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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

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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).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword — Supplementary information

The committee responsible for this document is ISO/TC 38, *Textiles*.

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. So, the synthetic fibre producers have been developing the fibres and textiles with an appropriate warm-feeling property.

This International Standard 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 International Standard specifies a test method for the determination of hygroscopic heat generated by flowing low then 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, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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*

3 Terms and definitions

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

3.1
generated hygroscopic heat
ΔT
hygroscopic heat generated by the loss of kinetic energy of water molecules which are adsorbed at a surface of textile material and then react with fibre molecules

Note 1 to entry: This is obtained from the difference between an initial temperature at low humidity air blow and a peak temperature at high humidity air blow in this test method.

3.2
peak temperature
maximum temperature in the case of *hygroscopic heat generation* (3.1)

4 Principle

Low humidity air is blown on one side of a specimen, then high humidity air is blown on the same side. The temperature of the same side of the specimen is measured during testing. When the air is switched from low humidity to high humidity, the temperature increases, reaches a peak and drops. The difference in the temperature between the initial temperature and the peak is defined as the hygroscopic heat generation. In this test method, the high humidity air flow rate is determined by a cotton control specimen in which the temperature difference becomes 2,8 °C.

5 Testing condition

5.1 Low humidity air. This air is taken from the constant temperature and humidity chamber (6.1) in which the temperature is set at 20 °C ± 2 °C and the humidity at (40 ± 3) % RH. The air flow rate is 1,0 l/min ± 0,1 l/min.

5.2   **High humidity air**, made by bubbling air through water in a bottle at a temperature, 20 °C ± 2 °C. The air source is the constant temperature and humidity chamber (6.1).

NOTE   High humidity air is controlled by the air flow rate only; therefore, humidity measurements are not essential. However, tests have shown that the humidity stabilizes at (90 ± 5) % RH.

6   Apparatus

6.1   **Constant temperature and humidity chamber**, capable of maintaining the temperature at 20 °C ± 2 °C and the humidity at (40 ± 3)% RH. The hygroscopic heat generation testing apparatus (6.2) is placed in the chamber

6.2   **Hygroscopic heat generation testing apparatus**.

The schematic diagram of the testing apparatus is shown in Figure 1. All devices are placed in the chamber (6.1), except for the air-flow-path switch controller. Four test positions (Figure 1, 13) against one air supply line (Figure 1, 14) are shown in this example. A practical example is shown in Annex C.
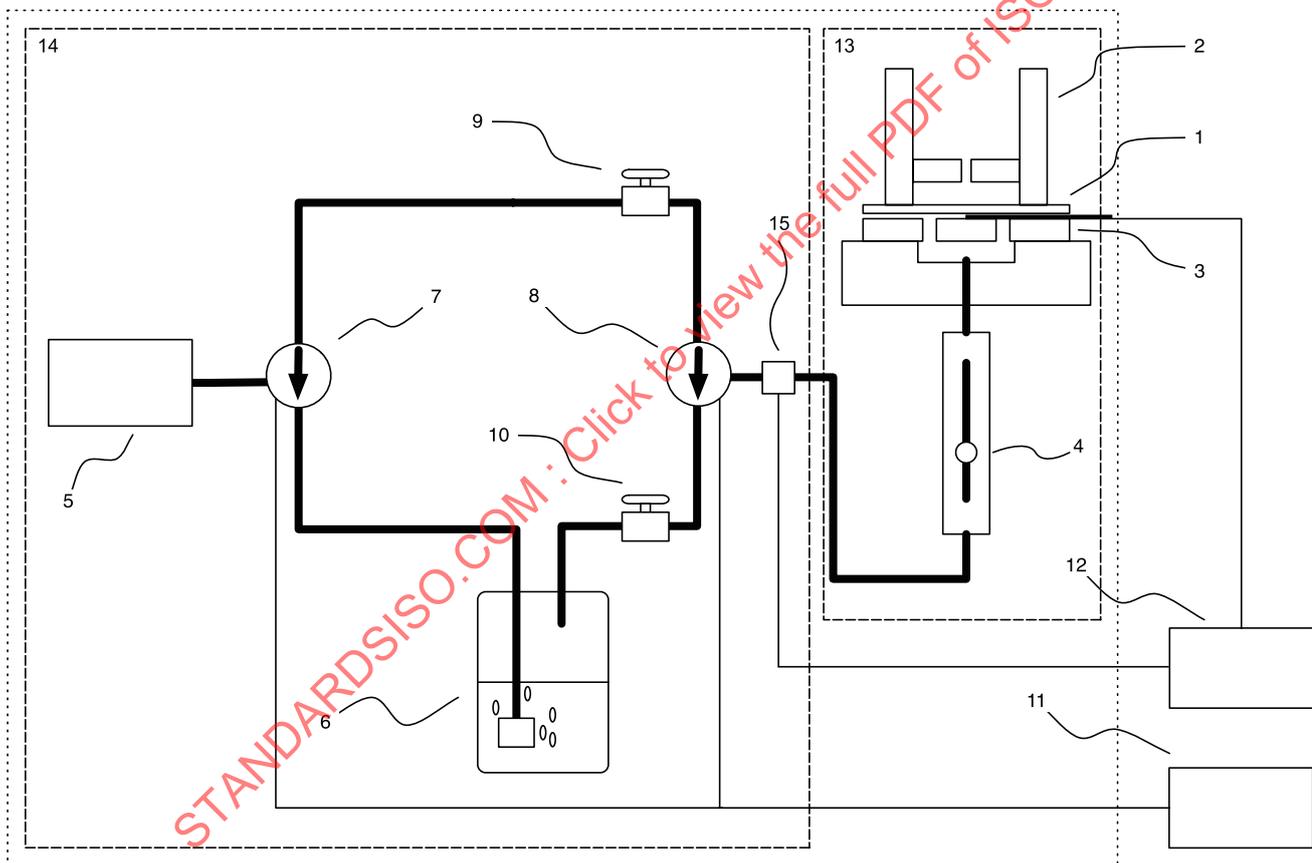
Key

1	specimen	9, 10	air valve
2	specimen holder	11	air-flow-path switch controller
3	specimen table	12	thermometer and monitoring recorder
4	air-flow-rate controller	13	test position
5	air pump	14	air supply line
6	air bubbling bottle with water	15	humidity sensor
7, 8	air flow path switch	16	porous cylinder

Figure 1 — Testing apparatus configuration

6.2.1   Air pump, capable of blowing air to the specimen at a rate of 1,0 l/min ± 0, 1 l/min.

6.2.2   Bubbling bottle, consisting of an air-tight bottle with an air inlet tube attached to a porous cylinder which is used to make air bubbles and with air outlet tube.

6.2.3   Air flow path switch, used for switching a low humidity air to take a path via 7, 9 and 8 or high humidity air to take a path via 7, 6, 10 and 8 through a water bubbling bottle in Figure 1.

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

6.2.5   Specimen table and holder, explained in Figure 2.
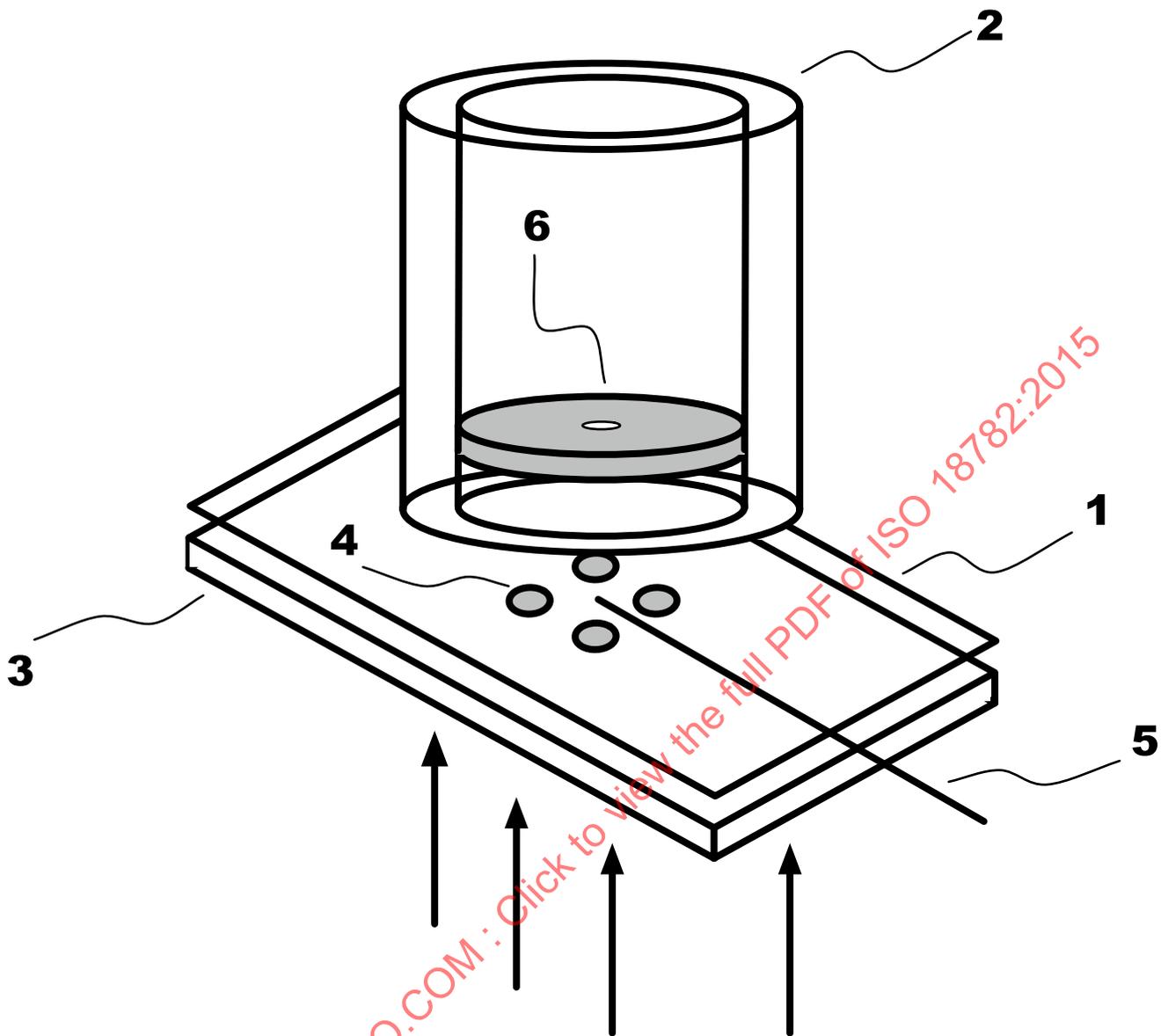
Key

1   specimen
2   specimen holder
3   specimen table
4   air path holes
5   thermometer
6   air lid with a vent hole

Figure 2 — Specimen table and holder

6.2.5.1   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.

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

6.2.5.3   Thermometer, with a film-type sensor as shown in <u>Figure 3</u>, placed on the specimen table located at the centre of the table 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

6.3   Monitoring recorder, connected to the thermometer, to record the temperature data continuously.

6.4   Oven, capable of heating at 105 °C ± 3 °C.

6.5   Desiccant dehumidifier.

7   Reagents and materials

7.1   Water, tap water.

7.2   Control specimen, cut from a cotton fabric as specified in ISO 105-F02.

8   Preparation of specimens

8.1   Dimension, with a square of 60 mm ± 2 mm

8.2   Number of specimens, 4 test specimens for each test sample and 4 control specimens.

8.3 Conditioning of specimens.

8.3.1 Place all the specimens in the oven (6.4) at 105 °C for 3 h.

8.3.2 After drying, place the specimens in a desiccant dehumidifier (6.5) for at least for 2 h to cool down.

8.3.3 Set up the constant temperature and humidity chamber (6.1) at 20 °C ± 2 °C and (40 ± 3)% RH, and keep it at these conditions for more than 12 h to obtain the stable condition.

8.3.4 Place the desiccant dehumidifier (6.5) with the specimens in the constant temperature and humidity chamber (6.1).

8.3.5 Take the specimens out of the desiccant dehumidifier (6.5) and place them in the constant temperature and humidity chamber (6.1).

8.3.6 Keep the specimens for more than 12 h in the constant temperature and humidity chamber (6.1) before testing.

9 Testing procedure

9.1 Mount 4 testing specimens (from 8.3.6) on each specimen table so that the side to be measured is in contact with thermometer. Place the specimen holders on the specimens.

9.2 Set the air flow path to 7, 9 and 8 for the low humidity air, using the air flow path switches 7 and 8.

9.3 Blow the low humidity air from the chamber (6.1), via the air pump at a rate of 1,0 l/min ± 0,1 l/min, onto the testing specimen. Maintain this flow for at least for 30 min to reach an equilibrium temperature.

9.4 Read the equilibrium temperature for each position as the initial temperature.

9.5 Turn the air flow path switches (7 and 8 in Figure 1) to open an air path through the air bubbling bottle (6.2.2) to blow the high humidity air onto the testing specimen at the air flow rate determined in accordance with Annex A. Keep the switches open at least 30 min to obtain a temperature curve which increases, reaches a peak and drops.

9.6 Read the peak temperature for each position.

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

$$\Delta T = T_{peak} - T_{initial} \tag{1}$$

where

   ΔT is the generated hygroscopic heat;

   T_{peak} is the peak temperature;

   $T_{initial}$ is the temperature at low humidity.

9.8 Calculate the average ΔT from the result of 4 specimens.

9.9 Record the average result in the test report.
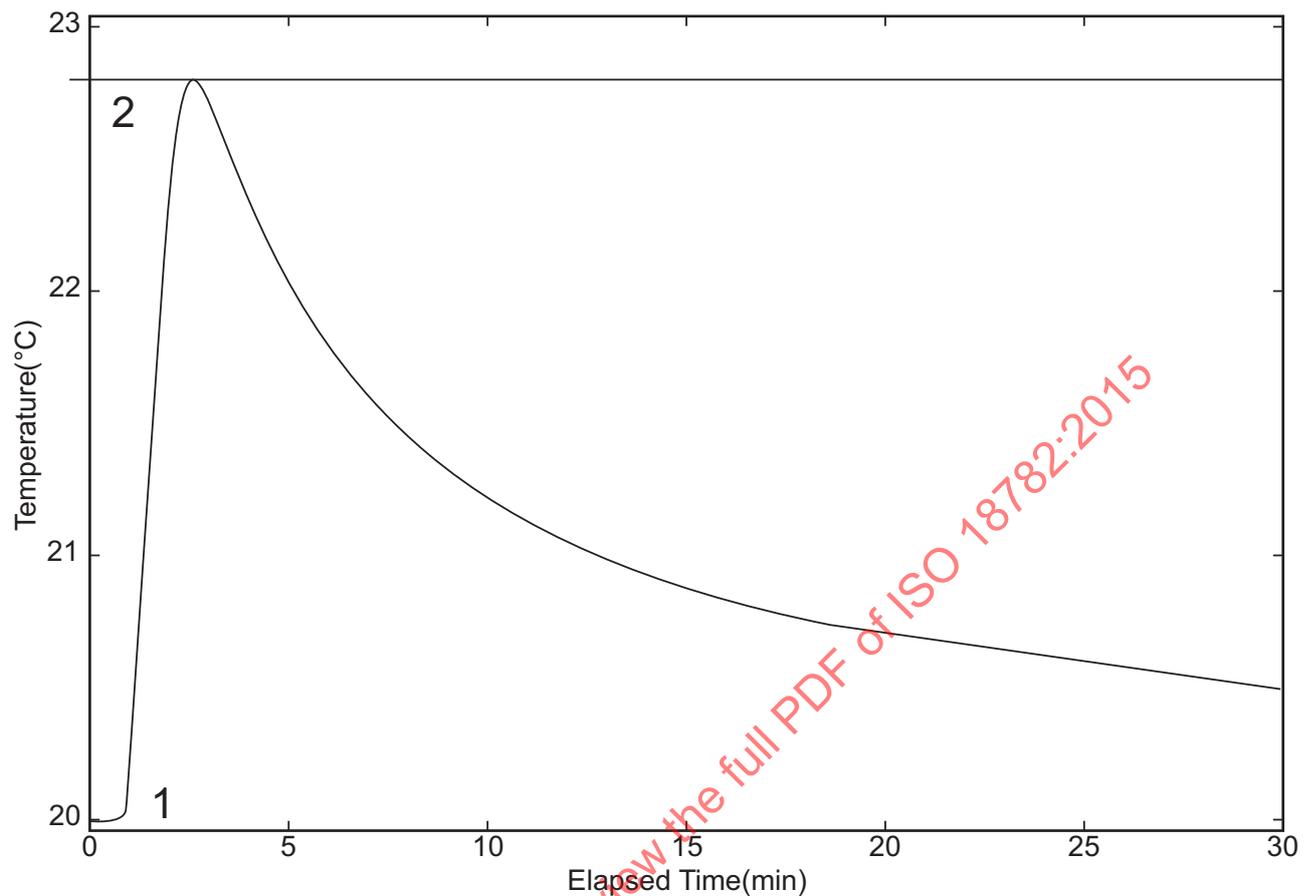
Key
1   initial temperature
2   peak temperature

Figure 4 — Test result and definition

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.

10 Test report

The test report shall contain the following:

a)   reference to this International Standard;

b)   details of the sample tested;

c)   test results;

d)   any deviation from the procedure described in this International Standard.

Annex A
(normative)

Determination of the air flow rate for high humidity air

A.1 General

In a 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 by the following procedure.

A.2 Procedure

A.2.1 Mount the control specimen (conditioned in the chamber) on the specimen table and place the specimen holder on the control specimen.

A.2.2 Set the air flow path of 7, 9 and 8 for low humidity air using the air flow path switches 7 and 8.

A.2.3 Blow the low humidity air from the chamber (6.1) via the air pump, at a rate of 1 l/min, onto the control specimen for at least 30 min to reach at an equilibrium temperature.

A.2.4 Turn the switches 7 and 8 to open an air path through the air bubbling bottle (6.2.2) to blow the high humidity air onto the control specimen for at least for 30 min in order to obtain a temperature curve which increases, reaches a peak and drops.

A.2.5 Find the air flow rate needed to obtain a 2,8 °C ± 0,3 °C peak temperature increase from the temperature at the low humidity air blow.

A.2.6 Record the air-flow-rate setting of the high humidity air for tests.

A.2.7 If the target temperature increase of 2,8 °C ± 0,3 °C cannot be obtained, repeat the test using a new control specimen.
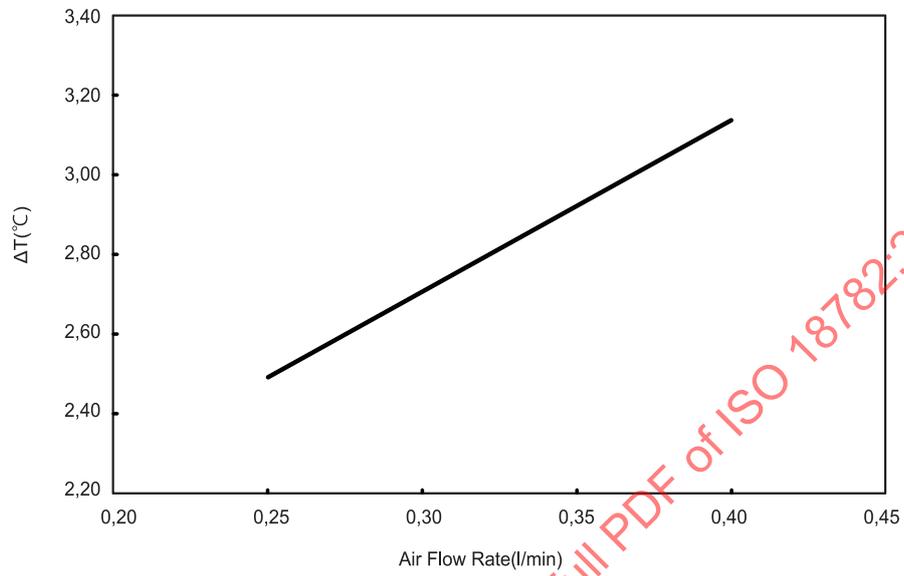
Figure A.1 — Example of an air flow rate and Δ*T*

Annex B
(informative)

Interlaboratory test results

B.1 Cotton control fabric

B.1.1 Sample details

The sample used in this test was a cotton 100 % fabric with a surface density of 100 g/m².

B.1.2 Test results

The test results obtained are shown in Table B.1.

Table B.1 — Test result for cotton control fabric

		Data obtained ΔT (°C)				Test result ΔT (°C)
Lab 1	Day 1	2,9	3,0	2,7	2,8	2,83
	Day 2	3,1	3,1	2,8	2,8	2,92
	Day 3	3,0	2,9	2,8	2,9	2,90
Lab 2	Day 1	2,8	2,8	3,0	3,0	2,88
	Day 2	3,0	2,7	3,0	2,9	2,92
	Day 3	2,8	2,6	2,8	2,8	2,72
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	2,89

B.2 Polyester fabric

B.2.1 Sample details

The sample used was a polyester 100 % fabric with a surface density of 70 g/m².

B.2.2 Test results

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

Table B.2 — Test result for polyester adjacent fabric

		Data obtained ΔT (°C)				Test result ΔT (°C)
Lab 1	Day 1	0,7	0,6	0,6	0,6	0,64
	Day 2	0,6	0,6	0,6	0,6	0,61
	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	0,74
Lab 3	Day 1	0,8	0,7	0,6	0,8	0,72
	Day 2	0,6	0,6	0,6	0,5	0,58
	Day 3	0,6	0,7	0,6	0,6	0,64

B.3   Polyamide

B.3.1   Sample detail

The sample used was a polyamide 100 % fabric with a surface density of 70 g/m^2.

B.3.2   Test results

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

Table B.3 — Test result for polyamide adjacent fabric

		Data obtained ΔT (°C)				Test result ΔT (°C)
Lab 1	Day 1	1,5	1,6	1,2	1,3	1,39
	Day 2	1,7	1,7	1,4	1,5	1,59
	Day 3	1,5	1,7	1,4	1,5	1,53
Lab 2	Day 1	1,6	1,5	1,6	1,6	1,56
	Day 2	1,5	1,5	1,7	1,5	1,56
	Day 3	1,5	1,4	1,5	1,4	1,44
Lab 3	Day 1	1,5	1,7	1,7	1,7	1,62
	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

B.4.1   Sample detail

The sample used was a wool 100 % fabric with a surface density of 102 g/m^2.

B.4.2   Test results

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

Table B.4 — Test result for wool adjacent fabric

		Data obtained ΔT (°C)				Test result ΔT (°C)
Lab 1	Day 1	3,1	3,0	2,8	2,9	2,96
	Day 2	3,4	3,6	2,9	3,4	3,34
	Day 3	3,1	3,6	3,1	3,3	3,27
Lab 2	Day 1	2,9	2,9	2,9	3,1	2,92
	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	3,37
	Day 2	3,3	3,6	3,5	3,6	3,47
	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 below correspond to ISO 5725-2.

Table B.5 — Test results: 4 fabrics (cotton, polyester, polyamide, wool)

Laboratory$_i$	n	Level$_j$			
		1	**2**	**3**	**4**
		cotton	**polyester**	**polyamide**	**wool**
Lab 1	Day 1	2,83	0,64	1,39	2,96
	Day 2	2,92	0,61	1,59	3,34
	Day 3	2,90	0,55	1,53	3,27
Lab 2	Day 1	2,88	0,63	1,56	2,92
	Day 2	2,92	0,78	1,56	3,28
	Day 3	2,72	0,74	1,44	3,08
Lab 3	Day 1	2,98	0,72	1,62	3,37
	Day 2	2,78	0,58	1,40	3,47
	Day 3	2,89	0,64	1,50	3,38

Table B.6 — Cell means: 4 fabrics (cotton, polyester, polyamide, wool)

Laboratory$_i$	Level$_j$							
	1: cotton		**2: polyester**		**3: polyamide**		**4: wool**	
	$\overline{y}_{ij}$	n_{ij}	$\overline{y}_{ij}$	n_{ij}	$\overline{y}_{ij}$	n_{ij}	$\overline{y}_{ij}$	n_{ij}
Lab 1	2,88	3	0,60	3	1,50	3	3,19	3
Lab 2	2,84	3	0,71	3	1,52	3	3,09	3
Lab 3	2,88	3	0,64	3	1,51	3	3,41	3

Table B.7 — Standard deviations: 4 fabrics (cotton, polyester, polyamide, wool)

Laboratory$_i$	Level$_j$							
	1: cotton		**2: polyester**		**3: polyamide**		**4: wool**	
	s_{ij}	n_{ij}	s_{ij}	n_{ij}	s_{ij}	n_{ij}	s_{ij}	n_{ij}
Lab 1	0,048 9	3	0,048 6	3	0,100 9	3	0,201 8	3
Lab 2	0,104 0	3	0,080 1	3	0,070 0	3	0,182 8	3
Lab 3	0,102 9	3	0,069 2	3	0,111 4	3	0,055 1	3

Table B.8 — Computed values of $\hat{m}_j$, s_{rj} and s_{Rj} for 4 fabrics

	Level$_j$			
	1: cotton	**2: polyester**	**3: polyamide**	**4: wool**
p_j	3	3	3	3
$\hat{m}_j$	2,87	0,65	1,51	3,23
s_{rj}	0,089 0	0,067 2	0,095 8	0,160 4
s_{Rj}	0,089 0	0,080 1	0,095 8	0,207 7
Repeatability standard deviation, s_r = 0,103 1				
Reproducibility standard deviation, s_R = 0,118 1				