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**Clothing and equipment for protection  
against heat — Test method for convective  
heat resistance using a hot air circulating  
oven**

*Vêtements et équipement de protection contre la chaleur — Méthode  
d'essai de la résistance à la chaleur de convection au moyen d'un four à  
circulation d'air chaud*

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## Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 17493 was prepared by Technical Committee ISO/TC 94, *Personal safety — Protective clothing and equipment*, Subcommittee SC 13, *Protective clothing*.

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# Clothing and equipment for protection against heat — Test method for convective heat resistance using a hot air circulating oven

## 1 Scope

This International Standard describes a test method for evaluating the heat resistance of protective clothing materials or items and equipment when exposed in a hot air circulating oven. The method is intended to evaluate physical changes in a material at a given exposure temperature. Materials are evaluated for visible changes or subjected to a material property measurement following heat exposure. This test method also enables the measurement of shrinkage that occurs as a result of the heat exposure.

Different procedures are provided depending on the type of the protective clothing material or item being tested.

## 2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 139:1973, *Textiles — Standard atmospheres for conditioning and testing*.

ISO 3759:1994, *Textiles — Preparation, marking and measuring of fabric specimens and garments in tests for determination of dimensional change*.

ISO 3873:1977, *Industrial safety helmets*.

ISO 4643:1992, *Moulded plastics footwear — Lined or unlined poly(vinyl chloride) boots for general industrial use — Specification*.

## 3 Terms and definitions

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

### 3.1

#### **charring**

formation of a carbonaceous residue when material is exposed to thermal energy

### 3.2

#### **clothing**

materials worn by a person, including textile and other sheet materials, accessories such as slide fasteners and hook and loop fasteners, bands, reflective tapes and small whole items such as gloves

### 3.3

#### **embrittlement**

formation of a brittle residue when material is exposed to thermal energy

**3.4  
equipment**

footwear, helmets and eye or face protection devices

**3.5  
ignition**

initiation and continuation of combustion

**3.6  
melt**

<materials> respond to heat by flowing or dripping

**3.7  
separate**

<materials> respond to heat by splitting, delamination or flaking

**3.8  
shrinkage**

a decrease in one or more dimensions of an object or material

## 4 Principle

Specimens are suspended in a hot air circulating oven for 5 min at the specified test temperature. Any ignition, melting, dripping, separation or shrinkage of the specimen is recorded. Specimens may also be subject to other property determinations following heat exposure.

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## 5 Apparatus

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**5.1 Forced air circulating oven**, capable of maintaining the test temperature over a period of 5 min and of sufficient internal volume to allow the test specimen (see clause 6) to be suspended as specified in clause 7. Testing shall be carried out at the test temperature specified in the referencing standard. If not specified, testing shall be carried out at a test temperature of  $(185 \pm 5)$  °C or  $(260 \pm 5)$  °C.

The test oven shall be a horizontal flow circulating oven with minimum interior dimensions such that the specimens can be suspended and be at least 50 mm from any interior oven surface or other test specimens.

The test oven shall have an airflow rate of 0,5 m/s to 1,5 m/s at the standard temperature and pressure of 20 °C at 1 atm, measured at the centre-point of the oven.

A test thermocouple shall be positioned so that it is level with the horizontal centreline of a mounted sample specimen. The thermocouple shall be equidistant between the vertical centreline of a mounted specimen placed in the middle of the oven and the oven wall where the airflow enters the test chamber. The thermocouple shall be an exposed bead, Type J or K, No. 30 AWG, or thermocouple with equivalent response time. The test oven shall be heated and the test thermocouple stabilized at the test temperature for a period of not less than 30 min.

**5.2 Rigid, square template for material specimens**, measuring 375 mm × 375 mm.

A small template measuring 150 mm × 150 mm may be used for materials that are not subjected to shrinkage measurements.

For specimens (such as straps) narrower than 150 mm in one dimension, use specimens at their normal width by 150 mm in length. Suspend these specimens with their long axis in a vertical direction.

**5.3 Ruler**, graduated in millimetres.

**5.4 Stretching frame for knit materials**, consisting of a board with uniformly spaced pins along the perimeter (at intervals of 25 mm) to secure knit materials before and after heat exposure. The stretching frame should be of a size on which the pins are located approximately 50 mm inward from the edge of the cut specimen size.

## 6 Specimens

### 6.1 Material specimen preparation and conditioning

Condition the material for at least 24 h in a standard atmosphere at  $(20 \pm 2)$  °C and  $(65 \pm 5)$  % relative humidity in accordance with ISO 139.

Mark and cut out a square specimen using the template (5.2). If the material or item for test is narrower than 375 mm, cut the specimen 375 mm in the direction of its length and turn the specimen so as this edge serves as the width. If the item for test is less than 375 mm × 375 mm, test the complete item.

As indicated in 5.2, the specimen may be of reduced size (using a template of 150 mm × 150 mm) when the specimens are not subjected to measurement of shrinkage.

Test a minimum of three specimens.

### 6.2 Glove, footwear, helmet and eyewear specimen preparation and conditioning

Small items of protective clothing or equipment may be tested whole such as gloves, footwear, helmets or eyewear, as long as the oven specifications specified in 5.1 are met. A minimum of three different items shall be tested.

Condition these items for at least 24 h in a standard atmosphere at  $(20 \pm 2)$  °C and  $(65 \pm 5)$  % relative humidity.

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## 7 Procedures

### 7.1 Procedure for flat textile or other sheet materials

Mark and measure specimens in accordance with the procedures specified in ISO 3759.

Turn on the oven and heat to test temperature. Allow the oven to stabilize at the test temperature for a minimum of 30 min.

Suspend the specimen by metal hooks at the top and centred in the oven so that the entire specimen is not less than 50 mm from any oven surface or other specimen, and airflow is parallel to the plane of the material.

Do not open the oven door for more than 15 s. Shut off the air circulation while the door is open and turn the air circulation on when the door is closed. The total oven recovery time after the door is closed shall not exceed 30 s.

Expose the specimen, mounted as specified, in the test oven for  $5^{+0,15}_0$  min. The test exposure time shall begin when the test thermocouple recovers to the test temperature  $t \pm 0,5$  °C.

Immediately after the specified exposure, remove the specimen and examine it for evidence of charring, embrittlement, ignition, melting or separation.

Five minutes after the specified exposure, where required, measure the specimen's marked dimensions to determine percentage shrinkage in both main directions. Using the stretching frame (5.4), pull knit fabric specimens to their original dimensions for 10 min, then remove the specimens from the frame, and allow the specimens to relax for 10 min prior to measurement to determine pass/fail.

If, in stretching knit fabric specimens, the specimens break or cannot be stretched to the original dimensions, then this observation shall be reported in lieu of the measured shrinkage.

Subject heat-exposed specimens to other evaluations as required.

## 7.2 Procedure for protective gloves

Measure the glove length from the tip of the middle finger to the end of the glove body on the palm side. Measure the glove width on the palm side 25 mm below the base of the fingers.

Turn on the oven and heat to test temperature. Allow the oven to stabilize at the test temperature for a minimum of 30 min.

Fill the glove body with dry vermiculite, clamp the opening of the glove together and suspend the specimen in the clamp in the oven so that the entire glove is not less than 50 mm away from any oven surface or other specimen, and airflow is parallel to the plane of the glove palm.

Do not open the oven door for more than 15 s. Shut off the air circulation while the door is open and turn the air circulation on when the door is closed. The total oven recovery time after door is closed shall not exceed 30 s.

Expose the specimen, mounted as specified, in the test oven for  $5^{+0,15}_0$  min. The test exposure time shall begin when test thermocouple recovers to the test temperature  $t^{+5}_0$  °C.

Immediately after the specified exposure, remove the specimen and examine it for evidence of charring, embrittlement, ignition, melting or separation.

Five minutes after the specified exposure, remove the vermiculite and remeasure the glove length and width as indicated above to determine the percentage shrinkage in each direction.

Have a test subject, whose hands are of suitable dimensions for the tested gloves, don the gloves before the exposure to check the size. The test subject shall then don the exposed gloves 15 min after the heat exposure and flex the gloves a total of 25 times by clenching and unclenching the hands repeatedly into a fist. Record any changes in the gloves as a result of heat exposure and flexing.

## 7.3 Procedure for protective footwear

Turn on the oven and heat to test temperature. Allow the oven to stabilize at the test temperature for a minimum of 30 min.

Fill the footwear with dry vermiculite, fasten all closures, and position the footwear in the exact centre of the oven, using a non-conductive stand in the centre of the oven or oven rack (with the toe of the footwear facing the oven door). Ensure that the footwear item is not less than 50 mm away from any oven surface and airflow is parallel to the length of the footwear item (front to back). Test only one footwear item at a time.

Do not open the oven door for more than 15 s. Shut off the air circulation while the door is open and turn the air circulation on when the door is closed. The total oven recovery time after door is closed shall not exceed 30 s.

Expose the specimen, mounted as specified, in the test oven for  $5^{+0,15}_0$  min. The test exposure time shall begin when test thermocouple recovers to the test temperature  $t^{+5}_0$  °C.

Immediately after the specified exposure, remove the specimen and examine it for evidence of charring, embrittlement, ignition, melting or separation.

Subject the footwear to a whole shoe flexer and flex for 10 000 cycles according to annex B of ISO 4643. Record any changes in the footwear as the result of heat exposure and flexing.



#### 7.4 Procedure for protective helmets and eye or face protection devices

Turn on the oven and heat to test temperature. Allow the oven to stabilize at the test temperature for a minimum of 30 min.

Place the helmet or eye/face protection device on a non-conductive ISO Size K headform as specified in ISO 3873. Mount and adjust the item on the headform in accordance with manufacturer's instructions. Position the headform in the exact centre of the oven (with the face of headform facing the oven door) using a non-conductive stand in the centre of the oven or oven rack. Ensure that the headform with helmet or eye/face protection device is not less than 50 mm away from any oven surface and airflow is parallel to the plane that bisects the headform in half (from front to back). Test only one helmet or eye/face protection device at a time.

Do not open the oven door for more than 15 s. Shut off the air circulation while the door is open and turn the air circulation on when the door is closed. The total oven recovery time after door is closed shall not exceed 30 s.

Expose the specimen, mounted as specified, in the test oven for  $5^{+0,15}_0$  min. The test exposure time shall begin when test thermocouple recovers to the test temperature  $t^{+5}_0$  °C.

Immediately after the specified exposure, remove the specimen and examine it for evidence of charring, embrittlement, ignition, melting or separation while still on the headform. Note, in particular, any deformation of helmet components that show a change in position by more than 40 mm with respect to the original position on the headform. Also, evaluate the functionality of any hardware, or components, such as chin straps, nape devices or adjustment bands.

#### 7.5 Procedures for small items and accessories on clothing

Turn on the oven and heat to test temperature. Allow the oven to stabilize at the test temperature for a minimum of 30 min.

For specimens that are narrower than 150 mm, use specimens with their normal width by 150 mm in length. Suspend these specimens with their long axis in the vertical direction.

When shrinkage measurements are specified, mark and measure specimens in accordance with the procedures specified in ISO 3759.

NOTE For some types of specimen, marking and measurement of only one dimension may be possible.

Prepare specimens using one of the following procedures.

- a) Attach specimens to the clothing fabric in the same orientation and method of attachment as used in the making of the clothing.
- b) Suspend the specimen by metal hooks at the top and centred in the oven so that the entire specimen is not less than 50 mm from any oven surface or other specimen, and airflow is parallel to the plane of the material.

Do not open the oven door for more than 15 s. Shut off the air circulation while the door is open and turn the air circulation on when the door is closed. The total oven recovery time after the door is closed shall not exceed 30 s.

Expose the specimen, mounted as specified, in the test oven for  $5^{+0,15}_0$  min. The test exposure time shall begin when test thermocouple recovers to the test temperature  $t^{+5}_0$  °C.

Immediately after the specified exposure, remove the specimen and examine it for evidence of charring, embrittlement, ignition, melting or separation.

Five minutes after the specified exposure, where required, measure the specimen's marked dimensions to determine percentage shrinkage in each marked direction.