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permeability of textiles**

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Contents

	Page
Introduction.....	1
1 Scope.....	1
2 Normative references	1
3 Terms and definitions.....	2
4 Testing location	3
5 Sampling and preparation of test specimens	3
6 Classification of tests	3
7 Test methods	4
7.1 Method A	4
7.2 Method B	7
7.3 Method C (sweating-guarded hotplate method).....	10
8 Test report.....	10
Annex A (normative) Method B-3 (alternative method II to the potassium acetate method)	11
Annex AA (informative) Water vapour permeability—Application of test results	19
Annex AB (informative) Physical principle behind the test method	20
Annex AC (informative) Dry desiccant cup methods	22
Annex B (normative) Method C (sweating guarded-hotplate method).....	23
Annex BA (normative) Mounting procedure for specimens containing loose filling materials or having uneven thickness	32
Annex BB (normative) Determination of correction terms for heating power	33
Annex JA (informative) Comparison table between JIS and corresponding International Standards	35

Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by Japan Textile Evaluation Technology Council (JTETC)/Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14.

Consequently **JIS L 1099:2006** is replaced with this Standard.

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Attention is drawn to the possibility that some parts of this Standard may conflict with a patent right, application for a patent after opening to the public or utility model right. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying the patent right, application for a patent after opening to the public or the utility model right.

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Testing methods for water vapour permeability of textiles

Introduction

This Japanese Industrial Standard has been prepared based on the first edition of **ISO 11092** published in 1993 and the first edition of **ISO 15496** published in 2004 with some modifications of the technical contents intended to reflect the actuality of the usage of the test method in Japan.

Among the methods specified in this Standard, method B-3 (alternative method II to the potassium acetate method) (see Annex A) and method C (sweating guarded-hotplate method) (see Annex B) given in clause **6** are derived from the corresponding International Standards, and method A-1 (calcium chloride method), method A-2 (water method), method B-1 (potassium acetate method) and method B-2 (alternative method I to the potassium acetate method) are the methods not given in the corresponding International Standard. A list of modifications with explanations is given in Annex JA.

1 Scope

This Standard specifies the testing methods for water vapour permeability of textiles.

NOTE : The International Standards corresponding to this Standard and the symbol of degree of correspondence are as follows:

ISO 11092:1993 *Textiles—Physiological effects—Measurement of thermal and water-vapour resistance under steady-state conditions (sweating guarded-hotplate test)*

ISO 15496:2004 *Textiles—Measurement of water vapour permeability of textiles for the purpose of quality control (Overall evaluation: MOD)*

The symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21-1**.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS K 0050 *General rules for chemical analysis*

JIS K 8125 *Calcium chloride (for U-tube) (Reagent)*

JIS K 8363 *Potassium acetate (Reagent)*

JIS L 0105 *General principles of physical testing methods for textiles*

JIS Z 8401 *Guide to the rounding of numbers*

3 Terms and definitions

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

3.1 (P_A and P_B) water vapour permeability

the mass of water vapour, in grammes, that has permeated a textile at a specified temperature and under a specified humidity, which is converted to the value per square metre of its textile and per hour

This term is used in method A, method B-1 (potassium acetate method), and method B-2 (alternative method I to the potassium acetate method).

3.2 porosity

the ratio of the volume of all the pores in a material to the volume of the whole

3.3 water vapour permeability (WVP)

characteristic of a textile material describing the amount of water vapour diffusing through the textile per square metre, per hour and per unit difference of water vapour pressure across the textile

This term is used in method B-3 (alternative method II to the potassium acetate method).

3.4 thermal resistance (R_{ct})

temperature difference between the two faces of a material divided by the resultant heat flux per unit area in the direction of the gradient

The dry heat flux may consist of one or more conductive, convective and radiant components. Water vapour resistance, (R_{ct}), expressed in square metres Kelvin per watt, is a quantity specific to textile materials or composites which determines the dry heat flux across a given area in response to a steady applied water vapour pressure gradient.

This term is used in method C (sweating guarded-hotplate method).

3.5 water vapour resistance (R_{et})

water vapour pressure difference between the two faces of a material divided by the resultant evaporative heat flux per unit area in the direction of the gradient

The evaporative heat flux may consist of both diffusive and convective components.

Water vapour resistance, (R_{et}), expressed in square metres pascal per unit, is a quantity specific to textile materials or composites which determines the “latent” evaporative heat flux across a given area in response to a steady applied water vapour pressure gradient.

This term is used in method C (sweating guarded-hotplate method).

3.6 water vapour permeability index (i_{int})

ratio of thermal and water vapour resistances in accordance with formula (1):

$$i_{int} = S \times \frac{R_{ct}}{R_{et}} \dots\dots\dots (1)$$

where, i_{mt} : water vapour permeability index
 S : wet and dry heat transfer coefficient ratio [60 (Pa/K)]
 R_{ct} : thermal resistance ($\text{m}^2 \cdot \text{K/W}$)
 R_{et} : water vapour resistance ($\text{m}^2 \cdot \text{Pa/W}$)

i_{mt} is dimensionless, and has values between 0 and 1. A value of 0 implies that the material is water vapour impermeable, that is, it has infinite water vapour resistance, and a material with a value of 1 has both the thermal resistance and water vapour resistance of an air layer of the same thickness.

This term is used in method C (sweating guarded-hotplate method).

3.7 water vapour permeability (W_d)

characteristics of textile material or composite depending on the water vapour resistance and temperature in accordance with formula (2):

$$W_d = \frac{1}{R_{\text{et}} \times \phi T_m} \dots\dots\dots (2)$$

where, W_d : water vapour permeability ($\text{g/m}^2 \cdot \text{h} \cdot \text{Pa}$)
 R_{et} : water vapour resistance ($\text{m}^2 \cdot \text{Pa/W}$)
 ϕT_m : latent heat per unit mass at a measuring temperature ($\text{W} \cdot \text{h/g}$)

In the above formula, ϕT_m is the latent heat of vaporization of water at the temperature of the measuring unit which equals 0.672 $\text{W} \cdot \text{h/g}$. The water vapour permeability is expressed in $\text{g/m}^2 \cdot \text{h} \cdot \text{Pa}$.

This term is used in method C (sweating guarded-hotplate method).

4 Testing location

The test shall be conducted in a laboratory maintained under the standard conditions specified in **JIS L 0105**. Where this is impractical, the conditions closest possible to those specified shall be employed, in which case the temperature and relative humidity employed at the test shall be reported in the test report given in clause 8.

5 Sampling and preparation of test specimens

Sampling and preparation of test specimens shall be in accordance with **6.3** and **6.4** of **JIS L 0105**.

6 Classification of tests

Classification of tests is as follows.

a) Method A

- 1) **Method A-1 (calcium chloride method) (7.1.1)**
- 2) **Method A-2 (water method) (7.1.2)**

b) Method B

- 1) **Method B-1 (potassium acetate method) (7.2.1)**

- 2) **Method B-2 (alternative method I to the potassium acetate method) (7.2.2)**
- 3) **Method B-3 (alternative method II to the potassium acetate method)** [See Annex A (normative)] **(7.2.3)**
- c) **Method C (sweating guarded-hotplate method)** [See Annex B (normative)] **(7.3)**

7 Test methods

7.1 Method A

Method A is classified into method A-1 (calcium chloride method) and method A-2 (water method), either of which shall be selected and performed.

7.1.1 Method A-1 (calcium chloride method)

Method A-1 (calcium chloride method) shall be as follows.

a) Apparatus and materials

- 1) **Thermohygrostat**, capable of maintaining the temperature and humidity at the specified value, and circulating the air inside the apparatus.
- 2) **Wind speed indicator**, capable of measuring the velocity inside the thermohygrostat with the precision of 0.1 m/s.
- 3) **Chemical balance**, capable of determining the mass of the test assembly with the precision of 1 mg.
- 4) **Disk plate**, in flat form, made of synthetic resin and 60 mm in diameter and 3 mm in thickness.
- 5) **Permeable cup**, as shown in figure 1, which is of a material not allowing permeation of water vapour, and which is free from corrosion and change of permeated area when it is subjected to the test procedure.
- 6) **Desiccant**, as specified in **JIS K 8125**.

Unit: mm

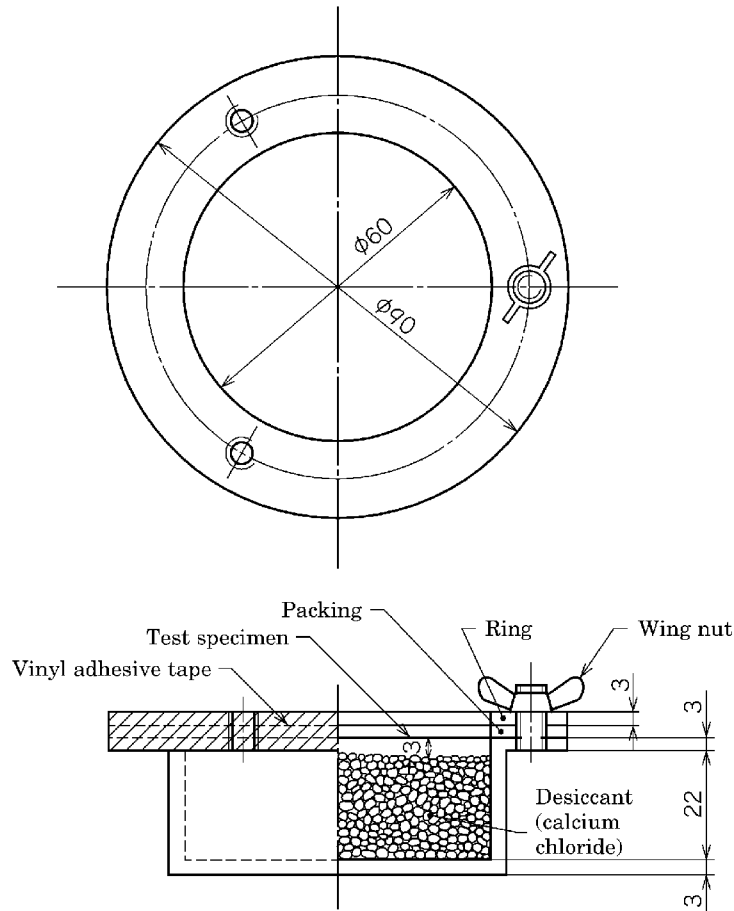


Figure 1 Permeable cup Method A-1 (calcium chloride method)

- b) **Operation** Put approximately 33 g of desiccant in a permeable cup which has been warmed at approximately 40 °C beforehand, make it uniform by vibrating the cup, then smoothen the surface by medical spoon and make the distance between the desiccant and the lower surface of the test specimen 3 mm by using a disk plate.

Prepare three test specimens of about 70 mm diameter as specified in clause 5, and as shown in figure 1, place the test specimen on the cup in such a way that its front surface faces the desiccant and it is concentric with the cup, and then put the packing and the ring in place and fix them with the wing nut. Seal the side periphery of the packing and the ring with vinyl adhesive tape and use this as a test assembly.

Place this test assembly in the position where the wind speed does not exceed 0.8 m/s at approximately 10 mm above the upper part of test specimen in a thermohygrostat maintained at 40 °C ± 2 °C and under (90 ± 5) %RH¹⁾.

Take out the specimen after 1 h and immediately weigh its mass (a_1) to the nearest 1 mg. After measuring, place the specimen again at the same position of the thermohygrostat. After 1 h, take out the specimen and immediately weigh the mass (a_2) to the nearest 1 mg.

Note ¹⁾ As occasion demands, the conditions of temperature and humidity may be altered. In any case, the temperature and humidity employed shall be mentioned in the test report.

- c) **Calculation** The water vapour permeability shall be calculated in accordance with the following formula (3) and the test result shall be expressed by the mean value of three tests rounded to an integer according to Rule B of **JIS Z 8401**:

$$P_{A1} = \frac{a_2 - a_1}{S_{A1}} \dots\dots\dots (3)$$

where, P_{A1} : water vapour permeability (g/m²·h)
 $a_2 - a_1$: change of mass of test assembly per hour (g/h)
 S_{A1} : permeated area (m²)

7.1.2 Method A-2 (water method)

Method A-2 (water method) shall be as follows.

a) **Apparatus and materials**

- 1) **Thermohygrostat**, specified in 7.1.1 a) 1).
- 2) **Wind speed indicator**, specified in 7.1.1 a) 2).
- 3) **Chemical balance**, specified in 7.1.1 a) 3).
- 4) **Permeable cup**, specified in 7.1.1 a) 5).

- b) **Operation** Pour 42 ml of water of approximately 40 °C in a permeable cup which has been warmed to approximately 40 °C beforehand, and make the distance between the water and the lower surface of the test specimen 10 mm. The water used shall be the purified water as specified in Japanese Pharmacopoeia or water of A2 or better as specified in **JIS K 0050**.

Prepare three test specimens of about 70 mm diameter as specified in clause 5, and place the test specimen on the cup in such a way that its rear surface faces the water and that it is concentric with the cup, and then put the packing and the ring in place and fix them with the wing nut. Seal the side periphery of the packing and the ring with an adhesive tape, and use this as a test assembly.

Place this test assembly at a position where the wind speed at approximately 10 mm above the upper part of test specimen does not exceed 0.8 m/s in a thermohygrostat maintained at 40 °C ± 2 °C and under (50 ± 5) %RH ¹⁾.

After 1 h, take out the test assembly and immediately weigh the mass (a_3) to the nearest 1 mg. After measuring, place the assembly again at the same position of the thermohygrostat. After 1 h, take out the assembly and immediately weigh the mass (a_4) to the nearest 1 mg.

Care shall be sufficiently taken in handling the specimen so as not to wet the test specimen by the water in permeable cup.

- c) **Calculation** The water vapour permeability shall be calculated in accordance with the following formula (4) and the test result shall be expressed by the mean value of three tests rounded to an integer according to Rule B of **JIS Z 8401**:

$$P_{A2} = \frac{a_3 - a_4}{S_{A2}} \dots\dots\dots (4)$$

where, P_{A2} : water vapour permeability ($\text{g}/\text{m}^2 \cdot \text{h}$)
 $a_3 - a_4$: change of mass of test assembly per one hour (g/h)
 S_{A2} : permeated area (m^2)

7.2 Method B

Method B is classified into method B-1 (potassium acetate method), method B-2 (alternative method I to the potassium acetate method) and method B.3 (alternative method II to the potassium acetate method), either of which shall be selected and performed.

7.2.1 Method B-1 (potassium acetate method)

Method B-1 (potassium acetate method) shall be as follows. This potassium acetate method is not applicable to test samples which allow permeation of water during the test. For these samples, the method described in 7.2.2 or 7.2.3 shall be applied.

a) Apparatus and materials

- 1) **Thermostat**, capable of regulating at the specified temperature.
- 2) **Chemical balance**, specified in 7.1.1 a) 3).
- 3) **Permeable cup**, as shown in figure 2, which is of a material not allowing permeation of water vapour, and which is free from corrosion and change of permeated area when it is subjected to the test procedure.
- 4) **Test specimen supporting frame**, made of synthetic resin and of a cylindrical form, approximately 80 mm in inside diameter, approximately 50 mm in height, and 3 mm in thickness.
- 5) **Water tank**, capable of being housed in the thermostat and having the structure capable of fixing the test specimen supporting frame.
- 6) **Auxiliary film for measuring water vapour permeability**, being polytetrafluoroethylene film of approximately 25 μm thickness having the micro porous structure of approximately 80 % porosity.
- 7) **Desiccant**, in the deposition state of crystal prepared by adding 100 ml of water to 300 g of potassium acetate specified in **JIS K 8363** and leaving to stand for 24 h.

Unit: mm

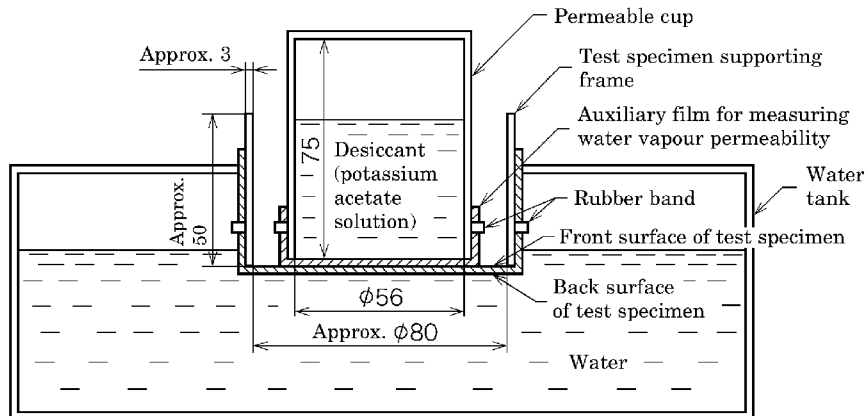


Figure 2 Test assembly Method B-1 (potassium acetate method)

b) **Operation** Prepare three test specimens of an approximate size of 200 mm × 200 mm as specified in clause 5, and fit the test specimen to the test specimen supporting frame by using rubber band so that the back surface of the test specimen faces outside of the supporting frame as shown in figure 2. Fix this test specimen supporting frame in a water tank containing water maintained at about 23 °C placed in the thermostat, in such a way that it is fully immersed in the water at approximately 10 mm water depth as shown in figure 2, and leave it to stand for 15 min or longer.

The air maintained at the temperature of 30 °C ± 2 °C is circulated in this thermostat.

Then, put the desiccant maintained at an approximate temperature of 23 °C in the permeable cup up to approximately two thirds of the volume of the permeable cup, fit the auxiliary film for measuring water vapour permeability approximately 100 mm × 100 mm in size by rubber band and use this as the test assembly. Weigh the mass (a_5) of this test assembly to the nearest 1 mg with the film-applied side facing up. After measuring, immediately make the specimen stand reversely and put it on the test specimen supporting frame fixed to the water tank. Take out the specimen after 15 min, turn it over and weigh the mass (a_6) to the nearest 1 mg.

c) **Calculation** The water vapour permeability shall be calculated in accordance with the following formula (5) and the test result shall be expressed by the mean value of three tests rounded to an integer according to Rule B of **JIS Z 8401**:

$$P_{B1} = \frac{a_6 - a_5}{S_{B1}} \dots\dots\dots (5)$$

where, P_{B1} : water vapour permeability ($\text{g}/\text{m}^2 \cdot \text{h}$)
 $a_6 - a_5$: change of mass of test assembly per 15 min (mg/min) converted to the change of mass in grammes per hour (g/h)
 S_{B1} : permeated area (m^2)

7.2.2 Method B-2 (alternative method I to the potassium acetate method)

Method B-2 (alternative method I to the potassium acetate method) shall be as follows.

- a) **Apparatus and materials** The apparatus and materials specified in 7.2.1 a) shall be used.
- b) **Operation** Prepare three test specimens of an approximate size of 200 mm × 200 mm as specified in clause 5, and cover the back surface of the test specimen with the auxiliary film for measuring water vapour permeability approximately 200 mm × 200 mm in size and fit it by rubber band with the auxiliary film facing the outside of the supporting frame as shown in figure 3. Fix this test specimen supporting frame in a water tank containing water maintained at about 23 °C placed in the thermostat, in such a way that it is fully immersed in the water at approximately 10 mm water depth as shown in figure 3, and leave it to stand for 15 min or longer.

The air maintained at the temperature of 30 °C ± 2 °C shall be circulated in this thermostat.

Then, put the desiccant maintained at an approximate temperature of 23 °C in the permeable cup up to approximately up to two thirds of the volume of the permeable cup, fit the auxiliary film for measuring water vapour permeability approximately 100 mm × 100 mm in size by rubber band and use this as the test assembly. Weigh the mass (a_7) of this test assembly to the nearest 1 mg with the film-applied side facing up. After measuring, immediately invert the specimen and put it on the test specimen supporting frame fixed to the water tank. Take out the specimen after 15 min, turn it over and weigh the mass (a_8) to the nearest to 1 mg.

Unit: mm

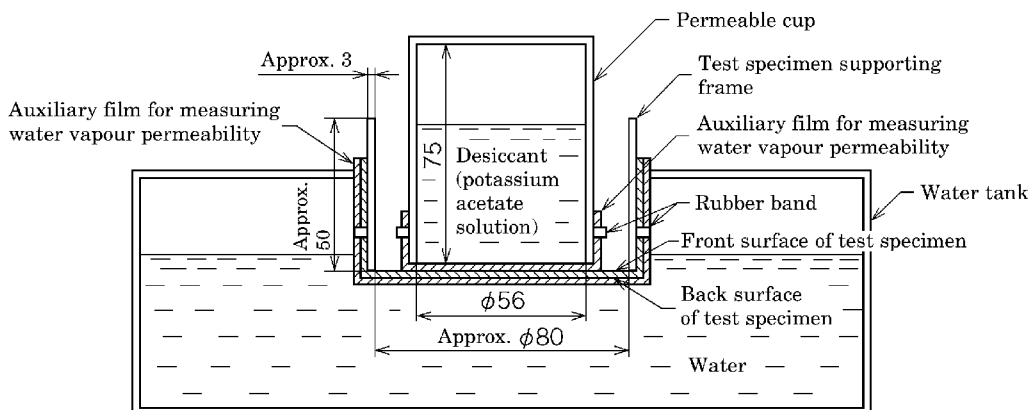


Figure 3 Test assembly Method B-2 (alternative method I to the potassium acetic method)

- c) **Calculation** The water vapour permeability shall be calculated in accordance with formula (6) and the test result shall be expressed by the mean value of three tests rounded to an integer according to Rule B of JIS Z 8401:

$$P_{B2} = \frac{a_8 - a_7}{S_{B2}} \dots\dots\dots (6)$$

where, P_{B2} : water vapour permeability ($\text{g}/\text{m}^2 \cdot \text{h}$)
 $a_8 - a_7$: change of mass of test assembly per 15 min
(mg/min) converted to the change of mass in
grammes per hour (g/h)
 S_{B2} : permeated area (m^2)

7.2.3 Method B-3 (alternative method II to the potassium acetate method)

Method B-3 (alternative method II to the potassium acetate method) shall be as specified in Annex A.

7.3 Method C (sweating-guarded hotplate method)

Method C (sweating-guarded hotplate method) shall be as specified in Annex B.

8 Test report

The test report shall contain the following information.

- a) Date of test
- b) Number of this Standard
- c) Testing method
- d) Test conditions (temperature and humidity at the testing location)
- e) Test results

Example 1 Date of test, **JIS L 1099**, Method A-1 (calcium chloride method), inside of apparatus 40 °C 90 %RH, 20 °C 65 %RH, 200 $\text{g}/\text{m}^2 \cdot \text{h}$

Example 2 Date of test, **JIS L 1099**, Method A-1 (calcium chloride method), inside of apparatus 35 °C 90 %RH, 25 °C 75 %RH, 200 $\text{g}/\text{m}^2 \cdot \text{h}$

Annex A (normative)

Method B-3 (alternative method II to the potassium acetate method)

This Annex has been prepared based on the first edition of **ISO 15496** published in 2004 without modifying the technical contents.

A.1 General

This Annex describes a comparatively simple method for testing the water vapour permeability of textiles that will provide the manufacturer with a clearly recognized method for quality control within the plant.

A.2 Symbols and units

Symbols and units shall be as follows.

Table A.1 Table of symbols and units

Symbol	Description	Unit
a	Area of measuring cup opening	m ²
Δt	Measuring time	h
Δm	Change in mass of the measuring cup during the period Δt	g
Δm_{app}	Change in mass of the measuring cup on the specimen holder with only membrane during the period Δt	g
Δp	Partial water vapour pressure difference across the specimen	Pa
p_{sa}	Saturated water vapour pressure at the test room temperature T_a	Pa
p_{sb}	Saturated water vapour pressure at the water bath temperature T_b	Pa
F	Relative humidity in equilibrium with saturated potassium acetate solution	%
T_a	Temperature in the test room	°C
T_b	Temperature of the water bath	°C
WVP	Water vapour permeability of the test specimen	g/m ² · Pa · h
WVP_{app}	Apparatus water vapour permeability	g/m ² · Pa · h

For the water vapour permeability (WVP) of test specimen, see Annex AA, and for the saturated water vapour pressure (p_{sa}) at the test room temperature T_a and the saturated water vapour pressure (p_{sb}) at the water bath temperature T_b , see Annex AB.

A.3 Principle

The specimen to be tested is placed, together with a waterproof but highly water vapour-permeable, hydrophobic, microporous membrane (hereafter referred to as “membrane”), on a ring holder and then put in a water bath so that the membrane is in contact with the water. This is then left for 15 min. A cup containing saturated potassium acetate solution, creating a relative humidity of about 23 % at the specimen’s upper face, and covered with a second piece of the same membrane, is weighed and

then inverted above the specimen in the ring holder, so that the membrane is in contact with the specimen. There will be a net transfer of water vapour through the specimen from the water side to the cup (see figure A.1). After 15 min the cup is taken off and re-weighed. At the same time a control test without a specimen is carried out to determine the water vapour permeability of the two membranes, the apparatus water vapour permeability. The water vapour permeability of the specimen can then be calculated, correcting for the influence of the two membranes.

A.4 Apparatus

The schematics of the test set-up are shown in figure A.1.

A.4.1 Membrane

Any membrane used shall be waterproof, microporous and hydrophobic. It shall have a high water vapour permeability, so that two layers of the membrane have a water vapour permeability of more than $1.2 \text{ g/m}^2 \cdot \text{Pa} \cdot \text{h}$.

A.4.2 Specimen holder

The specimen holder shall be a metal or plastic ring with a milled groove onto which the specimen in conjunction with the membrane is secured, using a rubber ring that fits into the groove, as shown in figure A.2.

The rubber ring shall fit tightly so that the specimen and membrane are held under tension.

The bottom outside edge of the specimen holder should be radiused (see figure A.2).

A.4.3 Support frame for specimen holders

The support frame should consist of two plastic plates, separated at an interval of 30 mm by spacers, that support the specimen in the water (see figure A.3). Both plates should have at least six holes cut out, those in the top plate being large enough to allow the holder with specimen and membrane to pass through. The holes in the lower plate are smaller than the specimen holder, but larger than the cup opening, and they are centred to the holes in the top plate.

The support frame is fitted with four vertically adjustable screws so that the specimen holder can be immersed to a depth of $5 \text{ mm} \pm 2 \text{ mm}$ in the water. The holes in the support frame should be sequentially numbered.

A.4.4 Water bath

The water bath shall consist of a transparent glass or plastic tank, large enough to accommodate the support frame, containing distilled water maintained at $23.0 \text{ }^\circ\text{C} \pm 0.1 \text{ }^\circ\text{C}$ by means of an immersion thermostat with a circulation pump.

The water temperature shall be measured in at least four positions simultaneously, adjacent to the four corners of the support frame.

In order to obtain a uniform temperature distribution in the water, the inlet or outlet pipe of the thermostat circulation pump shall be extended by means of a hose to the tank end opposite the thermostat. Care should be taken to prevent air bubble formation by either boiling the distilled water prior to use and/or reducing the speed of the thermostat agitator.

A.4.5 Measuring cup

A cup made from transparent plastic and having an internal diameter of between 85 mm and 95 mm, with a tolerance of ± 1 mm, and a volume of at least 250 ml (see figure A.2).

A.4.6 Potassium acetate solution

Saturated potassium acetate solution shall be made by thoroughly mixing of dry potassium acetate of pure reagent grade with distilled water in the ratio of 100 g potassium acetate to 31 g of water. The mixture shall be homogeneous and free of lumps; it shall be allowed to equilibrate at a temperature of $23\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ for a period of not less than 12 h. It shall be fluid enough to cover the membrane when the cup is inverted prior to testing.

The solution shall remain saturated (indicated by its white or opaque appearance) throughout the test.

A.4.7 Balance

A balance capable of determining a mass of approximately 50 g with a precision of ± 1 mg.

A.4.8 Test room

The test room shall be maintained at $23\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$.

A.5 Preparation

A.5.1 Test specimens

Cut three circular test specimens of the textile with diameter of approximately 180 mm. The membrane used as the specimen cover in the specimen holder should have a diameter of approximately 200 mm.

When the specimen is fitted onto the specimen holder, the side that during use would face the body shall be, unless otherwise requested, in contact with the specimen holder's membrane. Specimen and membrane shall be secured without creases or distortion on the specimen holder by means of a rubber ring. There shall be no air gaps between the specimen and membrane. Prepare a control specimen holder with membrane only, so that the apparatus water vapour permeability can be measured.

A.5.2 Measuring cups

Fill each measuring cup with approximately 120 g of the saturated potassium acetate solution and then seal with a circular piece of membrane. For this purpose, briefly roll the edges of the measuring cup against a hot iron or soldering iron, whilst keeping the membrane taut, e.g. by using a rubber band. Excess membrane should be trimmed in order that the contents of the cup can be seen. The cup seal should be tested for leaks prior to each measurement by inverting the cup over absorbent paper for about 3 min, which shall not become wet. The potassium acetate solution shall always be saturated (opaque or white) during the test.

A.6 Test procedure

A.6.1 Inserting the specimen and equilibration

Insert those specimen holders with textile and membrane, and the one with membrane only, into the support frame at $30 \text{ s} \pm 5 \text{ s}$ intervals in sequential order of the holes. Verify that there are no air bubbles between the membrane and water surface.

After $10 \text{ min} \pm 1 \text{ min}$ check the specimens for wrinkles and, if necessary, adjust without removal from the water bath.

The specimen holders shall be left on the bath for a total of $15 \text{ min} \pm 10 \text{ s}$ before the measuring cup is placed on the specimen.

A.6.2 Placing the measuring cups on the bath

Weigh (m_0) the measuring cups, invert and gently shake them to spread the potassium acetate solution evenly over the membrane, then centre them on the specimen surface at time intervals of $30 \text{ s} \pm 5 \text{ s}$, in the same order as the specimen holders were inserted into the support frame. Centre one cup on the control specimen holder with membrane only. Remove each cup $15 \text{ min} \pm 10 \text{ s}$ after having placed it on the specimen, and reweigh (m_{15}) it.

A.6.3 Check for waterproofness of the specimen holder membrane

Remove the specimen from the specimen holder and examine the membrane and the specimen for evidence of water leakage. If water leakage occurred, that particular specimen's value shall be excluded from the evaluation.

A.7 Calculation

Calculate the water permeability (*WVP*) of the specimen using equations (A.1) to (A.3) (see table A.1 for explanation of symbols).

$$\Delta m = m_{15} - m_0 \dots\dots\dots (A.1)$$

$$WVP_{\text{app}} = \frac{\Delta m_{\text{app}}}{a \times \Delta p \times \Delta t} \dots\dots\dots (A.2)$$

$$WVP = \left(\frac{a \times \Delta p \times \Delta t}{\Delta m} - \frac{1}{WVP_{\text{app}}} \right)^{-1} \dots\dots\dots (A.3)$$

The relative humidity in equilibrium with saturated potassium acetate solution at temperature T_a , expressed as a percentage, is

$$F = 22.4388 + 0.156288 \times T_a - (0.612868 \times 10^{-2}) \times T_a^2$$

If $T_a = T_b = 23.0 \text{ }^\circ\text{C}$ then $F = 22.8 \%$

and then,

$$\Delta p = \frac{P_{\text{sb}} - (P_{\text{sa}} \times F)}{100} = (2808 - 640) \text{ Pa} = 2168 \text{ Pa}$$

A.8 Precision of results

A.8.1 Repeatability (same apparatus)

Six laboratories tested two fabrics three times each. The mean of the standard deviation was $0.007 \text{ g/m}^2 \cdot \text{Pa} \cdot \text{h}$.

A.8.2 Reproducibility (different apparatuses)

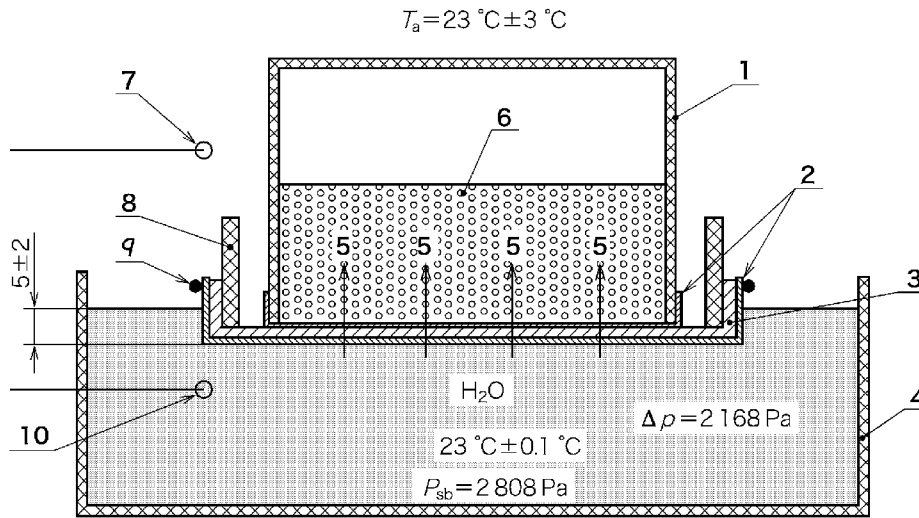
Six laboratories testing four specimens of four different fabrics with water vapour permeability ranging from $0.08 \text{ g/m}^2 \cdot \text{Pa} \cdot \text{h}$ to $0.24 \text{ g/m}^2 \cdot \text{Pa} \cdot \text{h}$ showed a standard deviation of $0.11 \text{ g/m}^2 \cdot \text{Pa} \cdot \text{h}$.

A.9 Test report

The test report shall include at least the following information.

- a) All information necessary for identification of the sample tested
- b) Number of this Standard
- c) Description of the test sample
- d) Orientation of the test specimens according to **A.6.1**
- e) Number of test specimens per sample
- f) Temperature in the test room: T_a and temperature the water bath: T_b during the test period
- g) Partial water vapour pressure difference across the specimens: Δp
- h) Water vapour permeability of test specimens: WVP
- i) Water vapour permeability of the test apparatus: WVP_{app}
- j) Any deviations from the procedure specified
- k) Any unusual features (anomalies) observed during the test
- l) Date of test

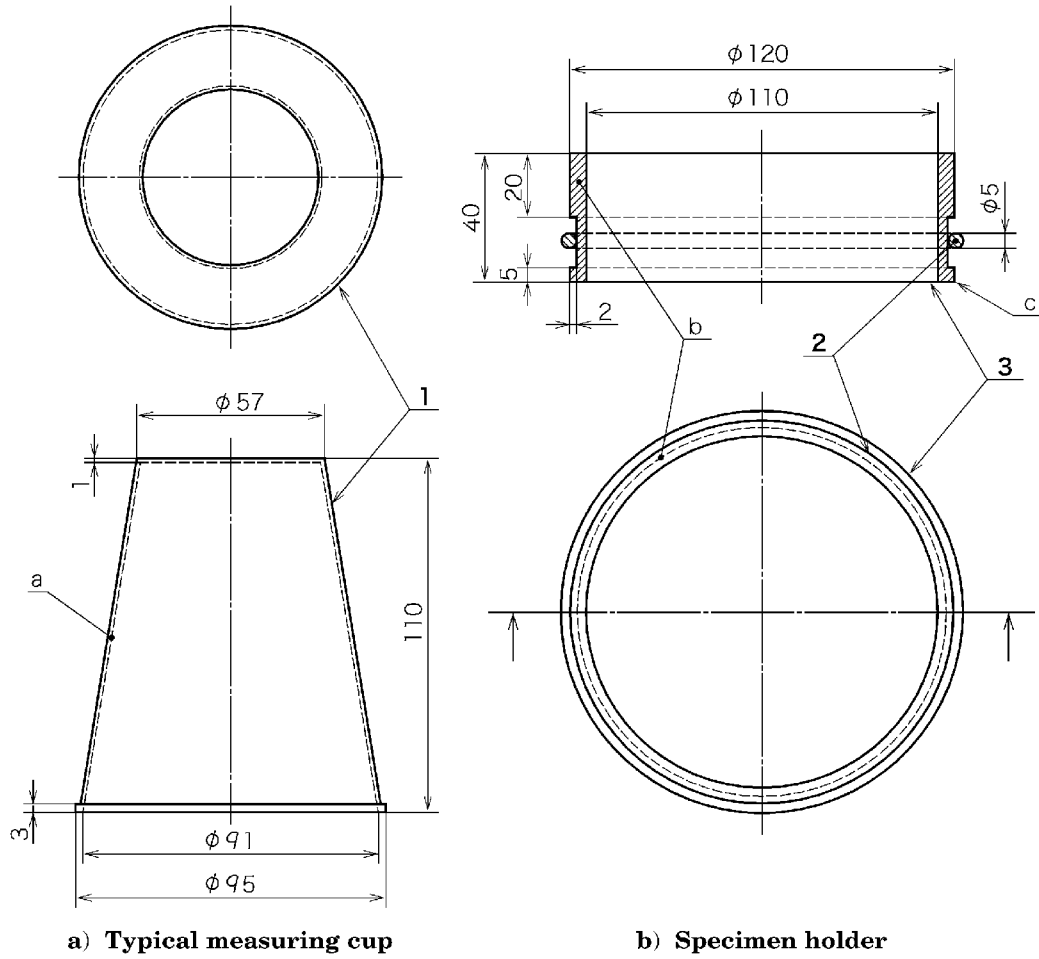
Unit: mm



- 1 Measuring cup
- 2 Membrane
- 3 Test specimen
- 4 Water tank
- 5 Water vapour
- 6 Saturated potassium acetate solution
- 7 Temperature sensor of the test room
- 8 Specimen holder
- 9 Rubber ring
- 10 Water temperature sensor

Figure A.1 Schematical test arrangement for the cup method

Unit: mm



- 1 Measuring cup
- 2 Rubber ring
- 3 Specimen holder
- a Plastic
- b Metal or plastic
- c Radiused edge

Figure A.2 Typical dimensions of measuring cup and specimen holder

Annex AA (informative)

Water vapour permeability—Application of test results

This Annex has been prepared based on Annex A of the first edition of **ISO 15496** published in 2004 without modifying the technical contents, and does not constitute a part of the provisions.

AA.1 Summary

Because the test conditions are different, the *WVP* values of table A.1 could be substantially different from the W_d (water vapour permeability) values derived from **ISO 11092**. Therefore, the *WVP* results cannot be used in the classification of physiological effects of textiles where **ISO 11092** is cited as the test method. A deviation from the water bath and test room temperatures of $23.0\text{ °C} \pm 0.1\text{ °C}$ and $23\text{ °C} \pm 3\text{ °C}$, respectively, as specified in **A.4.4**, can significantly change the test results.

Annex AB (informative)

Physical principle behind the test method

This Annex has been prepared based on Annex B of the first edition of **ISO 15496** published in 2004 without modifying the technical contents, and does not constitute a part of the provisions.

Water vapour is transported from a region with high water vapour pressure to a region with lower water vapour pressure.

The high water vapour pressure is maintained by a water surface kept at constant temperature. The water vapour pressure is calculated by the following formula, showing that the pressure is highly dependent on the water bath temperature T_b .

$$p_{sb} = 133.3 \times 10 \exp\{-[2\,919.611/(T_b + 273) - 4.795\,18 \times \lg(T_b + 273) + 23.037\,33]\}$$

Example:

Water bath temperature (T_b) °C	Water vapour pressure (p_{sb}) Pa
20	2 336
23	2 808

The relative humidity (%) of a water surface can for all practical purposes be considered to be 100 %.

The lower water vapour pressure is maintained in the air inside the pores of the membrane by a saturated aqueous solution of potassium acetate kept at constant temperature. The relative humidity (F) is calculated by the following formula, showing that it is not very temperature dependent.

$$F = 22.438\,8 + 0.156\,288 T_a - (0.006\,128\,68) \times T_a^2$$

Example:

Air temperature (T_a) °C	Relative humidity (F) %
20	23.1
23	22.8

Water vapour pressure p_{sa} is calculated as

$$p_{sa} = 133.3 \times 10 \exp\{-[2\,919.611/(T_a + 273) - 4.795\,18 \times \lg(T_a + 273) + 23.037\,33]\}$$

The partial water vapour pressure difference Δp varies largely with a variation of the temperature of the water bath T_b .

Example:

Water bath temperature (T_b) °C	Partial water vapour pressure difference (Δp) Pa
20	1 799
23	2 168

At the lower temperature the pressure gradient is also lower, giving a lower transport of water vapour, which implies a smaller mass differential to be weighed, thus decreasing the accuracy of the test method. This is the reason why in this Annex the water bath temperature was chosen as 23 °C, and the tolerance allowed is only ± 0.1 °C.

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Annex AC (informative)

Dry desiccant cup methods

This Annex has been prepared based on Annex C of the first edition of **ISO 15496** published in 2004 without modifying the technical contents, and does not constitute a part of the provisions.

Dry desiccant cup methods, as specified in a number of national standards, are unsuitable for measuring the water vapour permeability of textiles, for the purpose of this Standard, for the following reasons.

- a) With “breathable” textiles the amount of water vapour diffusing into the cup can be so high that the desiccant becomes saturated at its surface. Thus, the test result is not representative of the test specimen’s water vapour permeability, but expresses the desiccant’s absorbance characteristic. Furthermore, above a certain level of breathability, all textiles give approximately the same result, not showing the true difference in the water vapour permeability of textiles.
- b) The unavoidable air gap between the test specimen and the desiccant surface in many cases has a far lower water vapour permeability than the specimen. Because this air gap’s water vapour permeability cannot be determined with sufficient accuracy, it invalidates the test result.
- c) The measuring time of several hours is adverse to the demand for a quick test which gives the manufacturer the opportunity for timely corrections to the production process, if deviations from expected water vapour permeability of the textile are found.
- d) The test specimen must be sealed to the cup with adhesive, with which it is often difficult to achieve the necessary seal, and after the test the adhesive has to be cleaned from the cup. These procedures are cumbersome and time-consuming, which are incompatible with the demand for a quick test method with easy handling.

Annex B (normative)

Method C (sweating guarded-hotplate method)

This Annex has been prepared based on the first edition of ISO 11092 published in 1993 without modifying the technical contents.

B.1 General

This Annex specifies methods for the measurement of the thermal resistance and water vapour resistance, under steady-state conditions, of e.g. fabrics, films, coatings, foams and leather, including multilayer assemblies, for use in textile or textile-like products.

B.2 Symbols and units

Symbols and units shall be as given in table B.1.

Table B.1 Symbols and units

Symbol	Description	Unit
R_{ct}	Thermal resistance m^2	$m^2 \cdot K/W$
R_{et}	Water vapour resistance	$m^2 \cdot Pa/W$
i_{mt}	Water vapour permeability index	—
R_{ct0}	Apparatus constant for the measurement of thermal resistance	$m^2 \cdot K/W$
R_{et0}	Apparatus constant for the measurement of water-vapour resistance	$m^2 \cdot Pa/W$
W_d	Water vapour permeability	$g/m^2 \cdot h \cdot Pa$
ϕT_m	Latent heat (at the temperature T_m)	$W \cdot h/g$
A	Area of the measuring unit	m^2
p_a	Water vapour partial pressure (at the temperature T_a)	Pa
T_a	Air temperature	K
T_m	Temperature of the measuring unit	K
T_s	Temperature of the thermal guard	K
p_m	Saturation water vapour partial pressure (at the temperature T_m)	Pa
v_a	Speed of air	m/s
s_v	Standard deviation of air speed	m/s
F	Relative humidity	%
H	Heating power supplied	W
ΔH_c	Correction term for heating power supplied (for measurement of R_{ct})	W
ΔH_e	Correction term for heating power supplied (for measurement of R_{et})	W
α	Slope of the correction line	—
β	Slope of the correction line	—

B.3 Principle

The specimen to be tested is placed on an electrically heated plate with conditioned air ducted to flow across and parallel to its upper surface.

For the determination of thermal resistance, the heat flux through the test specimen is measured after steady-state conditions have been reached. The technique described in this Annex enables the thermal resistance of a material to be determined by subtracting the thermal resistance of the boundary air layer above the surface of the test apparatus from that of a test specimen plus boundary air layer, both measured under the same conditions.

For the determination of water vapour resistance, an electrically heated porous plate is covered by a water vapour permeable but liquid-water impermeable membrane 40 μm in thickness (13 of figure B.2). Water fed to the heated plate evaporates and passes through the membrane as vapour, so that no liquid water contacts the test specimen.

With the test specimen placed on the membrane, the heat flux required to maintain a constant temperature at the plate is a measure of the rate of water evaporation, and from this the water vapour resistance of the test specimen is determined. The technique described in this Annex enables the water vapour resistance of a material to be determined by subtracting the water vapour resistance of the boundary air layer above the surface of the test apparatus from that of a test specimen plus boundary air layer, both measured under the same conditions.

B.4 Apparatus

B.4.1 Measuring unit, with temperature and water supply control

The measuring unit, with temperature and water supply control shall consist of a metal plate (1 in figure B.1) approximately 3 mm thick with a minimum area of 0.04 m² (e.g. a square with each side 0.2 m in length) fixed to a conductive metal block containing an electrical heating element as shown in 6 in figure B.1.

For the measurement of water vapour resistance, the metal plate shown in 1 in figure B.1 must be porous. It is surrounded by a thermal guard shown in 9 in figure B.2 which is in turn located within an opening in a measuring table.

The coefficient of radiant emissivity of the plate surface shall be not less than 0.35, measured at 20 °C between the wavelengths 8 μm to 14 μm , with the primary beam perpendicular to the plate surface and the reflection hemispherical.

Channels are machined into the face of the heating element block where it contacts the porous plate to enable water to be fed from a dosing device (5 in figure B.1). The position of the measuring unit with respect to the measuring table shall be adjustable, so that the upper surface of test specimens placed on it can be made coplanar with the measuring table. Heat losses from the wiring to the measuring unit or to its temperature-measuring device should be minimized, e.g. by leading as much wiring as possible along the inner face of the thermal guard.

The temperature controller (3 in figure B.1), including the temperature sensor (2 in figure B.1) of the measuring unit (8 in figure B.2), shall maintain the temperature T_m of the measuring unit constant to within ± 0.1 °C.

The heating power H shall be measurable by means of a suitable device to within $\pm 2\%$ over the whole of its usable range. Water is supplied to the surface of the porous metal plate by a dosing device (5 in figure B.1) such as a motor-driven burette. The dosing device is activated by a switch which senses when the level of water in the plate falls more than approximately 1 mm below the plate surface, in order to maintain a constant rate of evaporation.

Before entering the measuring unit, the water shall be preheated to the temperature of the measuring unit. This can be achieved by passing it through tubes in the thermal guard before it enters the measuring unit.

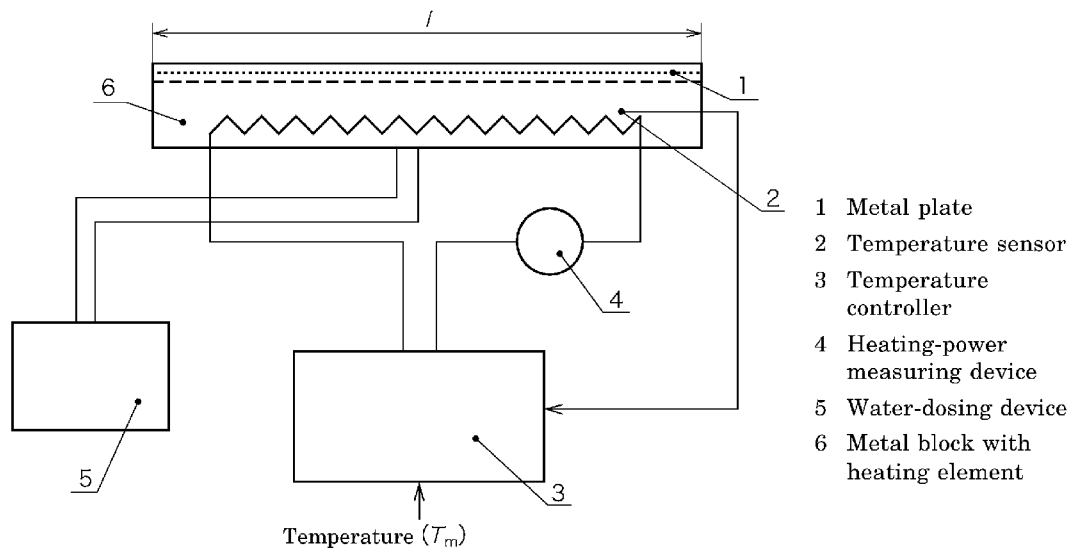


Figure B.1 Measuring unit with temperature and water supply control

B.4.2 Thermal guard with temperature control

The thermal guard with temperature control (9 in figure B.2) shall consist of a material with high thermal conductivity, typically metal and containing electrical heating elements. Its purpose is to prevent heat leakage from the sides and bottom of the measuring unit.

The width b of the thermal guard should be a minimum of 15 mm. The gap between the upper surface of the thermal guard and the metal plate of the measuring unit shall not exceed 1.5 mm.

The thermal guard may be fitted with a porous plate and water-dosing system similar to that of the measuring unit to form a moisture guard. The thermal guard temperature (T_s) measured by the temperature sensor shown in 11 in figure B.2 shall, by means of the controller shown in 10 of figure B.2, be maintained at the same temperature as the measuring unit (T_m) to within $\pm 0.1\text{ }^\circ\text{C}$.

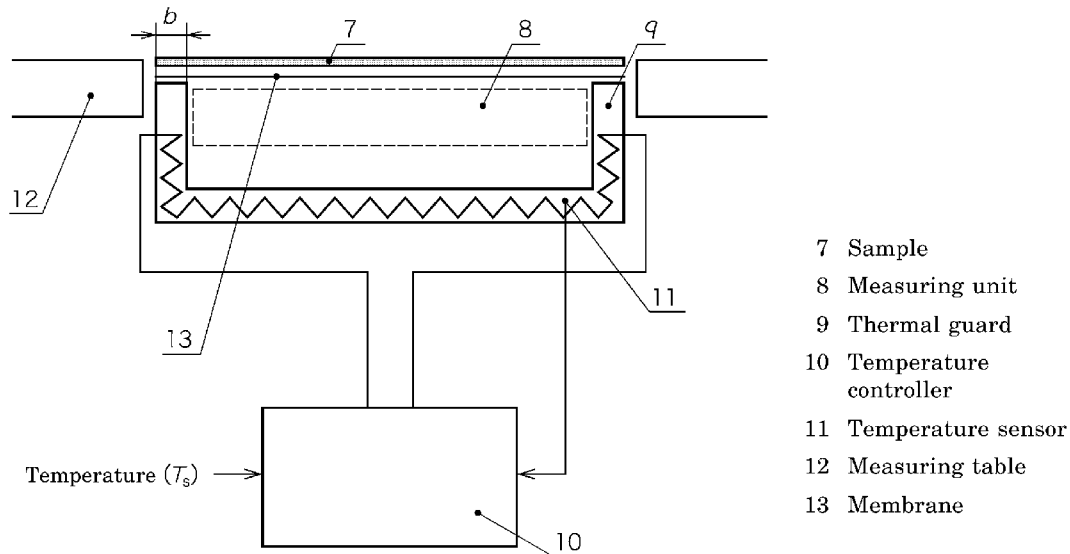


Figure B.2 Measuring unit and thermal guard with temperature controller

B.4.3 Test enclosure

The test closure, provided with measuring unit and thermal guard, and in which the ambient air temperature and humidity are controlled shall be used. The conditioned air shall be ducted so that it flows across and parallel to the upper surface of the measuring unit and thermal guard.

In order that the drift of the temperature (T_a) of this air flow does not exceed $20\text{ }^\circ\text{C} \pm 0.1\text{ }^\circ\text{C}$ for the duration of a test, the height of the duct above the measuring table shall not be less than 50 mm. For the measurement of thermal resistance and water vapour resistance values below $100\text{ m}^2 \cdot \text{Pa}/\text{W}$, an accuracy of $\pm 0.5\text{ }^\circ\text{C}$ is sufficient. The temperature (T_a) of this air flow is measured at a point 15 mm above the measuring table over the centre of the uncovered measuring unit.

The drift of the relative humidity RH of this air flow shall not exceed $\pm 3\%$ for the duration of a test. The air speed (v_a) measured at this point shall have a mean value of 1 m/s, with the drift not exceeding $\pm 0.05\text{ m/s}$ for the duration of a test. It is important that at this point the air flow shall have a certain degree of turbulence expressed by the related variation in air speed s_v/v_a of between 0.05 and 0.1, measured at approximately 6 s intervals over a time period of at least 10 min with an instrument which has a time constant of less than 1 s.

B.5 Preparation of test specimens

B.5.1 Materials of thickness 5 mm or under

Test specimens shall completely cover the surfaces of the measuring unit and thermal guard. From each material to be tested, three test specimens shall be cut and tested, each having a size of $200\text{ mm} + 2b\text{ mm}$ (b is the width of thermal guard shown in figure B.2) if the measuring unit (8 in figure B.2) is $200\text{ mm} \times 200\text{ mm}$ in size. Before testing, specimens shall be conditioned for a minimum of 12 h at the temperature and humidity specified in either B.6.3 or B.6.4 as appropriate.

B.5.2 Materials of thickness over 5 mm

Preparation of test specimens of materials of thickness over 5 mm shall be as follows.

- a) For avoiding loss of heat or water vapour from their edges of the specimens, the following correction shall be made.

In the measurement of thermal resistance, corrections for thermal edge losses are necessary if the specimen thickness is greater than approximately twice the width b of the thermal guard (see figure B.2). The deviation from the linear relationship between thermal resistance and specimen thickness can be determined and corrected by the factor $[1 + (\text{actually measured value of } \Delta R_{ct}/R_{ct})]$ using the measurement of the values for several thicknesses of a homogeneous material such as foam, up to a total thickness (d), as shown in figure B.3, of at least that of the specimen to be tested.

- b) If the thermal guard is not fitted with a porous plate and water-dosing system similar to that of the measuring unit, for the measurement of water vapour resistance the vertical sides of the cut specimens shall be surrounded by a water vapour impermeable frame of approximately the same height as that of the free-standing specimen.

The inner dimensions of the frame shall be the same on all sides as those of the porous plate of the measuring unit.

- c) Before testing, specimens shall be conditioned for a minimum of 24 h at the temperature and humidity specified in either **B.6.3** or **B.6.4** as appropriate.
- d) Specimens containing loose filling materials or having uneven thickness such as quilts and sleeping bags, require a special mounting procedure as described in Annex BA.

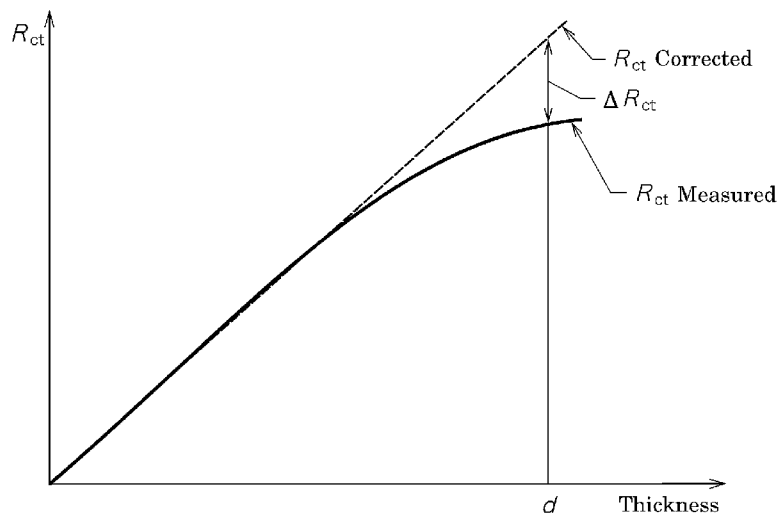


Figure B.3 Corrections for thermal edge losses during the measurement of thermal resistance

B.6 Test procedure

B.6.1 Determination of apparatus constants

In the values for thermal and water vapour resistance measured with the device described in this Standard, constants intrinsic to the apparatus are included. These constants comprise the resistance within the measuring unit itself, plus that of the boundary air layer adhering to the surface of the test specimen. The latter is dependent on the speed and degree of turbulence of the air flowing over the test specimen.

These apparatus constants, R_{ct0} , R_{et0} , are determined as “bare plate” values, and it is essential that the upper surface of the measuring unit is coplanar with the measuring table.

B.6.1.1 Determination of R_{ct0}

For the determination of R_{ct0} set the temperature of the measuring unit (T_m) at 35 °C and the air temperature (T_a) at 20 °C with a relative humidity (F) of 65 %. Set the air speed (v_a) at 1 m/s. Any deviations from these values shall be within the limits stated in clause B.4. Wait until the measured quantities T_m , T_a , F and H reach steady-state before recording their values.

The apparatus constant for the measurement of thermal resistance (R_{ct0}) is determined from equation (B.1):

$$R_{ct0} = \frac{(T_m - T_a) \times A}{H - \Delta H_c} \dots\dots\dots (B.1)$$

where, ΔH_c is a correction term and is determined as described in Annex BB.

B.6.1.2 Determination of R_{et0}

R_{et0} shall be determined as follows.

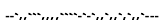
- a) During the determination of R_{et0} , the surface of the porous plate specified in B.4.1 is kept constantly moist. A smooth, water vapour permeable but liquid-water impermeable cellophane membrane of thickness 10 µm to 50 µm shall be fitted over the porous plate.

The cellophane membrane shall be moistened with distilled water and fixed to the measuring plate by appropriate means so that it remains completely free of wrinkles. The water supplied to the measuring plate shall be distilled, preferably double-distilled and reboiled prior to use so that it is free of gas in order to prevent the formation of gas bubbles beneath the membrane.

- b) Set the temperature of both the measuring unit (T_m) and the air temperature (T_a) at 35 °C, and set the air speed (v_a) at 1 m/s. The relative humidity (F), of the air shall be kept constant at 40 %, corresponding to a water vapour partial pressure (p_a) of 2 250 Pa.

The water vapour partial pressure (p_m) directly at the surface of the measuring unit can be assumed equal to the saturation vapour pressure at the temperature of this surface, i.e. 5 620 Pa, without compromising the accuracy of the test.

Any deviations from the above values of T_m , T_a , v_a and F shall be within the limits stated in B.4. Wait until the measured quantities T_m , T_a , F and H reach steady-state before recording their values.



- c) The apparatus constant for measurement of water vapour resistance R_{e10} is determined from equation (B.2):

$$R_{e10} = \frac{(p_m - p_a) \times A}{H - \Delta H_c} \dots\dots\dots (B.2)$$

where, ΔH_c is a correction term and is determined as described in Annex BB.

B.6.1.3 Reference material

A useful cross-check of the apparatus can be obtained by measuring a precalibrated thermal resistance material, e.g. a reference material for thermal conductivity.

B.6.1.4 Recalibration

Check the apparatus constants R_{ct0} and R_{e10} at regular intervals.

Where deviations greater than the accuracy of the measuring device occur (see **B.7**), an adjustment shall be made.

In most cases a change in R_{ct0} and R_{e10} is caused by a deviation in the speed of the air (v_a) over the surface of the test specimen. Air speed should be checked at regular intervals by the technique described in **B.4.3**.

The air flow (both speed and degree of turbulence) over the surface of the test specimen influences the resistance of the boundary layer which adheres to the outer surface of the specimen, and thus influences the test result.

B.6.2 Assembly of test specimens on the measuring unit

The assembly of test specimens on the measuring unit shall be as follows.

- a) Where appropriate, the orientation of the test specimens with respect to the air flow shall be defined and described in the test report.

The test specimens shall be placed so that they lie flat across the measuring unit, with the side normally facing the human body towards the measuring unit. In the case of multiple layers, specimens shall be arranged and stacked on the measuring unit as on the human body. Water vapour impermeable adhesive tape or a light metal frame may be used around the edges of the test specimen to keep it flat. Bubbles and wrinkles in the test specimen, or air gaps between the specimen and measuring unit or between the components of multilayer specimens, shall be prevented provided they are not specific to the surface profile of the specimens.

- b) Normally, test specimens are measured free from stretch or loading and in the case of multiple layers, without air gaps between layers. However, if a test is carried out under extension or applied pressure or with air gaps, this shall be mentioned in the test report.

- c) With test specimens thicker than 3 mm, the measuring unit shall be lowered so that the outer surface of the specimen is flush with the measuring table.

B.6.3 Measurement of thermal resistance R_{ct}

Thermal resistance R_{ct} shall be measured as follows.

- a) Set the temperature of the measuring unit (T_m) at 35 °C and the air temperature (T_a), at 20 °C with a relative humidity (F) of 65 %. Set the air speed (V_A) at 1 m/s. Any deviations from these values shall be within the limits stated in **B.4**. Other conditions of air temperature (T_a), relative humidity (F) and air speed (v_a) may be used. The test report shall describe the alternative conditions and shall include a statement to the effect that the results differ from those of tests carried out under the conditions stated in this Standard.

After placing the test specimen on the measuring unit, wait until the measured quantities T_m , T_a , F and H reach steady-state before recording their values.

- b) Calculate the thermal resistance (R_{ct}) from equation (B.3):

$$R_{ct} = \frac{(T_m - T_a) \times A}{(H - \Delta H_c)} - R_{ct0} \dots\dots\dots (B.3)$$

where, the symbols and units are as defined in table B.1. Calculate the thermal resistance (R_{ct}) of the material being tested as the arithmetic mean of the individual measurements.

B.6.4 Measurement of water vapour resistance R_{et}

Water vapour resistance R_{et} shall be measured as follows.

- a) For the measurement of water vapour resistance, a water vapour permeable but liquid-water impermeable cellophane membrane shall be fitted over the surface of the measuring unit as described in **B.6.1.2**.
- b) Set the temperature of the measuring unit (T_m) and the temperature of the air (T_a) at 35 °C, with a relative humidity (F) of 40 %. Set the air speed (v_a) at 1 m/s. Any deviations from these values shall be within the limits stated in **B.4**. These isothermal conditions prevent water vapour condensation within the test specimen. Other conditions of relative humidity (F) and air speed (v_a) may be used. The test report shall describe the alternative conditions and shall include a statement to the effect that the results may differ from those of tests carried out under the conditions stated in this Standard.

If the air temperature (T_a) is changed, the test is non-isothermal and this Standard no longer applies. After placing the test specimen on the measuring unit, wait until the measured quantities T_m , T_a , F and H have reached steady-state before recording their values.

- c) Calculate the water vapour resistance from equation (B.4):

$$R_{et} = \frac{(p_m - p_a) \times A}{H - \Delta H_c} - R_{et0} \dots\dots\dots (B.4)$$

where, the symbols and units are defined in table B.1. Calculate the water vapour resistance R_{et} of the material being tested as the arithmetic mean of the individual measurements

B.7 Precision of results

B.7.1 Repeatability (same apparatus)

For thermal resistance (R_{ct}), the precision of repeated measurements on the same specimens with values up to $50 \times 10^{-3} \text{ m}^2 \cdot \text{K/W}$ has been found to be $3.0 \times 10^{-3} \text{ m}^2 \cdot \text{K/W}$, as measured on single layers of fabrics. With R_{ct} values higher than $50 \times 10^{-3} \text{ m}^2 \cdot \text{K/W}$, the precision has been found to be about 7 %, as measured on foams.

For water vapour resistance (R_{et}), the precision of repeated measurements on the same specimens with values up to $10 \text{ m}^2 \cdot \text{Pa/W}$ has been found to be $0.3 \text{ m}^2 \cdot \text{Pa/W}$, as measured on single layers of fabrics. With R_{et} values higher than $10 \text{ m}^2 \cdot \text{Pa/W}$, the precision has been found to be about 7 %, as measured on foams.

B.7.2 Reproducibility (different apparatuses)

In an interlaboratory trial using three specimens of a foam material of 3 mm, 6 mm and 12 mm thickness tested in four laboratories, an average standard deviation of $6.5 \times 10^{-3} \text{ m}^2 \cdot \text{K/W}$ for R_{ct} and of $0.67 \text{ m}^2 \cdot \text{Pa/W}$ for R_{et} was found.

B.8 Test report

The test report shall include at least the following information.

- a) Number of this Standard
- b) Complete description of the material to be tested
- c) Arrangement of test specimens according to **B.6.2**
- d) Number of test specimens per material to be tested and number of individual measurements on each test specimen
- e) Test climate
- f) Arithmetic mean value of the thermal resistance and/or arithmetic mean value of the water vapour resistance
- g) Details of deviations from this Annex
- h) Date of test

Annex BA (normative)

Mounting procedure for specimens containing loose filling materials or having uneven thickness

This Annex has been prepared based on Annex A of the first edition of **ISO 11092** published in 1993 without any modifications of the technical contents.

BA.1 For samples containing loose filling materials or having uneven thickness, such as quilts and sleeping bags, a minimum of three test specimens shall be cut if possible. If not possible, the actual number of specimens tested shall be noted in the test report. With material composites such as quilts and sleeping bags which are of uneven thickness due to quilting, a minimum of two test specimens each are prepared for the measurement of thermal and water vapour resistance.

BA.2 These specimens shall be placed into frames of approximately the same height as that of the free-standing specimen. For the measurement of thermal resistance (R_{ct}), the inner dimensions of these frames shall be at least $1 \text{ mm} + 2b \text{ mm}$ (see figure B.1 and figure B.2).

For the measurement of water vapour resistance (R_{et}) the inner dimensions of the frames shall be the same on all sides as those of the porous plate of the measuring unit.

BA.3 Select the two specimens so that one has the maximum possible number of quiltings and the other the minimum possible number of quiltings located in their central areas.

Annex BB (normative)

Determination of correction terms for heating power

This Annex has been prepared based on Annex B of the first edition of ISO 11092 published in 1993 without any modifications of the technical contents.

BB.1 During the measurement of thermal resistance and water vapour resistance, the temperatures of the measuring unit and the thermal guard are set to the same value. However, the tolerances stated in **B.4.1** and **B.4.2** in practice may cause slight differences in temperature between measuring unit and thermal guard. In such cases the heating power supplied to the measuring unit does not equal the heat flux through the test specimen. This shall be taken into account by the application of correction terms ΔH_c or ΔH_e for the measurement of thermal resistance or water vapour resistance, respectively.

BB.2 The correction term for heating power (ΔH_c) is linearly related to the difference in temperature between measuring unit and thermal guard, as given by equation (BB.1):

$$\Delta H_c = \alpha(T_m - T_s) \dots\dots\dots (BB.1)$$

- where, α : slope of the correction line
 T_m : temperature of the measuring unit
 T_s : temperature of the thermal guard

The slope α is determined as follows.

The measuring unit and thermal guard are covered with a material of high thermal insulation (e.g. foam with a thickness of 40 mm) the air temperature is set to 20 °C, with the temperature of the measuring unit at 35 °C. The thermal guard shall be maintained as a temperature of 34 °C to 36 °C in steps of 0.2 °C by means of a temperature controller. After steady-state is reached at each setting, the heating power supplied to the measuring unit is recorded. A linear regression of this heating power versus the difference in temperature between measuring unit and thermal guard give a straight line with slope α .

BB.3 The correction term for heating power (ΔH_e) is determined as given by equation (BB.2):

$$\Delta H_e = \beta(T_m - T_s) \dots\dots\dots (BB.2)$$

- where, β : slope of the correction line
 T_m : temperature of the measuring unit
 T_s : temperature of thermal guard

The slope β is determined as follows.

The measuring unit is covered by a water vapour permeable membrane as described in **B.6.1.2** and supplied with water by the dosing device. The measuring unit and thermal guard are covered by a water vapour impermeable material (e.g. polyethylene

terephthalate film) and a material of high thermal insulation (e.g. foam with a thickness of 40 mm). The air temperature is set to 35 °C with a relative humidity RH of 40 % and the temperature of the thermal guard is set to 35 °C.

The temperature of the measuring unit is raised relative to the thermal guard in steps of 0.2 °C. After steady-state is reached at each setting, the heating power supplied to the measuring unit is recorded. The regression line of this heating power versus the difference in temperature between measuring unit and thermal guard gives the slope β .

BB.4 The slopes α and β for the correction terms for heating power shall be checked after changes or repairs to the apparatus.

Bibliography

- JIS K 6549 *Testing method for water vapour permeability of leather*
- JIS Z 0208 *Testing methods for determination of the water vapour transmission rate of moisture-proof packaging materials (dish method)*
- ISO 2528:1995 *Sheet materials—Determination of water vapour transmission rate—Gravimetric (dish) method*

Annex JA (informative)
Comparison table between JIS and corresponding International Standards

JIS L 1099:2012 <i>Testing methods for water vapour permeability of textiles</i>		ISO 11092:1993 <i>Textiles—Physiological effects—Measurement of thermal and water vapour resistance under steady-state conditions (sweating guarded-hotplate test)</i>		ISO 15496:2004 <i>Textiles—Measurement of water vapour permeability of textiles for the purpose of quality control</i>	
(I) Requirements in JIS		(II) International Standard number		(III) Requirements in International Standard	
No. and title of clause	Content	No. of clause	Content	Classification by clause	Detail of technical deviation
1 Scope	This Standard specifies the testing methods for water vapour permeability of textiles.	1	This International Standard specifies methods for the measurement of the thermal resistance and water vapour resistance of textile products, and also materials, film coating products and multilayer assemblies thereof for use in textile products.	Alteration	The method specified in ISO is intended to measure the thermal resistance and water vapour resistance of textiles and multilayer assemblies by simulating the processes of the said products occurring next to human skin, whereas the method specified in JIS is intended to measure the water vapour permeability of textiles by weighing the mass.
		1	This International Standard describes a comparatively simple method for testing the water vapour permeability for quality control.	Addition	JIS adds the test method other than those specified in ISO .
					(V) Justification for the technical deviation and future measures This deviation from the ISO is a result of reflecting the actual usage of this Standard in Japan. Reviewing will be made of this matter, including possibilities of harmonizing with ISO standards.

(I) Requirements in JIS		(II) International Standard number		(III) Requirements in International Standard		(IV) Classification and details of technical deviation between JIS and the International Standard by clause		(V) Justification for the technical deviation and future measures	
No. and title of clause	Content	No. of clause	Content	Classification by clause	Detail of technical deviation				
2 Normative references									
3 Terms and definitions	3.1 water-vapour permeability 3.2 porosity Other resistance values are defined.	2	The water-vapour permeability (WVP) and other resistance values are defined.	Alteration	Since JIS has adopted a method not given in ISO standard, the terms defined in JIS are those relevant to the JIS method.			This deviation from the ISO is a result of reflecting the actual usage of this Standard in Japan. Reviewing will be made of this matter, including possibilities of harmonizing with ISO standards.	
4 Testing location	Testing location shall be in accordance with, or closest possible to the standard conditions specified in JIS L 0105.	5.3	The test enclosure in which the ambient temperature and humidity are controlled is specified.	Alteration	Deviation due to difference in the test method applied.				
5 Sampling and preparation of test specimens	Sampling and preparation of test specimens shall be in accordance with JIS L 0105.	6 6.1	Practically identical with JIS.	Addition	In JIS, sampling from textiles and products and preparation of test specimens are specified in details through reference to 6.3 and 6.4 of JIS L 0105.				Reviewing will be made of this matter on the occasion of next revision of ISO, including possibilities of harmonizing with ISO standards.
		5.8	The temperature specified is 23 °C ± 3 °C.	Alteration	Deviation due to difference in the test method applied.			—	

(I) Requirements in JIS		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between JIS and the International Standard by clause		(V) Justification for the technical deviation and future measures
No. and title of clause	Content	No. of clause	Content	Classification by clause	Detail of technical deviation		
6	Classification of tests	ISO 11092 ISO 15496	—	Selection	In JIS, specification contents not given in ISO standards are added, permitting selection of one among all the presented methods.	Reviewing will be made of this matter on the occasion of next revision of ISO, including possibilities of harmonizing with ISO standards.	
7	Test methods					This deviation from the ISO is a result of reflecting the actual usage of this Standard in Japan. Reviewing will be made of this matter, including possibilities of harmonizing with ISO standards.	
7.1.1	Method A-1 (calcium chloride method)	—	—	Addition	In JIS, method A-1 (calcium chloride method) is added.		
7.1.2	Method A-2 (water method)	—	—	Addition	In JIS, method A-2 (water method) is added.		
7.2.1	Method B-1 (potassium acetate method)	—	—	Addition	In JIS, method B-1 (potassium acetate method) is added.		
7.2.2	Method B-2 (alternative method I to the potassium acetate method)	—	—	Addition	In JIS, method B-2 (alternative method I to the potassium acetate method) is added.		
7.2.3	Method B-3 (alternative method II to the potassium acetate method)	ISO 15496	Method B-3 (alternative method II to the potassium acetate method) is specified in Annex A.	Identical	—	—	—
7.3	Method C (sweating-guarded hotplate method)	ISO 11092	Method C (sweating-guarded-hotplate method) is specified in Annex B.	Identical	—	—	—

(I) Requirements in JIS		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between JIS and the International Standard by clause		(V) Justification for the technical deviation and future measures
No. and title of clause	Content		No. of clause	Content	Classification by clause	Detail of technical deviation	
Annex A (normative)	Method B-3 (alternative method II to the potassium acetate method)	ISO 15496		As a simple method of measuring the water-vapour permeability for quality control, the alternative method II to the potassium acetate method is specified.	Identical	—	—
Annex AA (informative)	Water-vapour permeability—Application of test results		Annex A	Explanation of how the water vapour permeability specified in ISO 15496 is different from that specified in ISO 11092 is given.	Identical	—	—
Annex AB (informative)	Physical principle behind the test method		Annex B	Description on temperature-dependence of partial water vapour pressure difference is given.	Identical	—	—
Annex AC (informative)	Dry desiccant cup methods	ISO 11092	Annex C	Unsuitability of the dry desiccant cup method for application in this International Standard is explained.	Identical	—	—
Annex B (normative)	Method C (sweating guarded-hotplate method)			Method for the measurement of thermal resistance and water-vapour resistance of textile products, and fabric materials and others used for textile products is specified.	Identical	—	—

(I) Requirements in JIS		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between JIS and the International Standard by clause		(V) Justification for the technical deviation and future measures
No. and title of clause	Content		No. of clause	Content	Classification by clause	Detail of technical deviation	
Annex BA (normative)	Mounting procedure for specimens containing loose filling materials or having uneven thickness	ISO 11092	Annex A	Number of specimens to be used and mounting procedure are specified.	Identical	—	—
Annex BB (normative)	Determination of correction terms for heating power		Annex B	Calculation method for correction terms for heating power is specified.	Identical	—	—

Overall degree of correspondence between JIS and International Standards (ISO 11092:1993, ISO 15496:2004): MOD

NOTE 1 Symbols in sub-columns of classification by clause in the above table indicate as follows:

- Identical: Identical in technical contents.
- Addition: Adds the specification item(s) or content(s) which are not included in International Standard.
- Alteration: Alters the specification content(s) which are included in International Standard.
- Selection: Provides an alternative choice by adding the specification content(s) of equal status, which may be used as an alternative to that given in the original International Standard.

NOTE 2 Symbol in column of overall degree of correspondence between JIS and International Standards in the above table indicates as follows:

- MOD: Modifies International Standards.

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