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Protective clothing for firefighters — Laboratory test methods and performance requirements for protective clothing with a reflective outer surface

Vêtements de protection pour sapeurs-pompiers — Méthodes d'essai en laboratoire et exigences de performance relatives aux vêtements de protection ayant une surface extérieure réfléchissante

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Contents

Page

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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.

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 15538 was prepared by Technical Committee ISO/TC 94, *Personal safety — Protective clothing and equipment*, Subcommittee SC 13, *Protective clothing*.

Annex A forms an integral part of this International Standard. Annexes B and C are for information only.

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Introduction

The purpose of this International Standard is to provide minimum performance requirements for protective clothing designed for use in certain techniques of firefighting.

The protective clothing should be loose-fitting and as light as possible commensurate with the risks to which the user might be exposed.

A risk assessment should be made to determine whether the clothing covered by this International Standard is suitable for the intended use for the expected exposure. The risk assessment should include consideration of any respiratory protection that may also be required.

Firefighters should be trained in the use, care and maintenance of the protective clothing covered by this International Standard, including an understanding of its limitations and of the necessity to remove personal protective equipment (PPE) as soon as possible after an incident.

Subject to risk assessment, the clothing covered by this International Standard may be suitable for use in activities other than those considered by this International Standard. Nothing in this International Standard is intended to restrict any jurisdiction, purchaser or manufacturer from exceeding these minimum requirements.

A list of International Standards related to this International Standard is given in the Bibliography.

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Protective clothing for firefighters — Laboratory test methods and performance requirements for protective clothing with a reflective outer surface

1 Scope

This International Standard specifies test methods and minimum performance requirements for protective clothing that relies upon the ability of the outer material to reflect intense radiant heat.

The clothing covered by this International Standard is intended to provide protection against flame lick and intense radiant heat and it should be worn for short periods only.

Subject to a risk assessment, this type of clothing may also be used for certain industrial and other applications.

Subject to a risk assessment, other types of protective clothing, for example clothing complying with the requirements of ISO 11613, may be used for the types of firefighting and industrial applications envisaged by this International Standard in conjunction with appropriate protection for the head, face, hands and feet as well as suitable respiratory protection.

This International Standard does not consider requirements for the protection of the head (including the face), hands and feet other than those specified in 4.2 and 4.3. Any other requirements specific to the protection of head (including the face), hands and feet required by the user should be determined by a risk assessment and specified.

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 811, *Textile fabrics — Determination of resistance to water penetration — Hydrostatic pressure test*

ISO 1421, *Rubber- or plastics-coated fabrics — Determination of tensile strength and elongation at break*

ISO 3175-1, *Textiles — Dry cleaning and finishing — Part 1: Method for assessing the cleanability of textiles and garments*

ISO 4674:1977, *Fabrics coated with rubber or plastics — Determination of tear resistance*

ISO 4920, *Textiles — Determination of resistance to surface wetting (spray test) of fabrics*

ISO 5077, *Textiles — Determination of dimensional change in washing and drying*

ISO 6330:2000, *Textiles — Domestic washing and drying procedures for textile testing*

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ISO 6942:—[1)], *Protective clothing — Protection against heat and fire — Method of test: Evaluation of materials and material assemblies when exposed to a source of radiant heat*

ISO 8782-1, *Safety, protective and occupational footwear for professional use — Part 1: Requirements and test methods*

ISO 8782-5, *Safety, protective and occupational footwear for professional use — Part 5: Additional requirements and test methods*

ISO 9151, *Protective clothing against heat and flame — Determination of heat transmission on exposure to flame*

ISO 12127, *Clothing for protection against heat and flame — Determination of contact heat transmission through protective clothing or constituent materials*

ISO 13688, *Protective clothing — General requirements*

ISO 13934-1, *Textiles — Tensile properties of fabrics — Part 1: Determination of maximum force and elongation at maximum force using the strip method*

ISO 13935-2, *Textiles — Seam tensile properties of fabrics and made-up textile articles — Part 2: Determination of maximum force to seam rupture using the grab method*

ISO 13938-2, *Textiles — Bursting properties of fabrics — Part 2: Pneumatic method for determination of bursting strength and bursting distension*

ISO 15025:2000, *Protective clothing — Protection against heat and flame — Method of test for limited flame spread*

ISO 15383, *Protective gloves for firefighters — Laboratory test methods and performance requirements*

ISO 17493, *Clothing and equipment for protection against heat — Test method for convective heat resistance using a hot air circulating oven*

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3 Terms and definitions

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

3.1
garment
single item of clothing which may consist of single or multiple layers

3.2
clothing ensemble
combination of two or more garments that collectively provide protection of the body

3.3
clothing assembly
series of outer and under garments to be worn together

3.4
component assembly
combination of all materials of a multi-layer garment presented exactly as the finished garment construction

1) To be published. (Revision of ISO 6942:1993)

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3.5
closure system
method of fastening openings in the garment including combinations of more than one method for achieving a secure closure, e.g. a slide fastener covered by an overflap fastened down with a touch-and-close fastener

NOTE This term does not cover seams.

3.6
seam
any method of permanent fastening between two or more pieces of material

3.7
main seam
seam that is necessary for the integrity of the garment

3.8
hardware
non-fabric items used in protective clothing including those made of plastic or metal, e.g. fasteners, rank markings, buttons

4 General clothing design

4.1 Garments

4.1.1 General

Firefighters' protective clothing covered by this International Standard may provide protection for the firefighters' full body including head, hands, and feet depending of the risk assessment. It shall consist of

a) a single garment, or

b) a clothing ensemble, or

c) a clothing assembly.

Where clothing assemblies are used to achieve the specified performance levels of this International Standard, the various garments shall be clearly labelled that they are always to be used in combination (see clause 9).

The reflective surface of each outer garment shall not be covered in any way except where a screen is attached, if fitted.

4.1.2 Hardware

Hardware penetrating the outer material shall not be exposed on the innermost surface of the component assembly.

4.1.3 Pockets

If external pockets are required they shall be constructed entirely from the outer material, and secured by flaps which shall be 2,5 cm wider on each side than the pocket. External pockets shall have a means for water drainage to the outside of the garment only.

4.1.4 Sizes

The sizes of the clothing shall be designated in accordance with ISO 13688.

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4.2 Hand protection

Sizing of gloves shall comply with ISO 15383.

4.3 Foot protection

Foot protection is to be worn over the boots as specified in ISO 8782-5. If the garment incorporates protective boots, the combination shall also meet the requirements of ISO 8782-1.

5 Sampling and pretreatment

5.1 Sampling

Test specimens shall be taken from the material or materials as used in the component assembly. They may also be cut from the original garment and shall not include construction features, such as seams, closure systems, or hardware.

5.2 Pretreatment

Before testing the thermal requirements of metallized materials and component assemblies with a non-separable metallized layer, they shall be cleaned five times in accordance with the manufacturer's instructions.

Before executing the radiant heat test, metallized materials shall also be pretreated in accordance with the method given in annex A.

All other materials shall be washed in a front-loading horizontal-drum machine with 1 g/l of ECE reference detergent A (annex B of ISO 6330:2000) in soft water and dried in accordance with the procedures of ISO 6330. Washing shall be carried out using Procedure 2A of ISO 6330:2000 at (60 ± 3) °C and drying by Procedure E (tumble drying) unless otherwise specified in the care labelling. Drying shall be in accordance with the procedures of ISO 6330. A total of five washing and drying cycles shall be used. Materials which are labelled as dry cleanable only shall be dry cleaned five times in accordance with ISO 3175-1.

6 Thermal requirements

6.1 Limited flame spread

Each individual layer of the component assembly shall meet the following requirements when tested in accordance with Procedure A of ISO 15025:2000.

— No specimen shall give flaming to the top or either side edge.

— No specimen shall give hole formation.

— No specimen shall give flaming or molten debris.

— The mean value of afterflame time shall be $\leqslant$ 2 s.

— The mean value of the afterglow time shall be $\leqslant$ 2 s.

6.2 Heat transfer (radiant heat)

The component assembly shall meet the levels of performance of Table 1 when tested according to Method B of ISO 6942:— with a heat flux density of 40 kW/m^2.

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Table 1 — Heat transfer (radiant heat)

Level	t_2 s
1	⩾ 60
2	⩾ 120

6.3 Heat transfer (convective heat)

The component assembly shall meet the levels of performance of Table 2 when tested according to ISO 9151.

Table 2 — Heat transfer (convective heat)

Level	**HTI** (24 °C)[a] s
1	⩾ 13
2	⩾ 21
[a] HTI = heat transfer index (see ISO 9151)	

6.4 Contact heat

The component assembly shall meet the levels of performance of Table 3 when tested according to ISO 12127 at a contact temperature of 300 °C.

Table 3 — Contact heat

Level	**Threshold time** s
1	⩾ 10
2	⩾ 15

6.5 Heat resistance

With the exception of fitted screens, each material used in the component assembly and any component of the closure system that is exposed and/or in contact with the body shall not melt, drip or ignite, and shall not shrink more than 5 %, when tested at a temperature of (255 ± 10) °C in accordance with the method given in ISO 17493.

7 Mechanical requirements

7.1 Dimensional change

The materials of the component assembly shall give a dimensional change ⩽ 3 % in both the length and transverse directions when tested in accordance with ISO 5077 using the cleansing procedure specified in 5.2. Where length

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and transverse directions cannot be identified for a material, samples shall be cut and measurements made in any two perpendicular axes.

7.2 Tensile strength

The outer material used in the construction of the component assembly shall give a tensile strength of at least 650 N when tested in both the length and transverse directions in accordance with ISO 13934-1, or in accordance with ISO 1421 for metallized materials.

When tested in both length and transverse directions, the innermost lining shall give a tensile strength of at least 350 N. Where length and transverse directions cannot be identified for a material, samples shall be cut and measurements made in any two perpendicular axes.

If the innermost lining is a knit material, the innermost lining shall be tested as specified in ISO 13938-2 and shall have a burst strength of at least 25 kPa.

7.3 Tear strength

The outer material used in the construction of the component assembly shall give a tear strength of at least 25 N when tested in both the length and transverse directions in accordance with Method A2 of ISO 4674:1977, or in accordance with Method A1 of ISO 4674:1977 for metallized materials at $(1{,}7 \pm 0{,}17)$ mm/s for both methods. Where length and transverse directions cannot be identified for a material, samples shall be cut and measurements made in any two perpendicular axes.

7.4 Seam strength

All main seams shall be tested in accordance with ISO 13935-2 at a rate of 300 mm/min and the following results shall be obtained:

— seam strength $\geqslant$ 650 N for outer material seams where rupture can possibly expose inner layers, undergarments or skin;

— seam strength $\geqslant$ 350 N for inner layers seams where rupture can possibly expose the next inner layer, undergarments or skin;

— seam strength $\geqslant$ 180 N for all other seams.

Main seams that are constructed of knit materials shall be tested in accordance with ISO 13938-2 and shall have a burst strength $\geqslant$ 180 kPa.

8 Other requirements

8.1 Water-penetration resistance

The component assembly shall be tested for water-penetration resistance in accordance with ISO 811 using a rate of water pressure increase of 10 mbar/min and shall have a minimum water-penetration resistance of 200 cm. Appearance of water drops shall constitute failure.

8.2 Surface wetting

The outer material when tested in accordance with ISO 4920 shall give a spray rating of $\geqslant$ 4.

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9 Marking

9.1 If the requirements of this International Standard are only met by the use of a clothing ensemble or a clothing assembly this shall be declared on the labels of all garments or layers involved.

All other marking requirements shall be in accordance with ISO 13688.

9.2 The reflective protective clothing for which compliance with this International Standard is claimed shall be marked with the pictogram (see Figure 1) and the number of this International Standard including the level of thermal performance. If a garment does not pass Level 2 where levels are provided (6.2, 6.3 and 6.4), the garment shall be marked with Level 1.

ISO 15538 — Level 1 or 2

Figure 1 — Pictogram ISO 7000-2418

10 Manufacturers' information

The manufacturer of the clothing shall provide information as specified in ISO 13688.

In addition, the manufacturer shall specifically warn the end user about the potential of being subjected to heat stress while wearing garments conforming to this International Standard.

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Annex A
(normative)

Mechanical pretreatment for metallized materials

A.1 Principle

The effectiveness of metallized coatings in reflecting radiant heat can be drastically reduced by the effects of wear. This method is designed to simulate the effect of repeated use. Specimens are mechanically pretreated using a test device which simultaneously twists and compresses the specimen.

A.2 Sampling

Specimens measuring 280 mm × 280 mm shall be taken from the material or garment. Specimens may include a seam if it is not possible to take a specimen of the specified size without one.

This specimen size is just sufficient to wrap around the circumference of the discs, but overlaps the discs at each end. Only the central portion of the specimen is used for subsequent testing. Thus, two specimens (230 mm × 70 mm) may be taken from each flexed specimen for subsequent testing in accordance with ISO 6942.

A.3 Apparatus

A.3.1 Test device (see Figure A.1), consisting of two discs, (90 ± 1) mm in diameter and (12 ± 0,5) mm thick; one disc is fixed and the other is mounted on a grooved shaft so that it moves towards the fixed disc in two stages:

a) forward movement of (90 ± 5) mm accompanied by rotation of (450 ± 10)°; followed by

b) forward movement with no rotation.

When the initial disc separation is set at (190 ± 1) mm, the disc separation at the completion of the forward motion shall be (35 ± 2) mm.

The movement of the revolving disc shall be uniform, except during the change from rotary to forward motion and vice versa. One cycle shall comprise one forward and one reverse movement. The device shall complete (40 ± 4) cycles/min.

A.4 Procedure

Adjust the distance between the two discs to (190 ± 1) mm. Attach the specimen to the discs without tensioning it, with the coating facing outwards and the specimen protruding over the edges of the two discs.

Subject the specimen to 2 500 cycles. Remove the specimen after every 500 cycles (approximately 12,5 min), rotate it through 90° and reclamp it.

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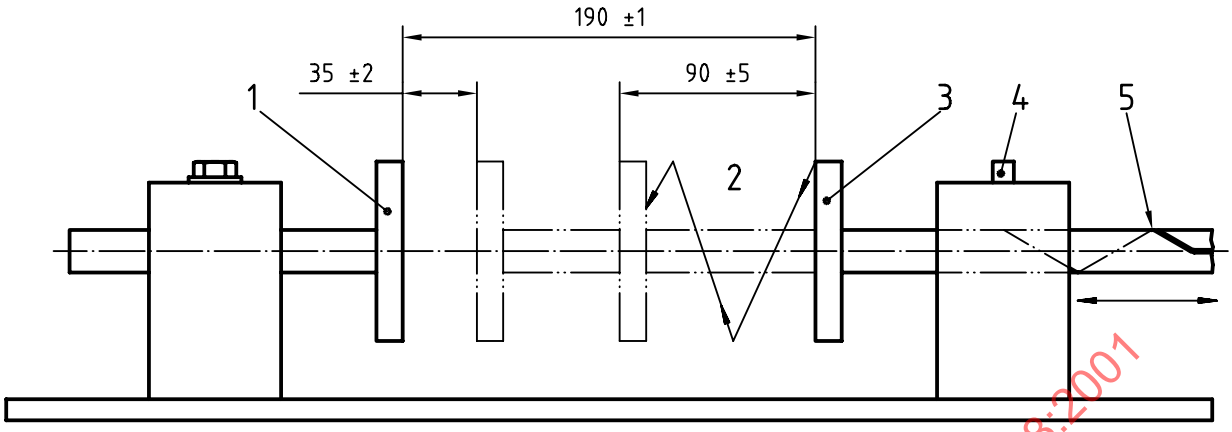
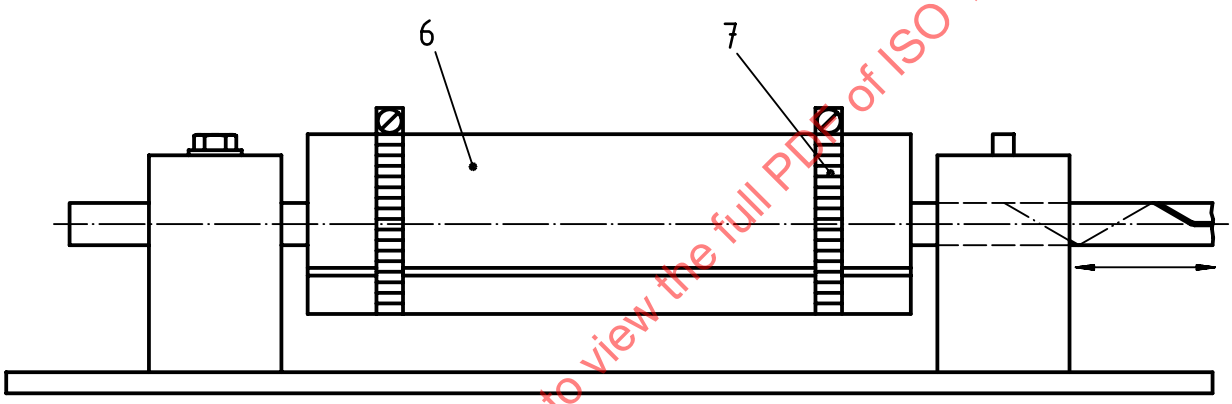
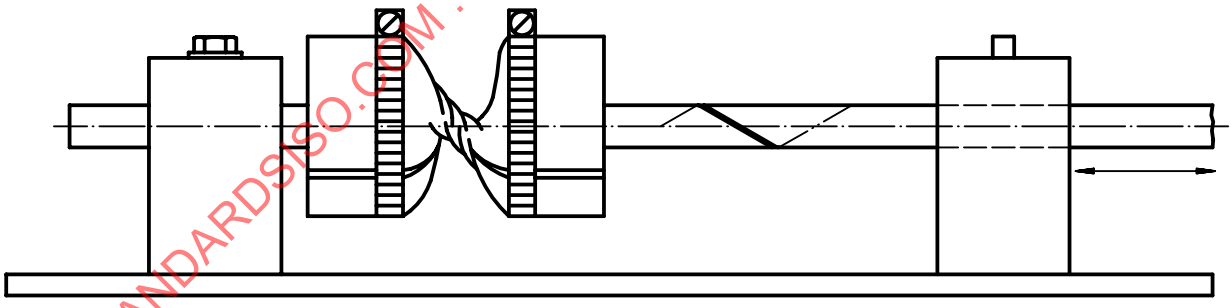
Dimensions in millimetres



a) Disk movement



b) Initial specimen position



c) Specimen fully compressed

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Key

1 Fixed disk
2 Rotation of 450°
3 Moving disk
4 Peg
5 Grooved shaft
6 Specimen
7 Clamp for attaching specimen to disc

Figure A.1 — Mechanical pretreatment apparatus

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Annex B
(informative)

Warning for flame engulfment

The following notes are not in any way intended to be portrayed as a recommendation nor as part of any standard for clothing or procedures but are set out to caution any potential user of such clothing about exposure to such conditions.

Without exception, it is recommended that persons not be deliberately exposed to flame engulfment due to the inherent danger to life safety. Of all the garments used by firefighters, covered in the series of standards for protective clothing (ISO 15384, ISO 11612 and ISO 11613 given in the Bibliography), the protective garments specified as Level 2 of this International Standard are the garments intended to provide the highest level of protection for firefighters.

Even these garments are not recommended as protection against flame engulfment but it is recognized that under certain conditions this may happen accidentally. It is recommended that persons wearing ISO 15538 Level 2 garments who are exposed to flame engulfment for a limited period should withdraw as soon as possible and carefully remove this clothing in a location at a safe distance from the incident. If considered necessary, medical advice should be sought after such exposure and the garments that have been exposed to limited flame engulfment should be carefully examined. If after examination, compliance to the requirements of Level 2 of this International Standard cannot be assured, the clothing should be removed from service.

If, after a risk assessment, it is decided that there is absolutely no alternative to working in conditions of short-term or prolonged flame engulfment, the most comprehensive safety procedures should be adopted. These procedures should include having suitable rescue and medical personnel and equipment available in the event of the break down of the safety systems and/or procedures.

The flame/heat hazard of continuous flame engulfment is more convective than radiative. Therefore clothing with a reflective outer surface should not be used as most of these types of material have high heat capacities and therefore there is a high risk of heat transfer to the inner layers of the garment.

Clothing manufactured to Level 1 or Level 2 of this International Standard is therefore not considered suitable for such use and nor is clothing manufactured to any of the other standards in the series of standards for protective clothing for firefighters given in the Bibliography. Such clothing should not be used for primary protection under such exposure.

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