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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

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ISO 15496 was prepared by Technical Committee ISO/TC 38, *Textiles*, Subcommittee SC 2, *Cleansing, finishing and water resistance tests*.

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

1 Scope

This International Standard 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 International Standard 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.

2 Terms and definitions

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

3.1
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

3 Symbols and units

Symbol	Description	Unit
a	Area of the 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
RH	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 specimen	$g/m^2 \cdot Pa \cdot h$
WVP_{app}	Apparatus water vapour permeability	$g/m^2 \cdot Pa \cdot h$

4 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.

5 Apparatus

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

5.1 Membrane

Any membrane used shall be waterproof, microporous and hydrophobic[1)]. 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^2·Pa·h when measured according to this International Standard.

5.2 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 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.

5.3 Support frame for specimen holders

The support frame should consist 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 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.

5.4 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 $\pm$ 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.

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1) This product is commercially available from, among others: W. L. Gore & Associates GmbH, PO Box 1149, D-85636 Putzbrunn, Germany; Goodfellow Cambridge Ltd., Ermine Business Park, Huntingdon, PE 29 6WR, UK; Goodfellow Corp., 800 Lancaster Av., Berwyn, PA 19312-1780, USA. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of these products.

5.5 Measuring 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.

5.6 Potassium acetate solution

Saturated potassium acetate solution shall be made by thoroughly mixing dry potassium acetate (p.a. 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 ± 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.

5.7 Balance, capable of determining a mass of approximately 150 g with a precision of ± 1 mg.

5.8 Test room, maintained at (23 ± 3) °C.

6 Preparation

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

6.2 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.

7 Test procedure

7.1 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 ± 5) s intervals in sequential order of the holes. Verify that there are no air bubbles between the membrane and water surface. After (10 ± 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 min ± 10 s before the measuring cup is placed on the specimen.

7.2 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 ± 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 min ± 10 s after having placed it on the specimen, and re-weigh (m_{15}) it.

7.3 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.

8 Calculation and expression of results

Calculate the water vapour permeability (WVP) of the specimen using Equations (1) to (3) (see Clause 3 for explanation of symbols):

$$\Delta m = m_{15} - m_0 \tag{1}$$

$$WVP_{\text{app}} = \frac{\Delta m_{\text{app}}}{a \times \Delta p \times \Delta t} \tag{2}$$

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

The relative humidity in equilibrium with saturated potassium acetate solution at temperature T_{a}, expressed as a percentage, is [1]

$$RH = 22{,}438\ 8 + 0{,}156\ 288 \times T_{\text{a}} - \left(0{,}612\ 868 \times 10^{-2}\right) \times T_{\text{a}}^2$$

If $T_{\text{a}} = T_{\text{b}} = 23{,}0$ °C, then $RH = 22{,}8$ %

and then, $\Delta p = p_{\text{sb}} - \frac{p_{\text{sa}} \times RH}{100} = (2\,808 - 640)\ \text{Pa} = 2\,168\ \text{Pa}$.

9 Precision of results

9.1 Repeatability

Six laboratories tested two fabrics three times each. The mean of the standard deviation was 0,007 g/m^2·Pa·h.

9.2 Reproducibility

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

10 Test report

The test report shall include at least the following information:

a) all information necessary for identification of the sample tested;

b) reference to this International Standard;

c) description of the test sample;

d) orientation of the test specimens according to 6.1;

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, Δp;

h) arithmetic mean of the water vapour permeability, WVP;

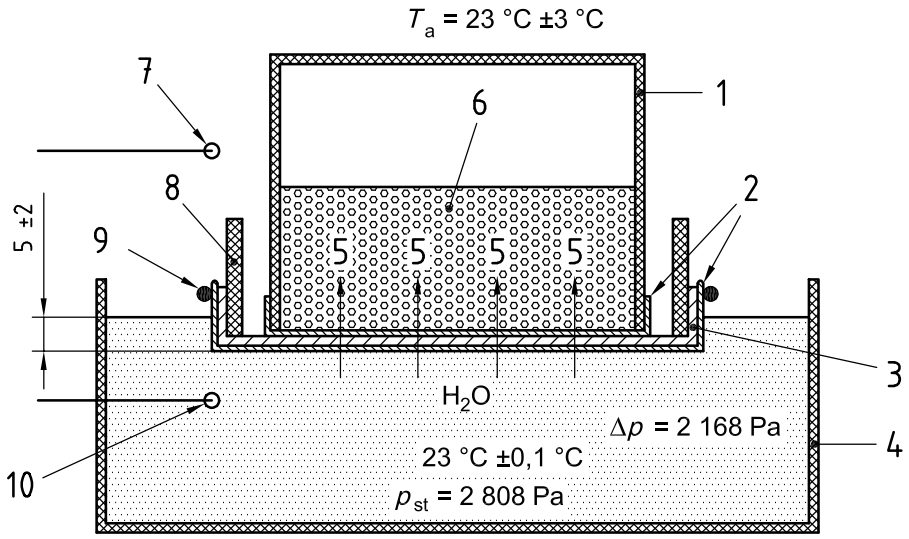
i) WVP_{app} of the test apparatus;

j) any deviations from the procedure specified;

k) any unusual features (anomalies) observed during the test;

l) date of test.

Dimensions in millimetres

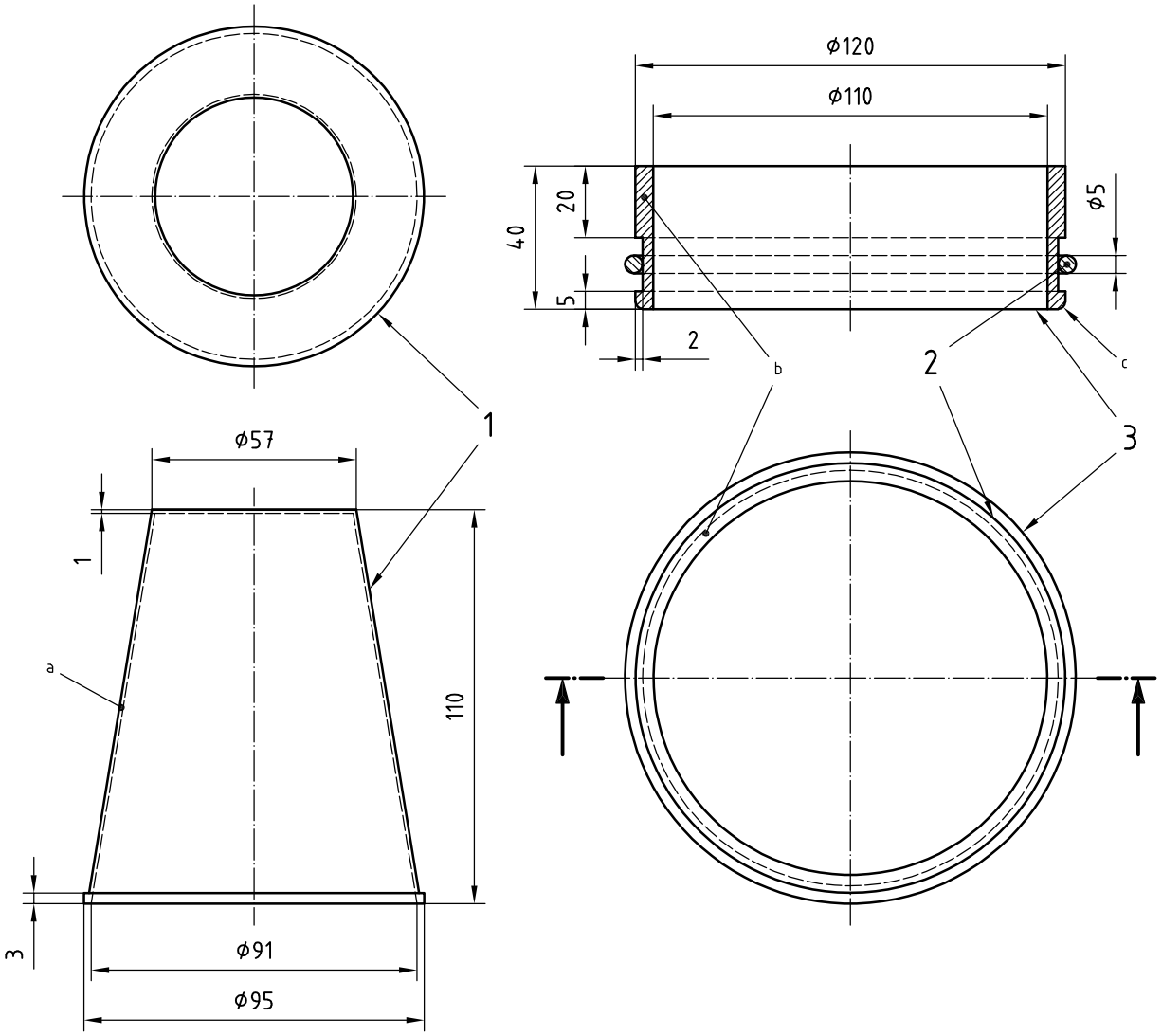


Key

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

Figure 1 — Schematical test arrangement for the cup method

Dimensions in millimetres



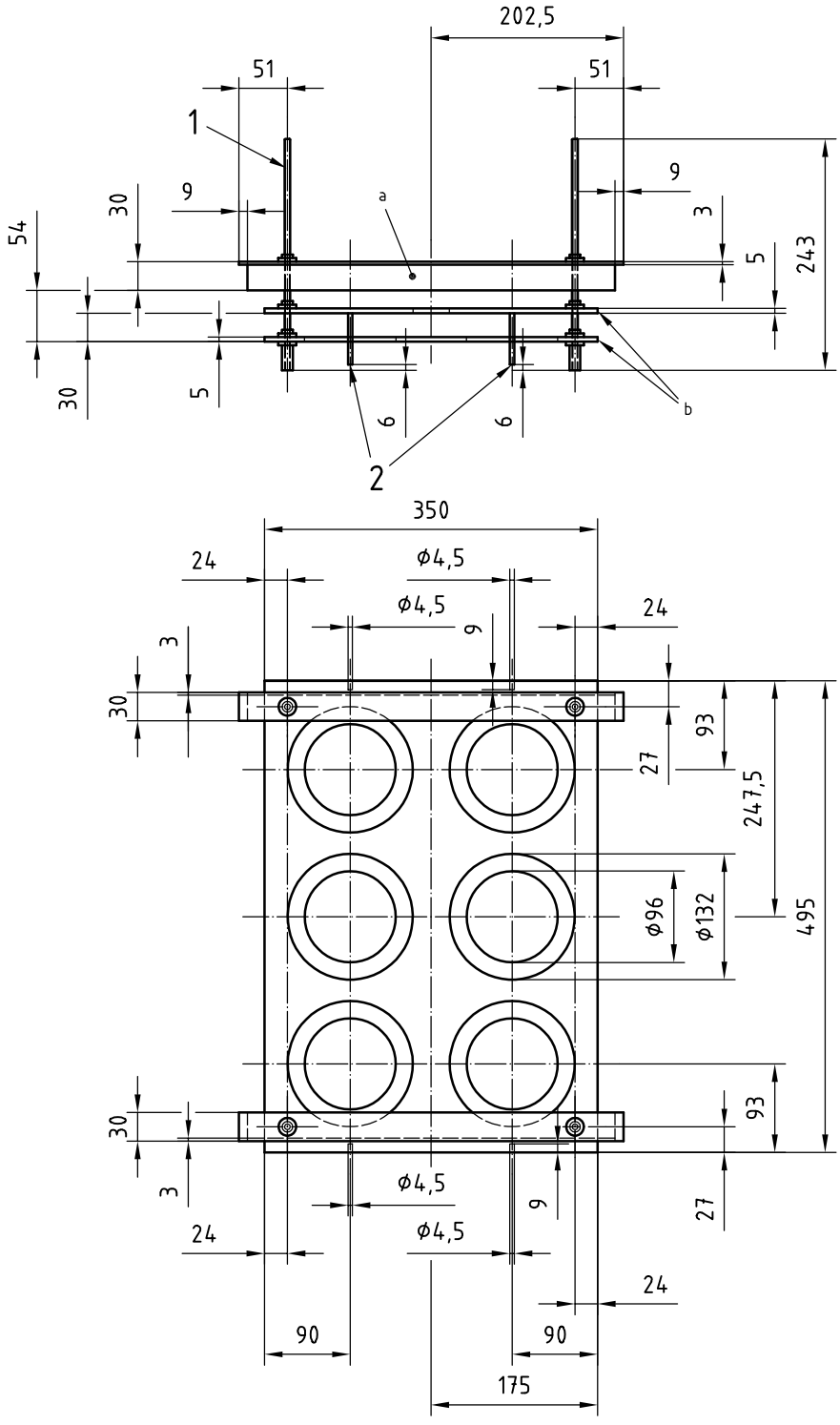
Key

1 measuring cup
2 rubber ring
3 specimen holder

a Plastic.
b Metal or plastic.
c Radiused edge.

Figure 2 — Typical dimensions of measuring cup and specimen holder

Dimensions in millimetres



Key

1 M6 threaded rod

2 glass tube (Pt 100)

[a] Metal.

[b] Plastic.

Figure 3 — Typical dimensions of support frame

Annex A
(informative)

Water vapour permeability — Application of test results

Because the test conditions are different, the values of WVP resulting from the test described in this International Standard could be substantially different from the W_d values derived from ISO 11092. Therefore, the WVP results can not 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 ± 0,1)°C and (23 ± 3)°C, respectively, as specified in this International Standard, can significantly change the test results.

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.

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

EXAMPLE

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

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

$$RH = 22{,}438\,8 + 0{,}156\,288 \times T_a - \left(0{,}006\,128\,68\right) \times {T_a}^2$$

EXAMPLE

Air temperature, T_a °C	RH (saturated) %
20	23,1
23	22,8

The water vapour pressure p_{sa} is calculated as

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

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 International Standard the water bath temperature was chosen as 23,0 °C, and the tolerance allowed is only ± 0,1 °C.

Annex C
(informative)

Dry desiccant cup methods

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 International 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 specimen's water vapour permeability, but expresses the desiccant's absorbance characteristics. 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 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 the expected water vapour permeability of the textile are found.

d) The sample 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.

Bibliography

[1] L. GREENSPAN, Humidity fixed points of binary saturated aqueous solutions. *J. Res., National Bureau of Standards*, 81A (1977) pp. 89-96

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