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**Textiles — Measurement of water vapour permeability of textiles for the purpose of quality control**

*Textiles — Mesurage de la perméabilité à la vapeur d'eau des textiles dans le but du contrôle qualité*

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## Foreword

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

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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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

This document was prepared by Technical Committee ISO/TC 38, *Textiles*, Subcommittee SC 2, *Cleansing, finishing and water resistance tests*.

This second edition cancels and replaces the first edition (ISO 15496:2004), which has been technically revised. It also incorporates the Technical Corrigendum ISO 15496:2004/Cor 1:2006.

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

- in the scope, it has been clarified that there is some limitation in the use of this method as it relates to ISO 11092;
- editorial changes have been made throughout the document, including to some symbols;
- in footnote 1, the list of suppliers of the membrane has been removed.

# Textiles — Measurement of water vapour permeability of textiles for the purpose of quality control

## 1 Scope

This document 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.

The simple test method described in this document is not applicable for classifying the water vapour resistance of textiles against values relating to physiological effects specified in product standards, and particularly not those relating to personal protective equipment.

The method can be used for quality control but has some limitation in relation to ISO 11092, which gives a more comprehensive and relevant result for evaluation of water vapour penetration. [Annex A](#) provides further explanation of applicability.

This document cannot be used to compare results to other “dry desiccant” methods as they will not correlate. An explanation of the reasons can be found in [Annex C](#).

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3696, *Water for analytical laboratory use — Specification and test methods*

## 3 Terms and definitions

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

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

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

### 3.1

#### water vapour permeability

$\mu_{WV}$

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

## 4 Symbols and abbreviated terms

Symbol	Description	Unit
$a$	Area of the measuring cup opening	m <sup>2</sup>
$\Delta t$	Measuring time	h
$\Delta m$	Change in mass of the measuring cup during the period $\Delta t$	g
$\Delta m_{\text{app}}$	Change in mass of the measuring cup on the specimen holder with only membrane during the period $\Delta t$	g
$\Delta p$	Partial water vapour pressure difference across the specimen	Pa
$p_{\text{sa}}$	Saturated water vapour pressure at the test room temperature $T_{\text{a}}$	Pa
$p_{\text{sb}}$	Saturated water vapour pressure at the water bath temperature $T_{\text{b}}$	Pa
$\varphi$	Relative humidity in equilibrium with saturated potassium acetate solution	%
$T_{\text{a}}$	Temperature in the test room	°C
$T_{\text{b}}$	Temperature of the water bath	°C
$\mu_{\text{WV}}$	Water vapour permeability of the specimen	g/m <sup>2</sup> ·Pa·h
$\mu_{\text{WV,app}}$	Apparatus water vapour permeability	g/m <sup>2</sup> ·Pa·h

## 5 Principle

The specimen to be tested is placed, together with a waterproof but highly water-vapour-permeable, hydrophobic, microporous membrane (henceforth 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 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. See [Annex B](#) for further explanation of the physical principle behind the test method.

## 6 Apparatus

The schematics of the test set-up are shown in [Figure 1](#).

**6.1 Membrane**, waterproof, microporous and hydrophobic<sup>1)</sup>. 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 g/m<sup>2</sup>·Pa·h when measured according to this document.

**6.2 Specimen holder**, either a metal or a 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 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.

**6.3 Support frame for specimen holders**, consisting of two plates, separated by spacers, that support the specimen holders in the water (see [Figure 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

1) This product is commercially available.

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  $(5 \pm 2)$  mm in the water.

The holes in the support frame should be sequentially numbered.

**6.4 Water bath**, consisting of a transparent glass or plastic tank, large enough to accommodate the support frame, containing distilled water maintained at  $(23,0 \pm 0,1)$  °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.

**6.5 Measuring cup**, made from transparent plastic and having an internal diameter of between 85 mm and 95 mm, with a tolerance of  $\pm 1$  mm, and a volume of at least 250 ml. See [Figure 2](#).

**6.6 Potassium acetate solution**, made by thoroughly mixing dry potassium acetate (p.a. grade) with grade 3 water in accordance with ISO 3696 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  $(23 \pm 3)$  °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.

**6.7 Balance**, capable of determining a mass of approximately 150 g with a precision of  $\pm 1$  mg.

**6.8 Test room**, maintained at  $(23 \pm 3)$  °C.

## 7 Preparation

### 7.1 Specimens

Cut three circular 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 specimen and membrane. Prepare a control specimen holder with membrane only, so that the apparatus water vapour permeability can be measured.

### 7.2 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, while 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.

## 8 Test procedure

### 8.1 Inserting the specimen and equilibration

Insert those specimen holders with textile and membrane, and the one with membrane only, into the support frame at  $(30 \pm 5)$  s intervals in sequential order of the holes. Verify that there are no air bubbles between the membrane and water surface. After  $(10 \pm 1)$  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.

### 8.2 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  $(30 \pm 5)$  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 re-weigh ( $m_{15}$ ) it.

### 8.3 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.

## 9 Calculation and expression of results

Calculate the water vapour permeability ( $\mu_{WV}$ ) of the specimen using [Formulae \(1\) to \(3\)](#) (see [Clause 4](#) for an explanation of the symbols):

$$\Delta m = m_{15} - m_0 \quad (1)$$

$$\mu_{WV,app} = \frac{\Delta m_{app}}{a \times \Delta p \times \Delta t} \quad (2)$$

$$\mu_{WV} = \left( \frac{a \times \Delta p \times \Delta t}{\Delta m} - \frac{1}{\mu_{WV,app}} \right)^{-1} \quad (3)$$

The relative humidity in equilibrium with saturated potassium acetate solution at temperature  $T_a$ , expressed as a percentage, is [\[2\]](#)

$$\varphi = 22,4388 + 0,156288 \times T_a - (0,612868 \times 10^{-2}) \times T_a^2$$

If  $T_a = T_b = 23,0 \text{ }^\circ\text{C}$ , then the relative humidity,  $\varphi = 22,8 \%$

and then,  $\Delta p = p_{sb} - \frac{p_{sa} \times \varphi}{100} = (2808 - 640) \text{ Pa} = 2168 \text{ Pa}$

## 10 Precision of results

### 10.1 Repeatability

Six laboratories tested two fabrics three times each. The mean of the standard deviation was  $0,007 \text{ g/m}^2 \cdot \text{Pa} \cdot \text{h}$ .

## 10.2 Reproducibility

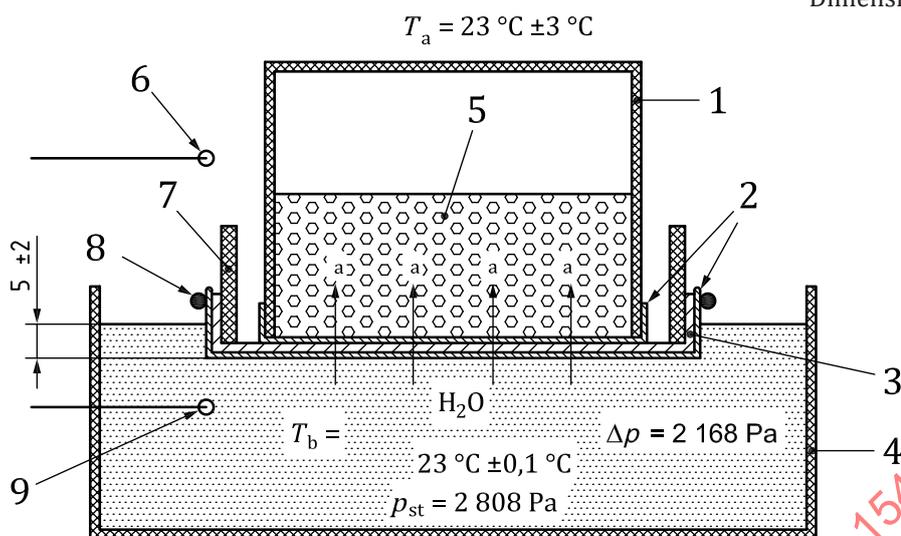
Six laboratories testing four specimens of four different fabrics with water vapour permeability ranging from 0,08 g/m<sup>2</sup>·Pa·h to 0,24 g/m<sup>2</sup>·Pa·h showed a standard deviation of 0,011 g/m<sup>2</sup>·Pa·h.

## 11 Test report

The test report shall include at least the following information:

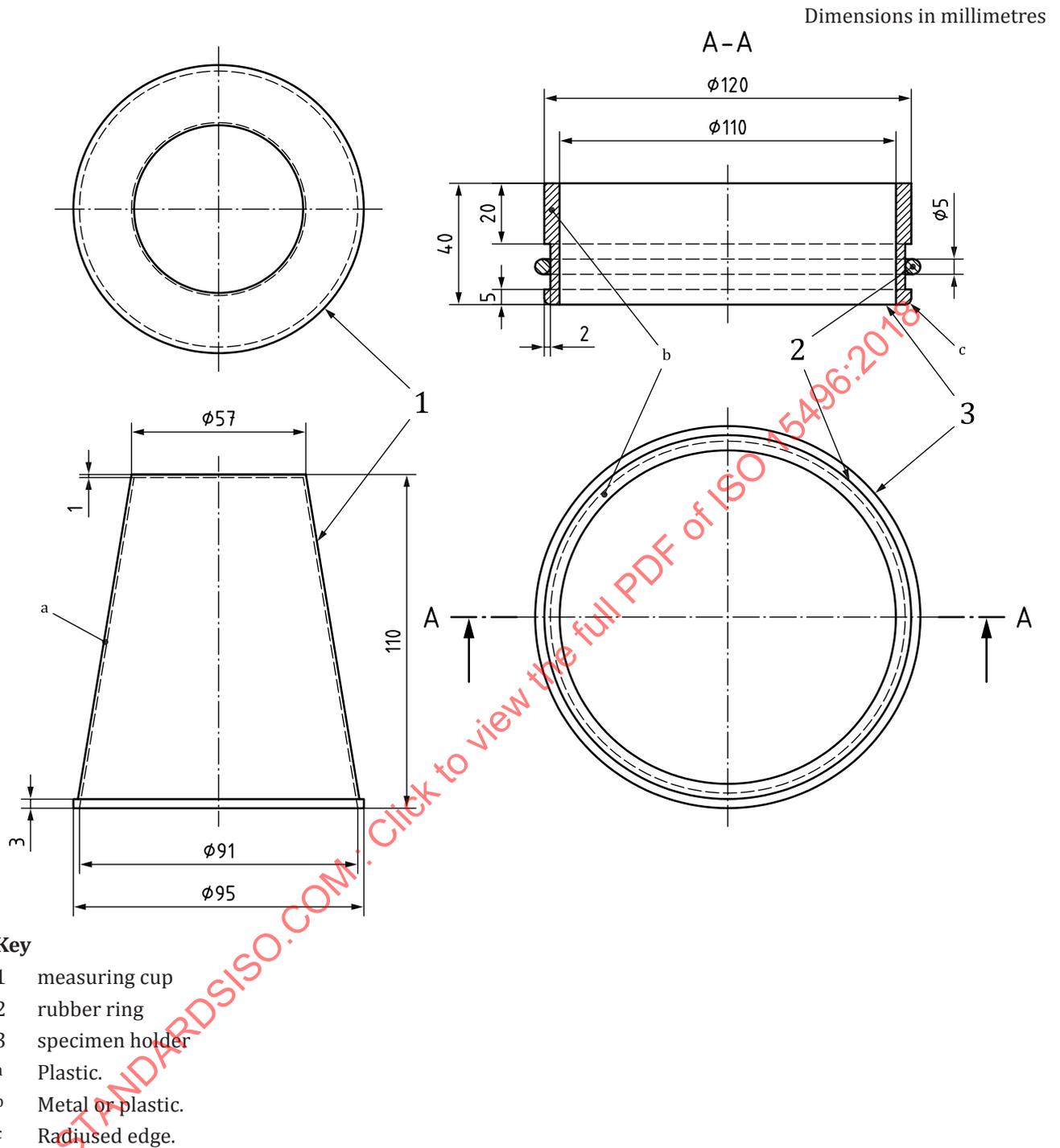
- a) all information necessary for identification of the sample tested;
- b) a reference to this document, i.e. ISO 15496:2018;
- c) description of the test sample;
- d) orientation of the test specimens according to [7.1](#);
- e) number of test specimens per sample;
- f) temperature in the test room,  $T_a$ , and of the water bath,  $T_b$ , during the test period;
- g) partial water vapour pressure difference across the specimens,  $\Delta p$ ;
- h) arithmetic mean of the water vapour permeability,  $\mu_{WV}$ ;
- i)  $\mu_{WV,app}$  of the test apparatus;
- j) any deviations from the procedure specified;
- k) any unusual features (anomalies) observed during the test;
- l) date of test.

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**Key**

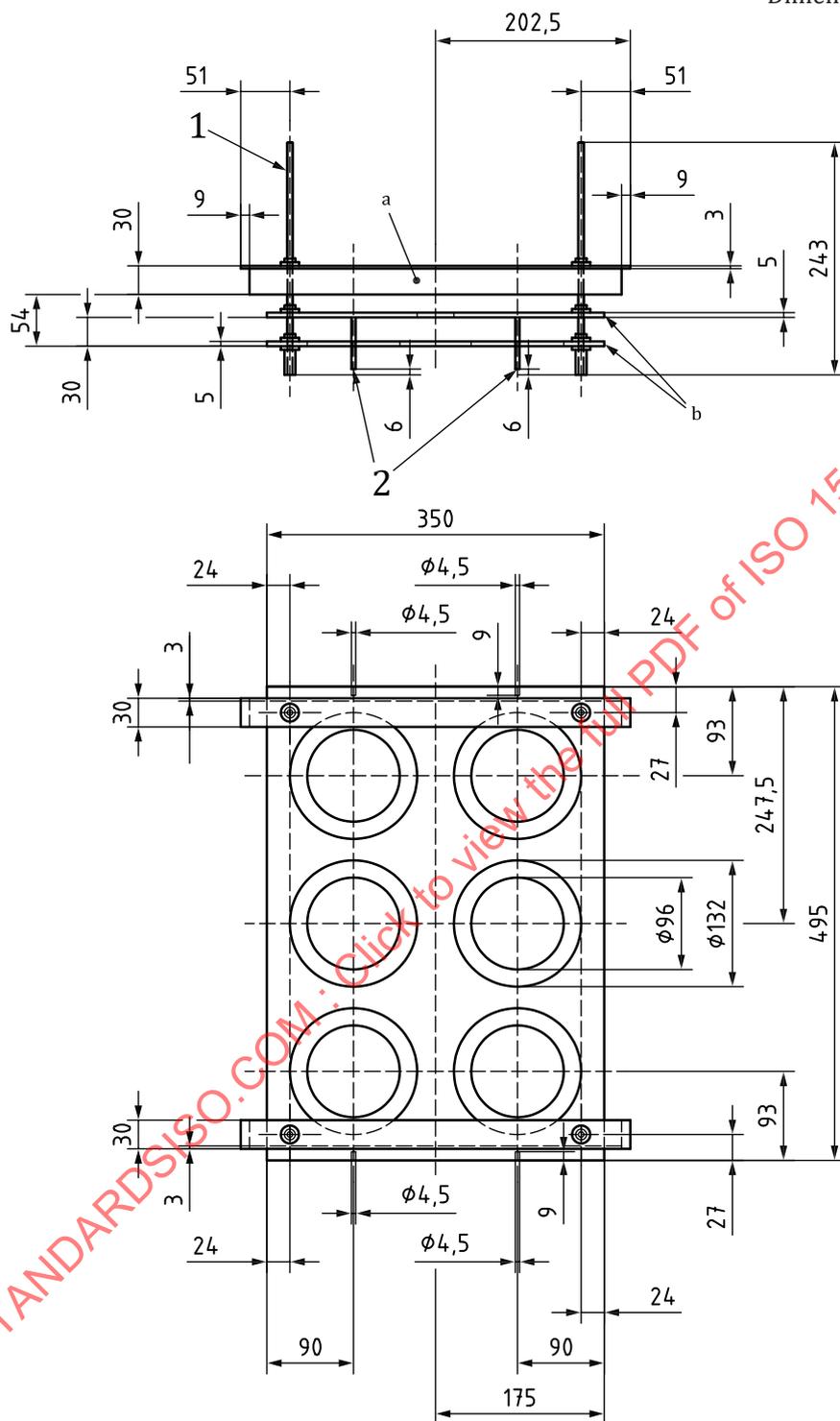
- 1 measuring cup
- 2 membrane
- 3 textile specimen
- 4 water tank
- 5 saturated potassium acetate solution
- 6 temperature sensor for  $T_a$
- 7 specimen holder
- 8 rubber ring
- 9 temperature sensor for  $T_b$
- a Water vapour.

**Figure 1 — Schematical test arrangement for the cup method**



**Figure 2 — Typical dimensions of measuring cup and specimen holder**

Dimensions in millimetres



**Key**

- 1 m6 threaded rod
- 2 glass tube (Pt 100 temperature sensor)
- a Metal.
- b Plastic.

**Figure 3 — Typical dimensions of support frame**

## Annex A (informative)

### Water vapour permeability — Classification of test results

Because the test conditions are different, the values of water vapour permeability resulting from the test described in this document could be substantially different from the water vapour permeability values derived from ISO 11092. Therefore, the water vapour permeability results cannot be used in the classification of physiological effects of textiles where ISO 11092 is cited as the test method.

NOTE A deviation from the water bath and test room temperatures of  $(23,0 \pm 0,1)$  °C and  $(23 \pm 3)$  °C, respectively, as specified in this document, can significantly change the test results.

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## Annex B (informative)

### Physical principle behind the test method

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,  $T_b$ .

$$p_{sb} = 133,3 \times 10 \exp \left\{ - \left[ 2\,919,611 / (T_b + 273) - 4,795\,18 \times \lg(T_b + 273) + 23,037\,33 \right] \right\}$$

EXAMPLE 1

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

The relative humidity ( $\varphi$ , %) 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 is calculated by the following formula, showing that it is not very temperature dependent.

$$\varphi = 22,4388 + 0,156\,288 \times T_a - (0,006\,128\,68) \times T_a^2$$

EXAMPLE 2

Air temperature	$\varphi$ (saturated) %
$T_a$ °C	
20	23,1
23	22,8

The water vapour pressure,  $p_{sa}$ , is calculated as

$$p_{sa} = 133,3 \times 10 \exp \left\{ - \left[ 2\,919,611 / (T_a + 273) - 4,795\,18 \times \lg(T_a + 273) + 23,037\,33 \right] \right\}$$

The partial water vapour pressure difference,  $\Delta p$ , varies largely with a variation of the temperature of the water bath,  $T_b$ .