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Textiles — Determination of dynamic hygroscopic heat generation

Textiles — Détermination de la production de chaleur dynamique hygroscopique

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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 document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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

This document was prepared by Technical Committee ISO/TC 38, *Textiles*.

This second edition cancels and replaces the first edition (ISO 18782:2015), which has been technically revised.

The main changes are as follows:

— in Clause 3, temperature definitions have been added;

— in Clause 7, Figure 1 has been changed from one testing position to 4 testing positions;

— in 7.2.5.5, rectifying plate was introduced for more stable testing;

— in Clause 10.2, the pretreatment process has been added;

— in Annex A, the pretreatment process has been added to the testing method for the determination of air flow rate for high humidity.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

In the apparel and clothing market, warm heat-comfort textile material is attracting consumers' attention. It offers comfortable warmth through the combined technology of the hygroscopic heat generation and heat insulation.

The phenomenon of the hygroscopic heat generation is known as a common function of natural fibres especially, but not so much for synthetic fibres. Therefore, the synthetic fibre producers have been developing fibres and textiles with an appropriate warm-feeling property.

This document provides a test method to obtain the practical heat generation of textiles under wearing conditions.

The apparatus used in this test method has multiple test positions. So, this method is practical and economical with high accuracy.

Textiles — Determination of dynamic hygroscopic heat generation

1 Scope

This document specifies a test method for the determination of hygroscopic heat generated by flowing low to high humidity air on one side of a surface. It is applicable to all kinds of sheet-shaped textile materials.

2 Normative references

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

ISO 105-F02, *Textiles — Tests for colour fastness — Part F02: Specification for cotton and viscose adjacent fabrics*

ISO 139, *Textiles — Standard atmospheres for conditioning and testing*

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 https://www.electropedia.org/

3.1
generated hygroscopic heat
hygroscopic heat generated by the loss of kinetic energy when gaseous water molecules are adsorbed on a surface of textile material

3.2
temperature at low humidity
$T_{initial}$
initial equilibrium temperature at measurement side of a specimen when the low humidity air is supplied

3.3
generated hygroscopic heat temperature
ΔT
temperature difference between the initial equilibrium temperature and the temperature when the high humidity air is supplied on measurement side of a specimen

3.4
maximum temperature at high humidity
T_{max}
maximum temperature at measurement side of a specimen when high humidity air is supplied

3.5
maximum generated hygroscopic heat temperature
ΔT_{max}
maximum value of the generated hygroscopic heat temperature ΔT

4 Principle

When the air supply is switched from low humidity to high humidity in instant, the temperature at the specimen increases and reaches a peak due to the hygroscopic heat generation. The temperature at one side of specimen is measured during this air change and the peak temperature is determined as ΔT_{max}. In this test method, the high humidity air flow rate is determined by a cotton control specimen in which the ΔT_{max} becomes 2,8 °C ± 0,3 °C.

5 Testing condition

5.1 Low humidity air

The air is taken from the atmosphere of the constant temperature and humidity chamber (7.1) in which the temperature is controlled at 20 °C ± 2 °C and the relative humidity at (40 ± 3) %. The air flow rate is set at 1,0 l/min ± 0,1 l/min.

5.2 High humidity air

The air in the constant temperature and humidity chamber (7.1) is passed through bubbling bottle (7.2.2) and supplied to specimen as a high humidity air.

NOTE High humidity air is controlled by the air flow rate only; therefore, humidity measurements are not essential. However, the humidity of high humidity air has been known as (90 ± 5) % RH.

6 Reagents and materials

6.1 Water, distilled water, ion exchanged water, grade 3 water according to ISO 3696 or equivalent for humidifying air in a bubbling bottle (7.2.2).

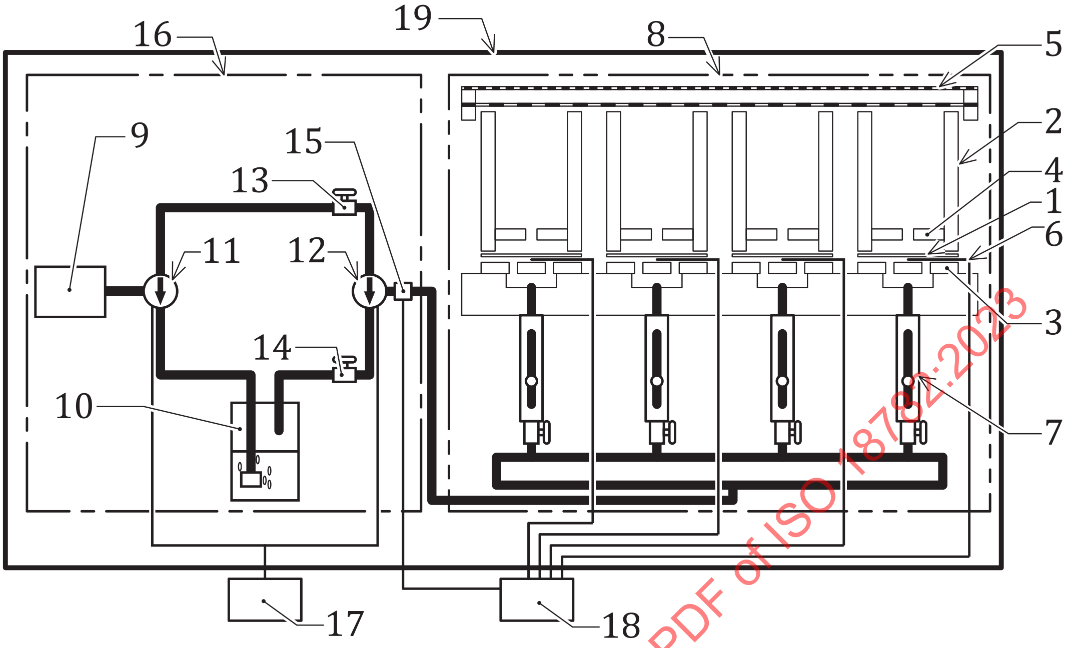
6.2 Control specimen, a cotton adjacent fabric as specified in ISO 105-F02.

7 Apparatus

7.1 Constant temperature and humidity chamber or room, capable of maintaining the temperature at 20 °C ± 2 °C and the relative humidity at (40 ± 3) %. The hygroscopic heat generation testing apparatus (7.2) is placed in the chamber or room.

7.2 Hygroscopic heat generation testing apparatus, shown in Figure 1. All devices are placed in the chamber (7.1) in case of cabin type. If in case the oven type, the switching valve and control device

(7.2.3) and monitoring recorder (7.3) are placed in the outside of the chamber. Air is supplied from one air supply path to four measuring units. An example of practical testing apparatus is shown in Annex C.



Key

Key

1 specimen
2 specimen holder
3 specimen table
4 air lid
5 rectifying plate
6 thermometer
7 flowmeter with regulating valve
8 measuring units
9 air pump
10 air bubbling bottle with water
11, 12 switching valve
13, 14 flow control valve
15 humidity sensor
16 air supply path
17 control device
18 monitoring recorder
19 constant temperature and humidity chamber

Figure 1 — Schematic diagram of the testing apparatus

7.2.1 Air pump, capable of collecting air from the atmosphere of the chamber (7.1) and supplying air to the specimen at a rate of 1,0 l/min ± 0,1 l/min.

7.2.2 Bubbling bottle, consisting of an air-tight bottle with an air inlet tube attached to a porous cylinder such as air stones to make fine air bubbles and with air outlet tube to collect high humidity air after bubbling. Completely submerge the porous cylinder in water during testing.

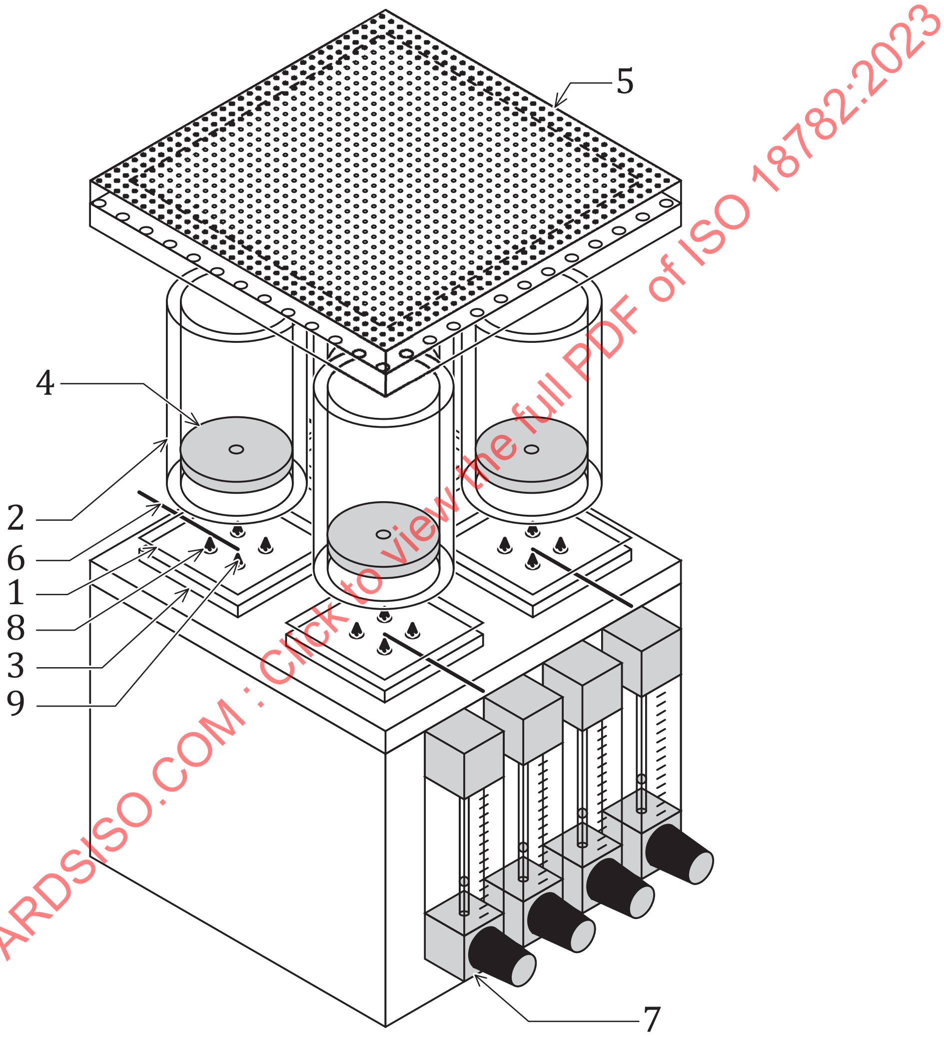
7.2.3 Switching valve with control device, used for switching to low humidity air path (11, 13, 12 and 15 in Figure 1) or high humidity air path (11, 14, 12 and 15 in Figure 1) passed through a bubbling bottle (10 in Figure 1 and 7.2.2).

7.2.4 Humidity sensor, used for detecting a humidity of air supply path, from 5 % RH to 100 % RH, with accuracy ±5 % RH.

7.2.5 Measuring units and rectifying plate, four measuring units (as shown in Figure 1) where each unit consists of: a specimen table (7.2.5.1), a specimen holder (7.2.5.2), a thermometer (7.2.5.3), and a flowmeter with regulating valve (7.2.5.4). Each measuring unit is positioned as shown in Figure 2, and a rectifying plate (7.2.5.5) is stacked to cover the entire measuring part.

7.2.5.1 Specimen table, consisting of a board of polystyrene foam with a square of 50 mm± 5 mm, a thickness of 7 mm ± 2 mm and 4 air holes with a diameter of 5,0 mm ± 0,3 mm each. The holes are located 10 mm from the centre of the table in diagonal positions in the square.

EXAMPLE For example, polystyrene foam with a thermal conductivity of 0,035 W/m K can be used as a heat-insulating material.



Key

1	specimen	6	thermometer
2	specimen holder	7	flowmeter with regulating valve
3	specimen table	8	air holes
4	air lid	9	air flow
5	rectifying plate		

Figure 2 — Measuring unit and rectifying plate

7.2.5.2 Specimen holder, consisting of a transparent acrylic cylinder with an outside diameter of 50 mm ± 5 mm, a thickness of 5 mm ± 3 mm and a height of 80 mm ± 5 mm. The air lid of the holder is placed at a height of 5 mm ± 1 mm from the bottom and an insulation material (polystyrene foam with a vent hole of a diameter of 3 mm ± 1 mm) is placed in the centre.

7.2.5.3 Thermometer, with a film-type sensor as shown in Figure 3, placed at the centre of the specimen table (7.2.5.1) and covered by a specimen. A film-type sensor has a width of about 4 mm and a thickness of about 0,2 mm, a length is greater than 25 mm. The accuracy is ±1,2 %.

Figure 3 — Sample of film type thermometer

7.2.5.4 Flowmeter with regulating valve, adjustable air flow rate supplying to specimen with a needle valve or similar. The maximum measurable flow rate shall be 1,0 l/min or more, and the measurement accuracy shall be ±10 %.

7.2.5.5 Rectifying plate, two acrylic frame openings, each covered with different types of perforated metal plates, stacked and fixed together. The upper and lower frames are made of acrylic, both with external dimensions of 200 mm ± 2 mm square, internal dimensions of 180 mm ± 2 mm square and a height of 10,0 mm ± 0,5 mm. The upper perforated metal plate is made of aluminium, with dimensions of 200 mm ± 2 mm square, a thickness of 1,0 mm ± 0,1 mm, a hole diameter of 1,0 mm ± 0,1 mm and a pitch of 2,0 mm ± 0,1 mm. The lower perforated metal plate is made of aluminium with dimensions of 200 mm ± 2 mm square, thickness of 0,5 mm ± 0,1 mm, hole diameter of 3,0 mm ± 0,1 mm and pitch of 5,0 mm ± 0,1 mm. The lower frame, the lower perforated metal plate, the upper frame and the upper perforated metal plate, in that order, are placed on top of each other and fixed so that the opening of the frame is covered by the perforated metal plate. As shown in Figure 1 and Figure 2, the rectifying plate is placed in contact to top side of the specimen holder (7.2.5.2).

7.3 Monitoring recorder, connected to the humidity sensor (7.2.4) and the thermometer (7.2.5.3), which continuously records the humidity in the flow path and the temperature of the specimen. When using an electronic recording medium, the recording interval is 1 s or less.

7.4 Drying oven, able to maintain a temperature at 105 °C ± 3 °C.

7.5 Desiccant dehumidifier, containing drying agent such as silica gel, etc.

8 Conditioning atmosphere for sampling

The standard atmosphere for sampling shall be as specified in ISO 139, 20 °C ± 2 °C and the relative humidity at (65 ± 4) %.

9 Preparation of specimens

9.1 Number and dimension of specimens, cut 4 test specimens from each test sample and 4 control specimens from cotton adjacent fabric (6.2), with a square of 60 mm ± 2 mm.

9.2 Conditioning of specimens

Place all the specimens in the oven (7.4) at 105 °C for at least 3 h. After drying, place the specimens in a desiccant dehumidifier (7.5) for at least 2 h to cool down. Keep the specimens for more than 12 h in the constant temperature and humidity chamber (7.1) before testing.

10 Test procedure

10.1 Mounting of test specimens

Mount 4 conditioned test specimens on each specimen table (7.2.5.1) so that the side to be measured is in contact with thermometer (7.2.5.3). Place the specimen holders (7.2.5.2) on the test specimens.

10.2 Pretreatment process immediately before measurement

10.2.1 Set the low humidity air path by the switching valve with the control device (7.2.3). Supply the low humidity air collected from the constant temperature and humidity chamber (7.1) to the test specimens by air flow rate of 1,0 l/min ± 0,1 l/min adjusted by regulating valve of flowmeter (7, see Figure 1).

10.2.2 Maintain low humidity air supply for at least 1 800 s until the temperature of the measurement surface of the test specimens becomes constant. No record of temperature is required in this time.

10.2.3 Switch the air supply path to high humidity air path by the switching valve (7.2.3) through the bubbling bottle (7.2.2) and supply the air to the test specimens. The supply flow rate for high humidity air shall be determined in accordance with Annex A. Maintain the high humidity air supply for at least 1 800 s. No record of temperature is required in this time.

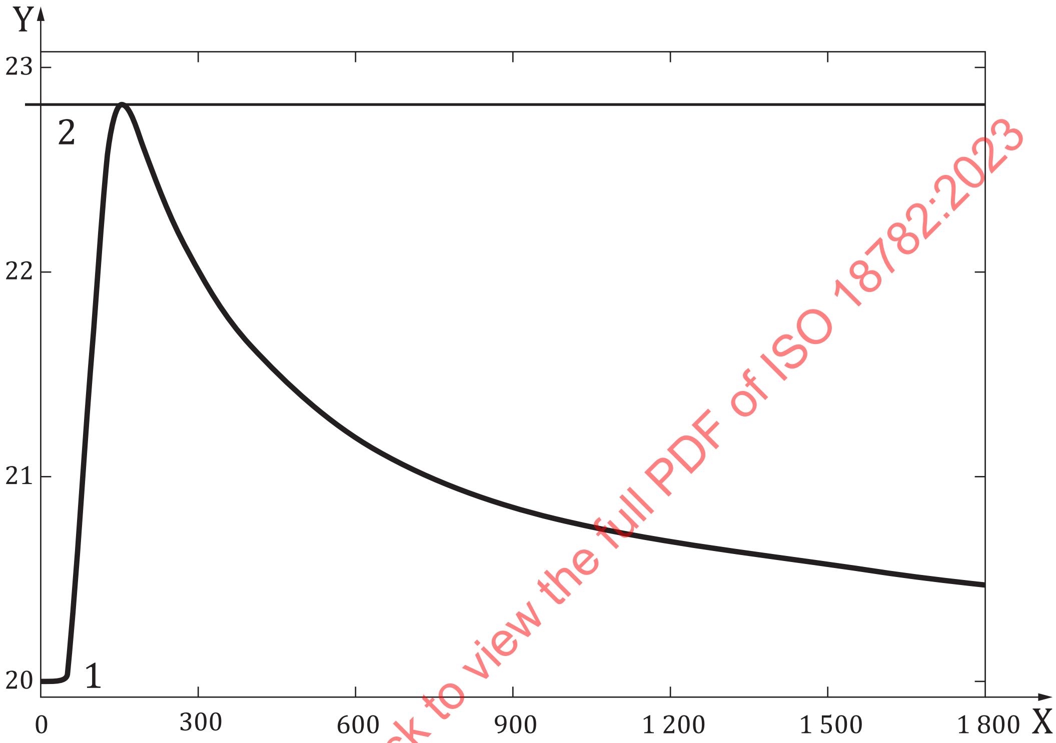
10.3 Measurement process

10.3.1 Set the low humidity air path by the switching valve with the control device (7.2.3). Supply the low humidity air collected from the constant temperature and humidity chamber (7.1) to the test specimens by air flow rate of 1,0 l/min ± 0,1 l/min adjusted by regulating valve of flowmeter (7, see Figure 1).

10.3.2 Maintain low humidity air supply for at least 1 800 s until the temperature of the measurement surface of the test specimen becomes constant, and read the temperature of each of the four test specimens and take an average for 60 s immediately before next step and record as T_{initial}.

10.3.3 Switch the air supply path to high humidity air path by the switching valve (7.2.3) through the bubbling bottle (7.2.2) and supply the air to the test specimens. The supply flow rate for high humidity air shall be determined in Annex A. Maintain the high humidity air supply for at least 1 800 s.

10.3.4 Measure and record the temperature of the measurement surface of the test specimen for at least 1 800 s while supplying high humidity air, and read the maximum temperature denoted as ΔT_{max} of each of the four test specimens. An example of the temperature curve is shown in Figure 4.



Key

X elapsed time (s)

Y temperature (°C)

1 $T_{initial}$

2 maximum temperature at high humidity, T_{max}

Figure 4 — Example of test result and definition

11 Calculation

Calculate the hygroscopic heat generation for each position by Formula (1).

$$\Delta T_{max} = T_{max} - T_{initial} \quad (1)$$

where

ΔT_{max} is the maximum generated hygroscopic heat temperature (°C);

T_{max} is the maximum temperature (°C) at high humidity;

$T_{initial}$ is the temperature (°C) at low humidity.

Calculate the average ΔT_{max} from the result of 4 specimens and rounded to the one decimal position. Record it in the test report.

Interlaboratory test results for 4 fabrics are provided in Annex B. An example of the interpretation of a test result is given in Annex D.

12 Test report

The test report shall contain the following:

a) a reference to this document, i.e. ISO 18782:2023;

b) test date;

c) details of the sample tested;

d) test results;

e) any deviation from the procedure described in this document.

Annex A
(normative)

Determination of the air flow rate for high humidity air

A.1 General

In the test series, the air flow rate setting for the high humidity air shall be controlled once every two weeks or, if no testing is undertaken for a long period, just before resuming the testing.

The air flow rate for the high humidity air for testing is determined as follows.

A.2 Procedure

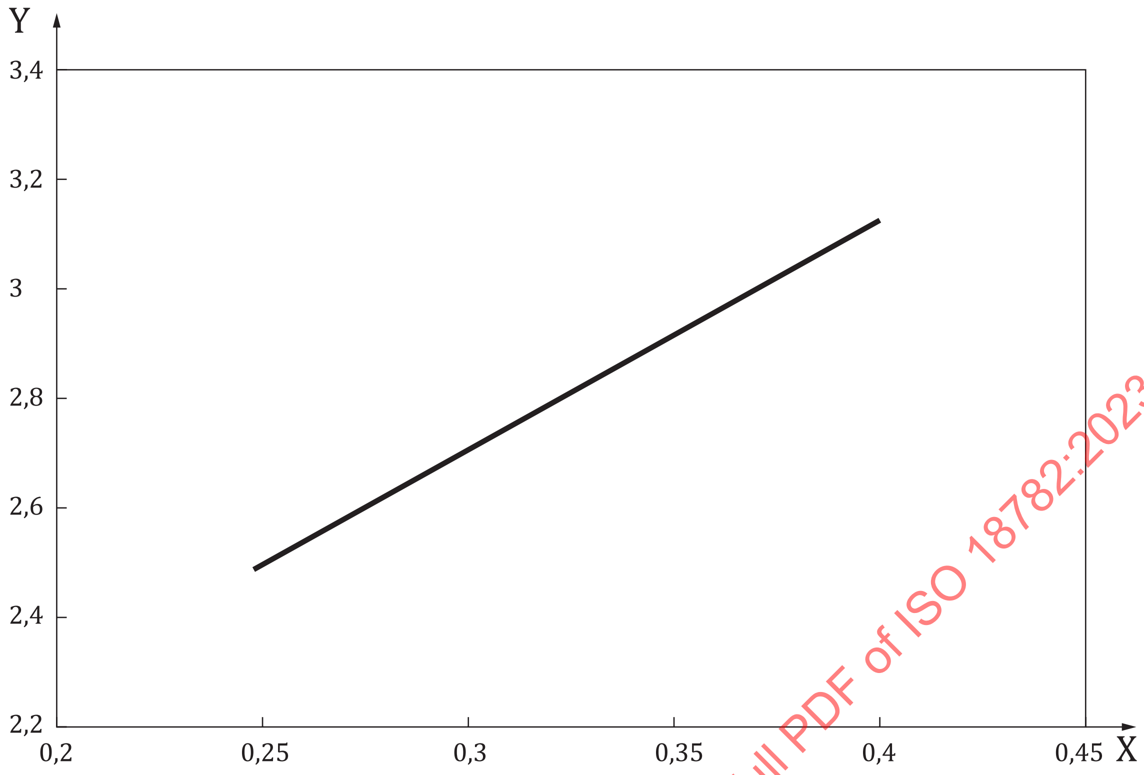
The procedure is according to Clause 10, using a control specimen instead of a test specimen. The supply flow rate of the high-humidity air at the start of the process shall be an arbitrary flow rate.

For each repetition of the procedure, four new control specimens shall be used.

A.3 Repetition and determination

Repeat A.2 with different flow rate of the high-humidity air and find the air flow rate which gives the average value of the maximum generated hygroscopic heat temperature ΔT_{max} of the control specimen within 2,8 °C ± 0,3 °C. Record the air flow rate as the determined air flow rate for the high humidity air for this test.

An example of measuring ΔT_{max} and air flow rate of the control specimen is shown in Figure A.1.



Key

X air flow rate (l/min)

Y ΔT_{max} (°C)

Figure A.1 — Example of an air flow rate and ΔT_{max}

Annex B
(informative)

Interlaboratory test results

B.1 Cotton fabric

B.1.1 Sample details

The sample used in this test was a cotton 100 % fabric with a mass per unit area of 100 g/m^2, thickness of 0,21 mm, warp 74,5 threads per 2,54 cm, weft 66,5 threads per 2,54 cm.

B.1.2 Test results

The test results obtained (ΔT_{max}) are shown in Table B.1.

Table B.1 — Test result of ΔT_{max} for cotton fabric

		ΔT_{max} (°C)				Average of ΔT_{max} (°C)
Lab 1	Day 1	2,9	3,0	2,7	2,8	2,85
	Day 2	3,1	3,1	2,8	2,8	2,95
	Day 3	3,0	2,9	2,8	2,9	2,90
Lab 2	Day 1	2,8	2,8	3,0	3,0	2,90
	Day 2	3,0	2,7	3,0	2,9	2,90
	Day 3	2,8	2,6	2,8	2,8	2,75
Lab 3	Day 1	2,9	3,1	3,0	2,9	2,98
	Day 2	2,6	2,9	2,8	2,8	2,78
	Day 3	2,9	3,0	2,9	2,9	2,93

B.2 Polyester fabric

B.2.1 Sample detail

The sample used was a 100 % polyester adjacent fabric as specified in ISO 105-F04.

B.2.2 Test results

The test results obtained are shown in Table B.2.

Table B.2 — Test result of ΔT_{max} for polyester adjacent fabric

		ΔT_{max} (°C)				Average of ΔT_{max} (°C)
Lab 1	Day 1	0,7	0,6	0,6	0,6	0,63
	Day 2	0,6	0,6	0,6	0,6	0,60
	Day 3	0,7	0,4	0,6	0,5	0,55
Lab 2	Day 1	0,6	0,6	0,7	0,6	0,63
	Day 2	0,7	0,7	0,8	0,9	0,78
	Day 3	0,7	0,6	0,9	0,8	0,75
Lab 3	Day 1	0,8	0,7	0,6	0,8	0,73
	Day 2	0,6	0,6	0,6	0,5	0,58
	Day 3	0,6	0,7	0,6	0,6	0,63

B.3 Polyamide fabric

B.3.1 Sample detail

The sample used was a 100 % polyamide adjacent fabric as specified in ISO 105-F03.

B.3.2 Test results

The test results obtained are shown in Table B.3.

Table B.3 — Test result of ΔT_{max} for polyamide adjacent fabric

		ΔT_{max} (°C)				Average of ΔT_{max} (°C)
Lab 1	Day 1	1,5	1,6	1,2	1,3	1,40
	Day 2	1,7	1,7	1,4	1,5	1,58
	Day 3	1,5	1,7	1,4	1,5	1,53
Lab 2	Day 1	1,6	1,5	1,6	1,6	1,58
	Day 2	1,5	1,5	1,7	1,5	1,55
	Day 3	1,5	1,4	1,5	1,4	1,45
Lab 3	Day 1	1,5	1,7	1,7	1,7	1,65
	Day 2	1,3	1,4	1,4	1,5	1,40
	Day 3	1,6	1,3	1,5	1,6	1,50

B.4 Wool fabric

B.4.1 Sample detail

The sample used was a 100 % wool adjacent fabric as specified in ISO 105-F01.

B.4.2 Test results

The test results obtained are shown in Table B.4.

Table B.4 — Test result of ΔT_{max} for wool adjacent fabric

		ΔT_{max} (°C)				Average of ΔT_{max} (°C)
Lab 1	Day 1	3,1	3,0	2,8	2,9	2,95
	Day 2	3,4	3,6	2,9	3,4	3,33
	Day 3	3,1	3,6	3,1	3,3	3,28
Lab 2	Day 1	2,9	2,9	2,9	3,1	2,95
	Day 2	3,2	3,2	3,2	3,5	3,28
	Day 3	3,1	3,0	3,2	3,0	3,08
Lab 3	Day 1	3,4	3,5	3,3	3,2	3,35
	Day 2	3,3	3,6	3,5	3,6	3,50
	Day 3	3,3	3,3	3,3	3,6	3,38

B.5 Calculation of repeatability and reproducibility

Using the test results for 4 fabrics (cotton, polyester, polyamide, wool) from Table B.1 to Table B.4, the repeatability and reproducibility were calculated (see Tables B.5 to B.8). The calculations were performed by using ISO 5725-2. The symbols and abbreviations used in the following tables correspond to ISO 5725-2.

Table B.5 — Average of test results (ΔT_{max}) for 4 fabrics (cotton, polyester, polyamide, wool)

Laboratory$_i$	*n*	**Level$_j$**			
		1: cotton	**2: polyester**	**3: polyamide**	**4: wool**
Lab 1	Day 1	2,85	0,63	1,40	2,95
	Day 2	2,95	0,60	1,58	3,33
	Day 3	2,90	0,55	1,53	3,28
Lab 2	Day 1	2,90	0,63	1,58	2,95
	Day 2	2,90	0,78	1,55	3,28
	Day 3	2,75	0,75	1,45	3,08
Lab 3	Day 1	2,98	0,73	1,65	3,35
	Day 2	2,78	0,58	1,40	3,50
	Day 3	2,93	0,63	1,50	3,38

Table B.6 — mean value in each Lab for 4 fabrics (cotton, polyester, polyamide, wool)

Laboratory$_i$	**Level$_j$**							
	1: cotton		**2: polyester**		**3: polyamide**		**4: wool**	
	$\bar{y}_{ij}$	n_{ij}	$\bar{y}_{ij}$	n_{ij}	$\bar{y}_{ij}$	n_{ij}	$\bar{y}_{ij}$	n_{ij}
Lab 1	2,90	3	0,59	3	1,50	3	3,19	3
Lab 2	2,85	3	0,72	3	1,53	3	3,10	3
Lab 3	2,90	3	0,65	3	1,52	3	3,41	3