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Textiles — Measurement of exothermic and endothermic properties of textiles under humidity change

Textiles — Mesurage des propriétés exothermiques et endothermiques de textiles sous conditions d'humidité changeantes

Reference number
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Foreword

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

Introduction

The thermal properties of textile materials contribute to a wearer's physiological comfort, product's durability, etc. Hence, there are many kinds of products with specific thermal performances and various test methods that have been developed and standardized. However, these tests should be conducted in a certain humidity. The method for thermal properties in elevated or reduced humidity has not been standardized.

All materials generate heat when absorbing moisture and absorb heat when releasing moisture. The heat of absorption varies according to the material, for example, the heat of absorption in wool fibre is much bigger than that in common synthetic fibre. Recently, with this property, some heat-generating textiles have been developed and applied to various products, such as outdoor wear, sportswear, inner wear, special working wear, and healthcare wear. Therefore, the test for the hygroscopic and exothermic properties of textiles is needed for both producers and customers. Despite these needs, accurate and reliable information about hygroscopic and exothermic properties of textiles cannot be offered because of the absence of a standard test method.

The exothermic and endothermic properties of textiles under changing conditions of environmental humidity can be measured with this test method and apparatus proposed in this International Standard.

Textiles — Measurement of exothermic and endothermic properties of textiles under humidity change

1 Scope

This International Standard specifies a method for the measurement of exothermic and endothermic properties by moisture absorption and desorption in sheet-like textiles, e.g. fabrics, knit or nonwovens for clothing, bedding, upholstery, and similar textile products.

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 3696:1987, *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.

3.1
exothermic property
property of material whereby it releases heat to the surroundings

3.2
endothermic property
property of material whereby it absorbs heat from the surroundings

3.3
hygroscopic and exothermic property
property of material whereby it generates heat by absorbing moisture and releases the generated heat to its surroundings where relative humidity changes from low to high over time

3.4
hygroemissive and endothermic property
property of material whereby it loses heat and cools down by releasing moisture through evaporation to its surroundings where relative humidity changes from high to low over time

4 Symbols and units

T_A is the ambient temperature in a temperature and humidity controlled chamber, in degrees Celsius.

RH_A is the ambient relative humidity in a temperature and humidity controlled chamber, in per cent.

RH_1 is the relative humidity in the first constant humidity container, starting humidity, in per cent.

RH_2 is the relative humidity in the second constant humidity container, target humidity, in per cent.

T_{peak} is the peak temperature, determined using a temperature sensor with or without the test specimen mounted on the sensor probe in the second constant humidity container during the hygroscopic and exothermic property test, in degrees Celsius.

T_{bottom} is the bottom temperature, determined using a temperature sensor with or without the test specimen mounted on the sensor probe in the second constant humidity container during the hygroemissive and endothermic property test, in degrees Celsius.

ΔT_{exo} is the difference in the peak temperature, determined between a state with and another without the test specimen mounted on the sensor probe during the hygroscopic and exothermic property test, in degrees Celsius.

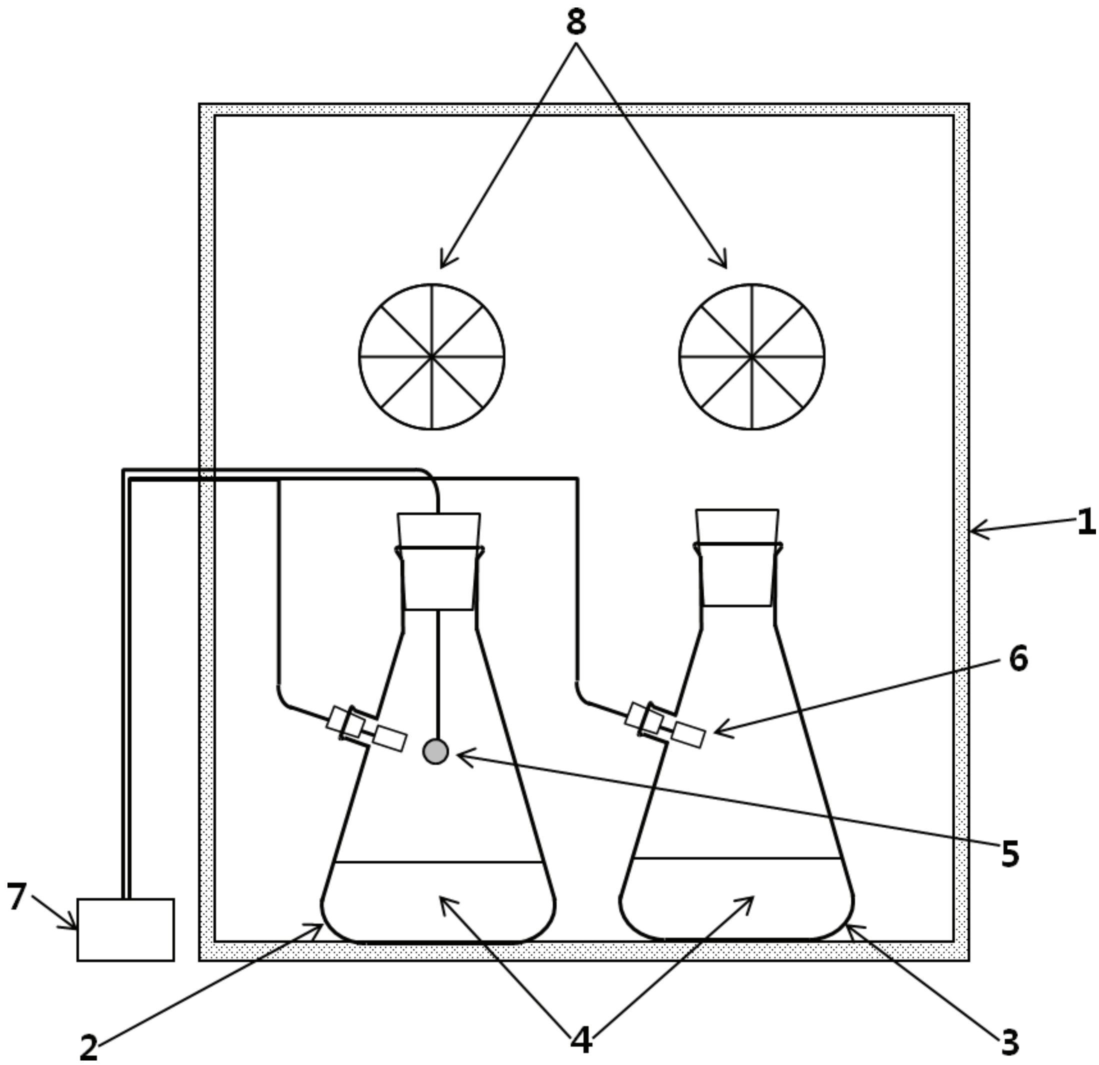
ΔT_{endo} is the difference in the bottom temperature, determined between a state with and another without the test specimen mounted on the sensor probe during the hygroemissive and endothermic property test, in degrees Celsius.

5 Principle

A test specimen is placed in a low humidity atmosphere and then exposed to a high humidity atmosphere, and then the other way round. The temperature of the test specimen is measured over time with a temperature sensor. The exothermic and endothermic properties of the test specimen are determined from the difference in temperature measured with the temperature sensor, between a test with and another without the test specimen mounted on the sensor probe.

6 Apparatus

6.1 Testing apparatus, composed of a temperature and humidity controlled chamber and small containers in which the humidity is controlled by chemicals and the test specimens are set through the rubber plugs as shown in Figure 1.



Key

1 temperature and humidity-controlled chamber with inner door

2 constant humidity container (first)

3 constant humidity container (second)

4 humidity control material

5 temperature sensor

6 humidity sensor

7 data collecting unit

8 arm hole in inner door

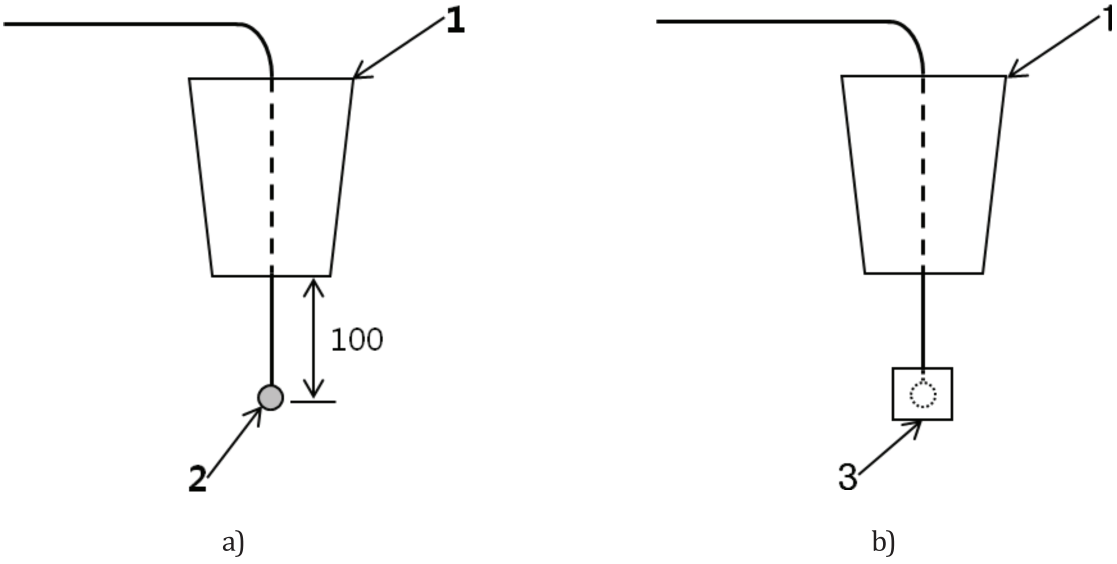
Figure 1 — Configuration of the testing apparatus

6.2 Temperature and humidity-controlled chamber, with a capacity of more than 200 l with inner door and arm holes as shown in Figure 1. The tolerance of the temperature and humidity shall not exceed ±0,5 °C and ±3 % RH, respectively.

6.3 Constant humidity containers, 2 l conical flasks with branch. Humidity sensor is inserted in the branch.

6.4 Plugs for constant humidity containers, made of silicone rubber for making a flask airtight. Temperature sensor is inserted in centre of the plug and the sensor probe protrudes 100 mm from the bottom of silicone rubber plug as shown in Figure 2a.

Dimensions in millimetres



Key
1 silicone rubber plug
2 temperature sensor probe
3 test specimen

Figure 2 — Silicone rubber plug

6.5 Temperature sensor, disk type with (5 ± 1) mm in diameter and (2,5 ± 0,5) mm in thickness.

6.6 Humidity sensor, for monitoring the humidity in constant humidity containers.

6.7 Clip, with (34 ± 3) mm in length and (8 ± 1) mm in outside width, nickel-plated wire.

6.8 Oven, for drying specimen at (105 ± 3) °C.

6.9 Dessicator.

7 Reagent

7.1 Sulfuric acid, reagent grade sulfuric acid.

7.2 Water, obtained by single distillation, or by ion exchange, or by reverse osmosis, as specified in ISO 3696, grade 3 water.

8 Preparation of the humidity control material

1 000 g ± 10 g of sulfuric acid solution can be prepared according to Table 1.

Table 1 — Relative humidity values for sulfuric acid/water solutions at a temperature of 34 °C

Relative humidity %	Sulfuric acid mass %
10	65
40	48
90	20

NOTE The values shown in this table are stated with an uncertainty ± 3 % RH. If necessary, concentration of sulfuric acid can be controlled.

9 Test procedure

9.1 Preparation of test specimen

9.1.1 Specimen dimension

Cut the sample into three test specimens of (50 ± 1) mm × (50 ± 1) mm.

9.1.2 Conditioning

Dry the specimens at 105 °C for 2 h or more by using the oven (6.8), then condition them in a desiccator until immediately before testing.

9.2 Preparation of apparatus

9.2.1 Set the condition of the temperature and humidity-controlled chamber (6.2) at 34 °C and 90 % RH.

9.2.2 Place the constant humidity containers (6.3) with the prepared sulfuric acid solution in the temperature and humidity-controlled chamber (6.2) for 2 h.

9.2.3 Read the humidity of each container when it reaches the constant value. Then, check that the humidity reaches the required values. If humidity reaches the constant value but falls outside ±3 % RH, adjust concentration of sulfuric acid or change the sulfuric acid solution for a new one and repeat the step.

NOTE 1 Humidity in the first and second container can be set according to the test purpose by consent among the concerned parties. In case of testing at a humidity of 40 % RH, replace the 10 % RH container by a 40 % RH container.

NOTE 2 Instead of 34 °C, another chamber temperature can be applied by consent among the concerned parties.

9.3 Test specimen mounting

9.3.1 The test specimen is mounted on the probe at the tip of the temperature sensor stuck through a silicon rubber plug in the manner shown in Figure 2b.

NOTE A pair of gloves can ensure avoiding the humidity change from handling the test specimen.

9.3.2 Fold a specimen in half and place the temperature sensor probe on the centre of upper half area to be tested.

9.3.3 Fold one more time in order to wrap the temperature sensor probe.

9.3.4 Hold the test specimen with a clip.

Dimensions in millimetres

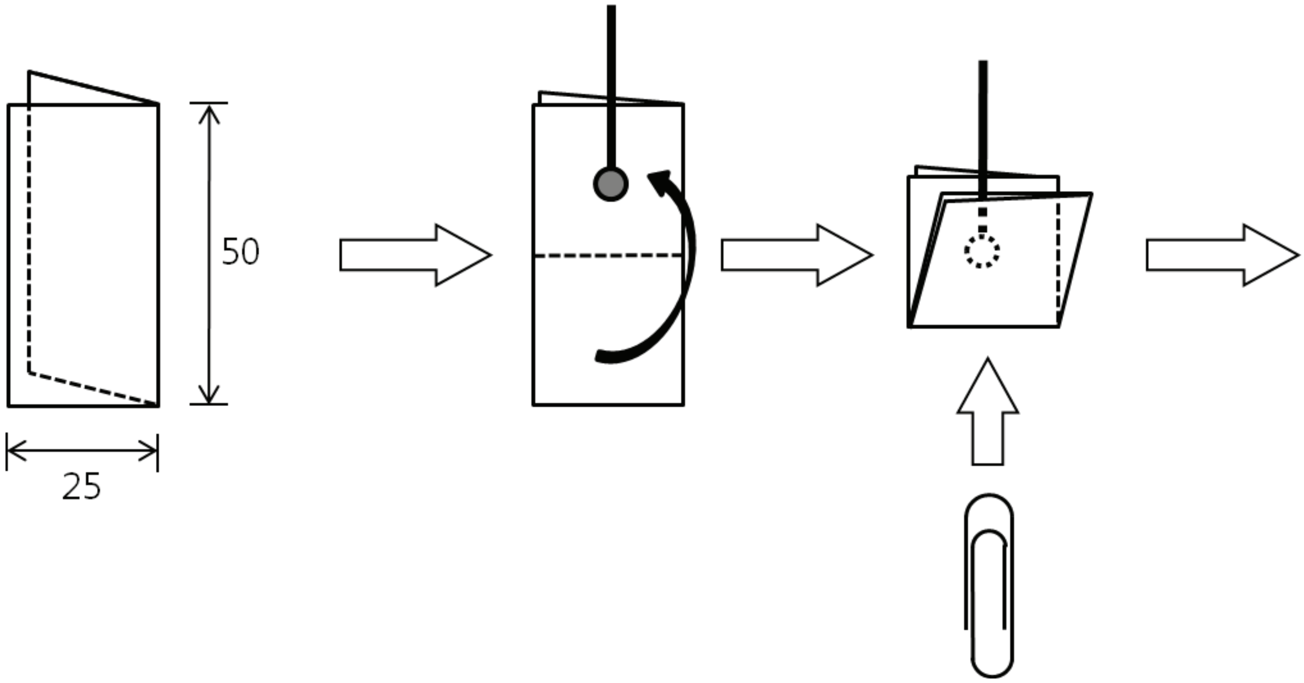


Figure 3 — Mounting of test specimen

9.3.5 After mounting the specimen, insert the plug into the mouth of a first container immediately.

9.4 Measurement of exothermic and endothermic properties

9.4.1 Hygroscopic and exothermic property test

9.4.1.1 Insert a silicone rubber plug mounted with the test specimen and sensor (6.5) into the mouth of a low humidity container (a first container) with an internal relative humidity of 10 % RH and push it down until it is secure. Then, allow the container to stand for a minimum of 3 h.

NOTE 40 % RH and any other humidity can be applied by consent among the concerned parties.

9.4.1.2 Start recording the sensor temperature. Then, remove the plug with test specimen and transfer it to the mouth of a high humidity container (a second container) with an internal relative humidity of 90 % RH; then, push it down again until it is secure.

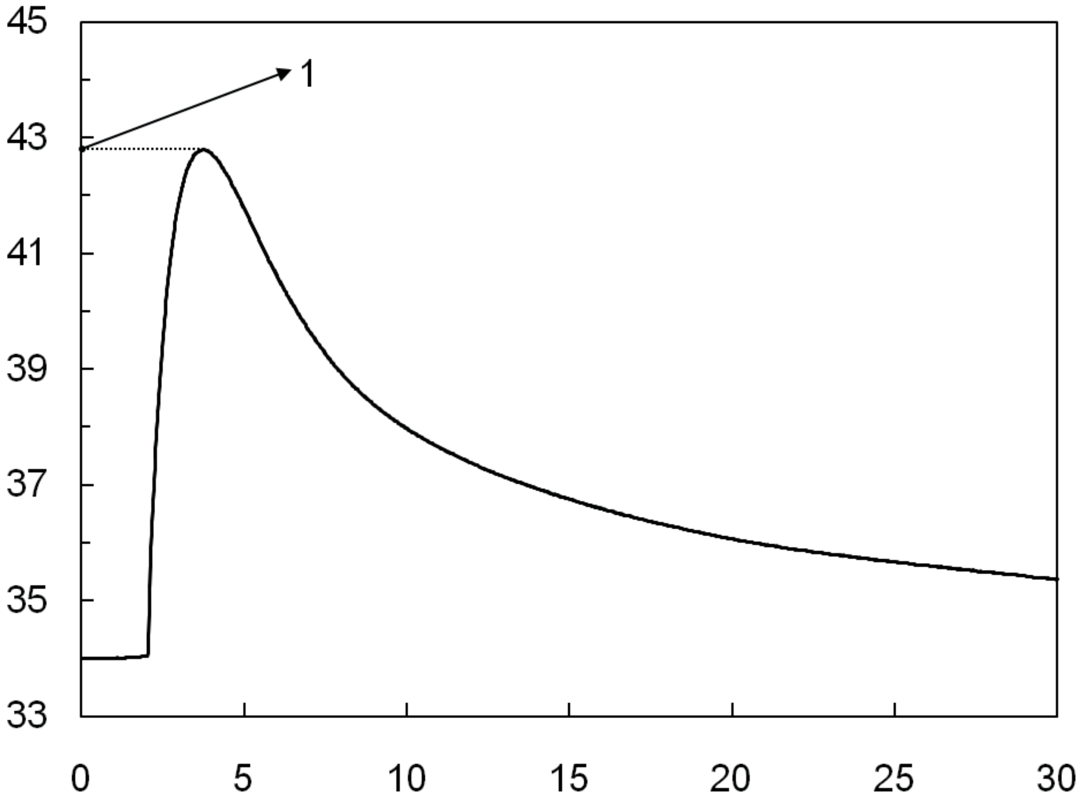
9.4.1.3 Record the sensor temperature for 30 min or more.

9.4.1.4 Read the peak temperature, T_{peak}, from the recorded temperature data as shown in Figure 4.

9.4.1.5 Read the blank peak temperature using the silicon rubber plug and the temperature sensor without the test specimen in the same manner as for determining the peak temperature of the test specimen.

9.4.1.6 Calculate ΔT_{exo} from Formula (1):

$$\Delta T_{exo} = T_{peak} \text{ of test specimen} - T_{peak} \text{ of blank state} \qquad (1)$$



Key

1 T_{peak}

X time, min

Y temperature, °C

Figure 4 — Hygroscopic and exothermic property test data

9.4.2 Hygroemissive and endothermic property test

9.4.2.1 Insert a silicone rubber plug mounted with the test specimen and sensor (6.4) into the mouth of a high humidity container (a first container) with an internal relative humidity of 90 % RH and push it down until it is secure and allow the container to stand for a minimum of 3 h.

9.4.2.2 Start recording the sensor temperature. Then remove the plug with the test specimen and transfer it to the mouth of a low humidity container (a second container) with an internal relative humidity of 10 % RH, then push it down again until it is secure.

NOTE 40 % RH and any other humidity can be applied by consent among the concerned parties.

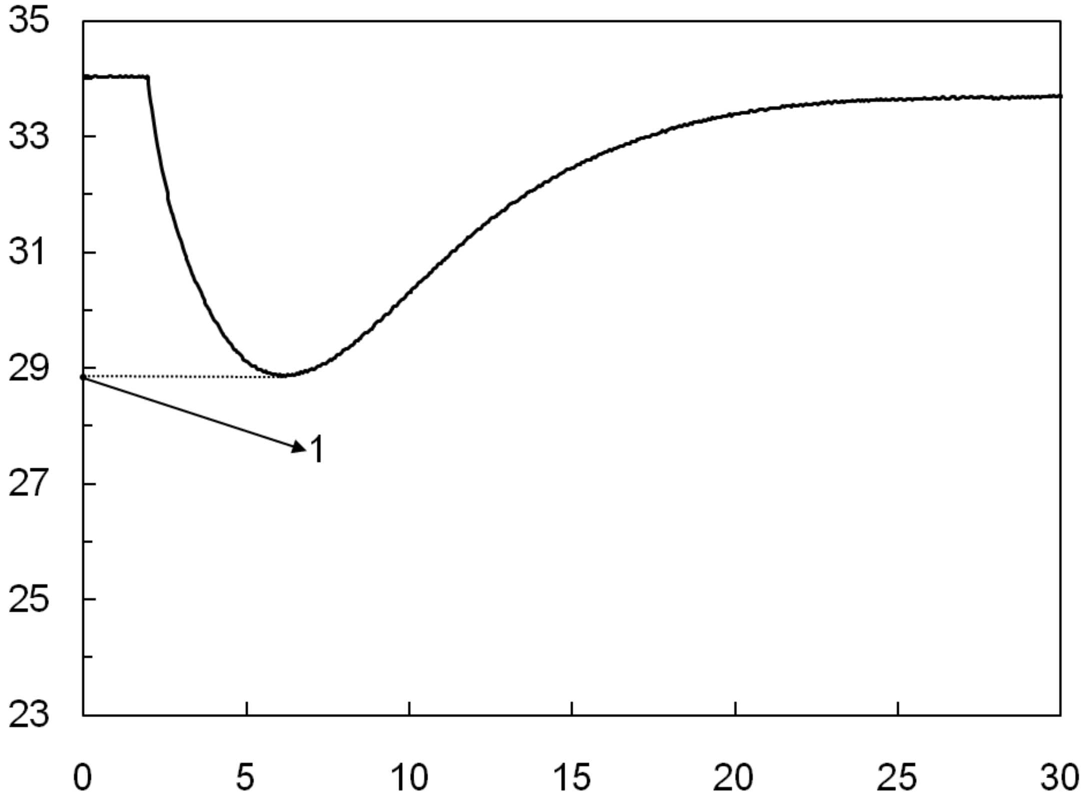
9.4.2.3 Record the sensor temperature for 30 min or more.

9.4.2.4 Read the bottom temperature, T_{bottom}, from the recorded temperature data as shown in Figure 5.

9.4.2.5 Read the blank bottom temperature using the silicon rubber plug and the temperature sensor without the test specimen in the same manner as for determining the bottom temperature of the test specimen.

9.4.2.6 Calculate ΔT_{endo} from Formula (2):

$$\Delta T_{endo} = T_{bottom} \text{ of test specimen - } T_{bottom} \text{ of blank state} \quad (2)$$



Key

1 T_{bottom}

X time, min

Y temperature, °C

Figure 5 — Hygroemissive and endothermic property test data

10 Test report

The test report shall include the following information:

a) a reference to this International Standard;

b) complete description of the sample tested, i.e. sample name, fibre content, and mass per unit area;

c) deviations from this International Standard;

d) test condition;

e) test result.

Annex A
(informative)

Example of hygroscopic and exothermic property test

A.1 Sample description

Sample name	Sample A
Fibre content	100 % wool
Mass per unit area	208 g/m^2

A.2 Test condition

Chamber	T_A	34 °C
	RH_A	90 % RH
Container	RH_1	10 % RH
	RH_2	90 % RH

A.3 Test result

Temperature difference, ΔT_{exo} (°C)	7,8

Annex B
(informative)

Example of hygroemissive and endothermic property test

B.1 Sample description

Sample name	**Sample B**
Fibre content	100 % cotton
Mass per unit area	192 g/m^2

B.2 Test condition

Chamber	T_A	34 °C
	RH_A	10 % RH
Container	RH_1	90 % RH
	RH_2	10 % RH

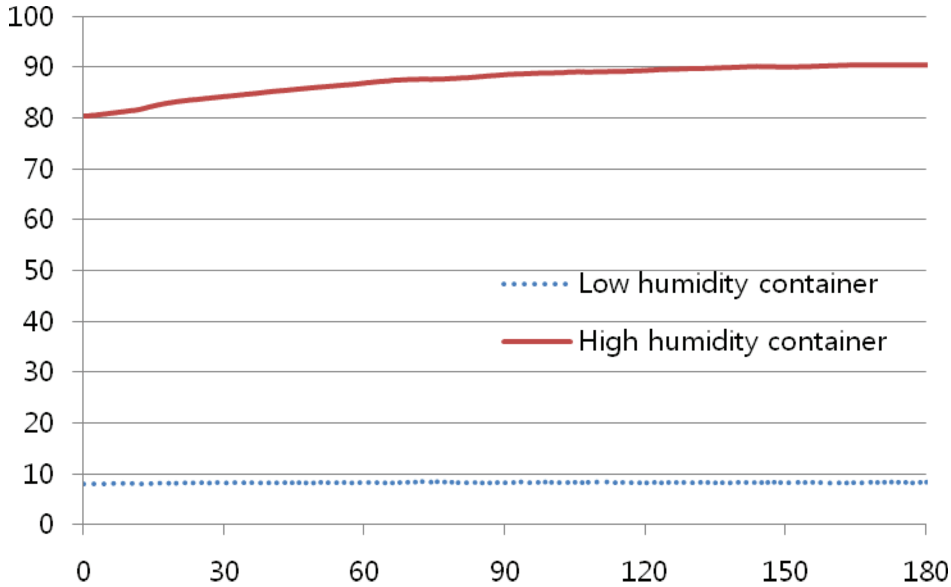
B.3 Test result

Temperature difference, ΔT_{endo} (°C)	-5,2

Annex C
(informative)

Example of practical humidity measurement

C.1 Example of humidity measurement during preparation of apparatus



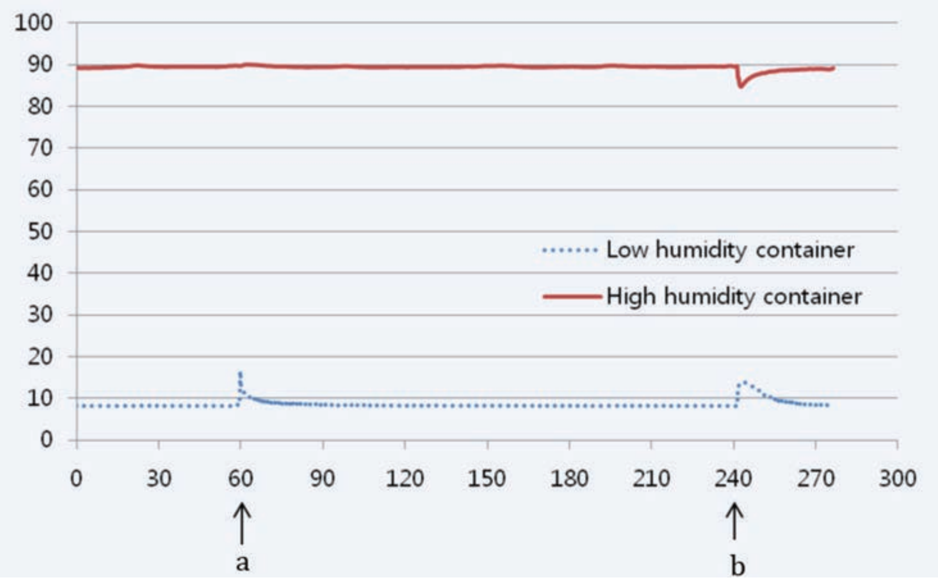
Key

X time, min

Y relative humidity, %

Figure C.1 — Humidity in containers during preparation of apparatus

C.2 Example of humidity measurement during test



Key

X time, min

Y relative humidity, %

a The moment that the test specimen is inserted in the low humidity container.

b The moment that the test specimen is moved to the high humidity container.

Figure C.2 — Humidity in containers during test

Bibliography

[1] ASTM E104-85:1991, *Standard practice for maintaining constant relative humidity by means of aqueous solutions*

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