specimen to be used for setting water vapour surface resistance on the specimen surface, prepare two identical specimens which conform to the following conditions:

a) specimen having a moisture permeating resistance of 6,7 $m^2 \cdot h \cdot Pa/\mu g$ to 26,7 $m^2 \cdot h \cdot Pa/\mu g$;

b) specimen having a smooth surface.

NOTE A sheet of similar drawing paper (0,5 ± 0,2) mm in thickness can fit these conditions.

A.3 Tray for fitting calibration specimen

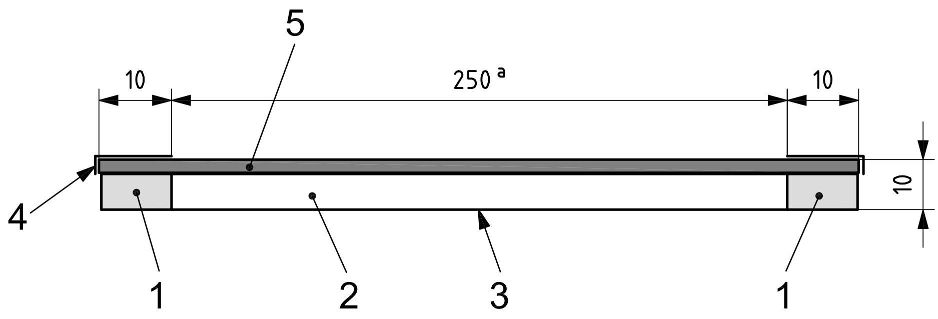
A tray to which a calibration specimen is attached, shall be shaped as shown in Figure A.1. Place a desiccant specified in ISO 12572 in the tray as shown in Figure A.1. The content of moisture that can be adsorbed on the permeable area of the desiccant (calibration specimen) shall be equal to the moisture adsorption/desorption content of the test specimen.

Use trays made of polyvinylchloride, acrylic plastics or another material having a sufficiently large moisture permeating resistance to the calibration specimen.

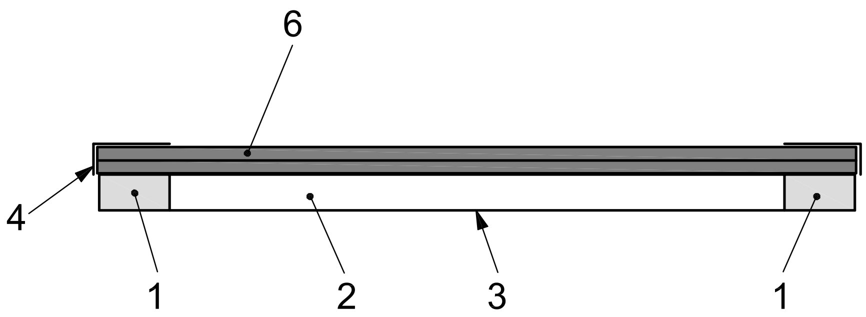
A.4 Fitting of calibration specimen

Fit the calibration specimen specified in A.2 to the tray specified in A.3 as shown in Figure A.1. Figure A.1 a) shows an example of a single-layered specimen and Figure A.1 b) shows an example of a double-layered specimen (two specimens stacked). Fit the calibration specimen such that the inside surface is at the same height as that of the tray edge, and hermetically seal it with a sealing material specified in ISO 12572:2001 so that moisture does not seep in from surroundings.

Dimensions in millimetres



a) Fitting of a single-layered specimen



b) Fitting of a double-layered specimen

Key

1 spacer

2 calcium chloride

3 tray (made of polyvinylchloride)

4 moisture-proof seal (aluminium sheet and paraffin)

5 calibration specimen (one sheet of drawing paper)

6 calibration specimen (two sheets of drawing paper overlapped)

a Moisture permeable area.

Figure A.1 — Calibration specimen for setting water vapour surface resistance

A.5 Measurement of water vapour surface resistance

Keep both single-layered specimens and double-layered specimens prepared as specified in A.4 under the stable desired conditions under which the moisture adsorption/desorption test is to be carried out. Carry out measurements in accordance with the tray method specified in ISO 12572:2001.

During measurement, keep the temperature constant at (23 ± 0,5) °C, relative humidity constant at (53 ± 3) %. Calculate the water vapour surface resistance of the specimen using Equation (A.1).

$$1/\beta = 2R_1 - R_2 \quad \text{(A.1)}$$

Annex B
(informative)

Apparatus using salt saturated aqueous solution

B.1 General

The test apparatus for a salt saturated solution consists of an electronic balance, a moisture-proof box, a thermometer, a hygrometer and a fan for mixing the air inside the moisture-proof box, temperature conditioning room or chamber as shown in Figure B.1.

B.2 Moisture-proof box

A moisture-proof box shall be made of materials that do not adsorb/desorb water vapour.

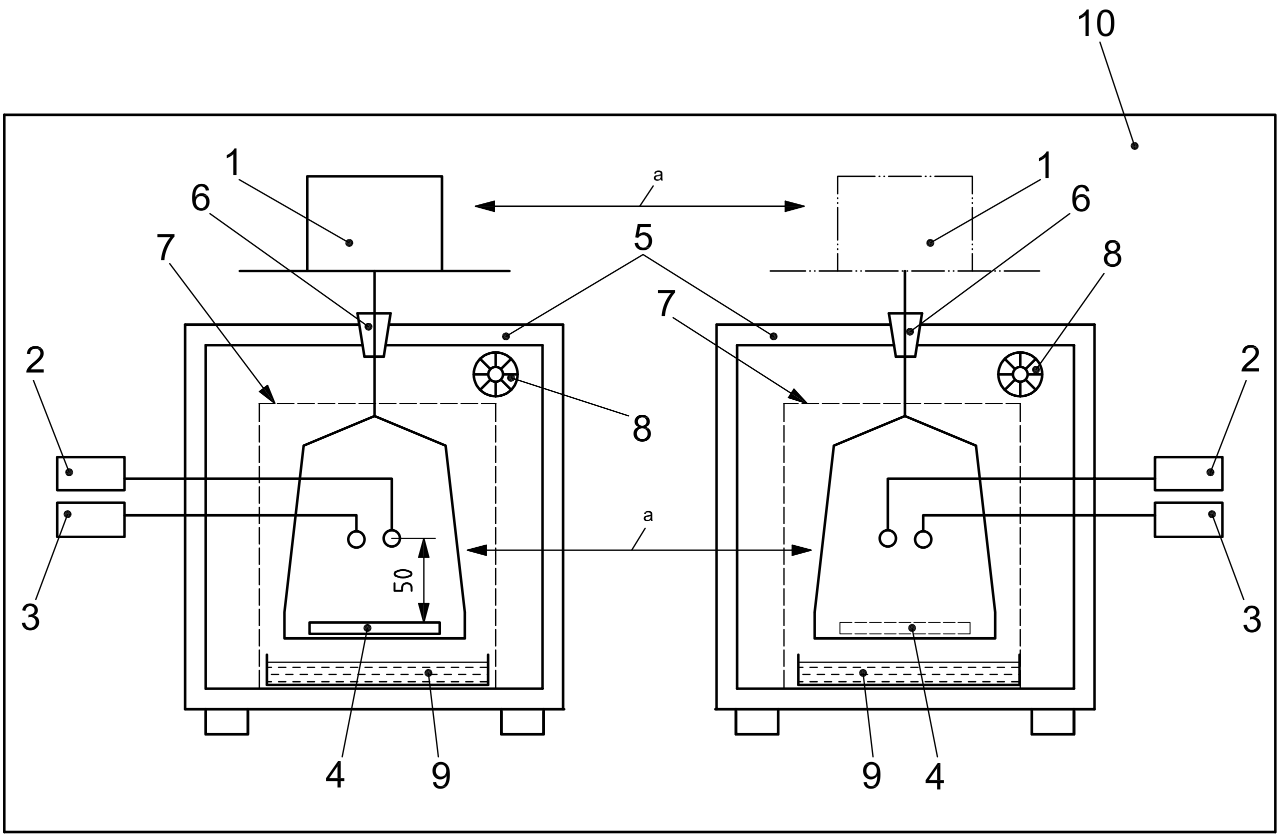
B.3 Fan for mixing air inside the moisture-proof box

A fan for stirring air of moisture-proof box shall be provided for keeping water vapour resistance of the specimen surface constant, and shall be capable of supplying a changeable and constant air velocity to the specimen surface.

B.4 Temperature conditioning room or chamber

Maintain the air temperature constant in the room or chamber at (23 ± 0,5) °C.

Dimensions in millimetres



a) Step 1: Lower humidity

b) Step 2: Higher humidity

Key

1 electronic balance
2 hygrometer
3 thermometer
4 specimen
5 moisture-proof box
6 rubber plug
7 windscreen
8 fan for stirring air inside the box
9 salt-saturated aqueous solution
10 temperature conditioning room or chamber

[a] Move the specimen from lower humidity to higher humidity after 12 h. Measure the change in mass using the electronic balance.

Figure B.1 — Apparatus using salt-saturated aqueous solution

B.5 Single cycle test procedure

The test shall be carried out in two steps:

a) Step 1: with relative humidity set at one value for the moisture adsorption process;

b) Step 2: with relative humidity set at a lower value for desorption process.

Typical humidity values are given for reference in Table B.1. Other values may be selected in accordance with the needs of users and characteristics of the materials tested.

Place the preconditioned test specimen into the test apparatus and quickly bring the water vapour surface resistance of the test specimen to the same value as that set for the calibration specimen.

With water vapour surface resistance thus adjusted, maintain the relative humidity at the Step 1 value for 12 h, then lower it to the Step 2 value and maintain it at this value for 12 h.

Place the test specimen in a moisture-proof box in which the relative humidity is maintained at the Step 1 value. After 12 h, move the specimen to another moisture-proof box of which relative humidity is maintained at the Step 2 value. Maintain the test specimen at the Step 2 value for 12 h.

Measure the change in mass of the test specimen over a consecutive 24 h period. Take the mass at the beginning of the 12 h Step 1 period to be zero, then measure the mass of the test specimen (m_n) at 10 min intervals to the nearest 0,01 g. Record the mass at the end of the first 12 h period, the moisture adsorption process, as m_a, and at the end of the second 12 h period, the moisture adsorption process, as m_d.

Table B.1 — Relative humidity levels to be set for the preconditioning and moisture adsorption/desorption process

Humidity conditions	Relative humidity %		
	Preconditioning	Moisture adsorption process	Moisture desorption process
		Step 1	Step 2
Low humidity level	33	53	33
Middle humidity level	53	75	53
High humidity level	75	93	75

B.6 Cyclic test procedure

Conduct the test as specified in 7.2.3 using the relative humidity values given in Table B.2. Maintain the relative humidity at the Step 1 value for 12 h, then lower it to the Step 2 value and maintain it at this value for 12 h. This process constitutes one cycle. Repeat this process to obtain a total of four cycles. Measure the mass, temperature and humidity as specified in 7.2.3.

Table B.2 — Setting relative humidity for the periodic test of moisture adsorption/desorption processes

Humidity conditions	Relative humidity %		
	Preconditioning	Moisture adsorption process	Moisture desorption process
		Step 1	Step 2
Low humidity level	43	53	33
Middle humidity level	69	75	53
High humidity level	85	93	75

B.7 Saturated salts and relative humidity

If salt-saturated aqueous solutions are to be used, use the salts given in Table B.3 taken from ISO 12571:2000. Desired relative humidity for testing with each salt is also given in Table B.3.

Table B.3 — Salts used for saturating solutions and relative humidity

Salts	Relative humidity %
$MgCl_2$	33
K_2CO_3	43
$Mg(NO_3)_2$	53
KI	69
NaCl	75
KCl	85
KNO_3	93

Annex C
(informative)

Calculation procedure of moisture infiltration coefficient

The moisture infiltration coefficient can be correlated to the degree of moisture diffusion throughout a specimen. Based on the measurement results obtained in 7.2, the moisture infiltration coefficient can be calculated according to the following procedure.

a) Moisture infiltration coefficient

Assuming that a specimen is a semi-infinite and homogeneous body, the change of specimen's mass m is given by the Equation (C.1).

$$m = 2\zeta \cdot \Delta X \sqrt{\frac{\lambda_{\mathrm{m}} \cdot t}{\pi \cdot \zeta}} \qquad \text{(C.1)}$$

where

ζ is the moisture differential capacity, expressed in kg/m^3;

ΔX is the absolute humidity difference between Step 1 and Step 2, expressed in kg/kg;

λ_{m} is the moisture conductivity, expressed in kg/(m·s·Pa);

t is the time, expressed in seconds.

b) Regression

Equation (C.1) can be rewritten as follows.

$$m = C \cdot \sqrt{t} \qquad \text{(C.2)}$$

where C is the slope of the regression line for m against $\sqrt{t}$.

Calculate the regression line by plotting the mass of a specimen m against the square root of time t and determine the slope of the regression line, C.

c) Calculation procedure

Calculate the moisture infiltration coefficient, $\sqrt{\lambda_{\mathrm{m}} \cdot \zeta}$, expressed in kg/[m^2·h$^{1/2}$·(kg/kg)], of a test specimen using Equation (C.3).

$$\sqrt{\lambda_{\mathrm{m}} \cdot \zeta} = \frac{\sqrt{\pi}}{2 \cdot \Delta X} \cdot C \qquad \text{(C.3)}$$

Bibliography

[1] ISO 7345, *Thermal insulation — Physical quantities and definitions*

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

[3] JIS A 1470-1, *Test method of adsorption/desorption efficiency for building materials to regulate an indoor humidity — Part 1: Response method of humidity*

[4] WAKAKI, K., MIYANO, N., TAKANO, T., SHIMABARA, T., MURATA, Y. and MIYANO, A. Coordination of the moisture environment by using Xonotlite calcium silicate as building materials to regulate indoor humidity in museums and other cultural facilities, *Proceedings of the 5th International Symposium on Architectural Interchanges in Asia*, June 1-4, 2004, Matsue, Japan, pp. 74-79

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